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**The Syrian Refugees' Impact on Lebanon's  
Food Security**

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## Abstract

The outbreak of the civil war in Syria in 2011 and the influx of Syrian refugees impacted Lebanon's food security as well as its other natural resources such as water, ecosystems, and woodlands. This research study considers the literature found in the reports coupled with mathematical reasoning, to analyze the impact of the presence of the Syrian refugees on Lebanon's food security. This research fills the gap in the literature by presenting the missing tangible calculations. To do so, the yearly change in the harvested area of each crop as well as the total harvested areas, the production, and the yearly demand versus the supply were examined. Based on the calculations, the Syrian refugees did not affect the number of areas harvested nor the production. The arrival of more than one million people to the country in three years was an undeniable challenge for the stability of national food availability but given that Lebanon is highly reliant on food imports and due to the flexibility of the external supply the influx of refugees has been correlated with a proportional increase in food imports. The absence of resources and statistical data about the agricultural sector in Lebanon explains the lack of numerical-based studies in the literature. It is challenging to conclusively say whether the displaced Syrian refugees negatively impacted Lebanon's food security based on the findings of the study. However, it is safe to say that despite the tremendous stress on the local demand that an influx of over one million people is likely to place in a small country like Lebanon, the predicted stress on the harvest and yield did not occur.

**Key Words:** Agriculture, Crisis, Crop, Food Availability, Food Security, Harvest, Import, Lebanon, Syrian Refugees, Production

## Table of Contents

Acronyms.....	9
1. Introduction.....	10
2. Literature Review.....	12
2.1. Lebanon Overview .....	12
I. Lebanon's Profile.....	12
II. Lebanon's History .....	13
III. Lebanon's Geography.....	13
IV. Lebanon's Agricultural Sector.....	15
2.2. Syrian War and Refugee Status Overview .....	18
2.3. Food Security .....	21
2.4. Intersection and Impact of the Syrian Crisis on Lebanon .....	21
I. Impact on the Food Security.....	21
II. Impact on Food Availability .....	22
III. Impact on Access to Food.....	23
IV. Impact on Food Utilization.....	24
V. Impact on Water Resources .....	25
VI. Impact on Other Natural Resources.....	26
3. Methods.....	27
4. Results.....	33
5. Discussion .....	53
6. Conclusion .....	58
7. References.....	61
8. Appendix.....	67

## List of Tables

Table 1 - Food Import Value in Thousand Euros (ITC, Trade Map) .....	17
Table 2 - Area Harvested by Governorate, 2010 .....	33
Table 3 - Crop Characteristics (FAO).....	38
Table 4 - Green and Blue Water Required per Crop in Km <sup>3</sup> , 2008 – 2012.....	39
Table 5 - Green and Blue Water Required per Crop in Km <sup>3</sup> , 2012 – 2016.....	39
Table 6 - Number of Syrian Refugees per District .....	42
Table 7 - Lebanon's Population, 2008 – 2012 .....	43
Table 8 - Lebanon's Population, 2012 – 2016 .....	43
Table 9 - Production in tons.....	44
Table 10 - Net Production Including Trade in tons, 2008 – 2010 .....	45
Table 11 - Net Production Including Trade in tons, 2011 – 2013 .....	45
Table 12 - Net Production Including Trade in tons, 2014 – 2016 .....	45
Table 13 - Share of the Net Production Between the Population, 2008 – 2010 .....	46
Table 14 - Share of the Net Production Between the Population, 2011 – 2013 .....	46
Table 15 - Share of the Net Production Between the Population, 2014 – 2016 .....	47
Table 16 - Recommended Serving of Each Crop (FoodData Central) .....	47
Table 17 - Supply and Demand in grams/capita/day .....	48
Table 18 - Net Production vs Demand in grams/capita/day .....	48
Table 19 - Supply and Demand in kcal/capita/day .....	49
Table 20 - Net Production vs Demand in kcal/capita/day .....	49



Table 21 – Supply and Demand in Optimum Conditions in g/capita/day .....	50
Table 22 - Net Production vs Demand in Optimum Conditions in g/capita/day .....	50
Table 23 - Area Harvested per Governorate in Hectares, 2008 – 2009 .....	67
Table 24 - Area Harvested per Governorate in Hectares, 2011 – 2012 .....	67
Table 25 - Area Harvested per Governorate in Hectares, 2013 – 2014 .....	68
Table 26 - Area Harvested per Governorate in Hectares, 2015 – 2016 .....	68
Table 27 - Production by Governorate in tons, 2008 – 2009 .....	69
Table 28 - Production by Governorate in tons, 2010 – 2011 .....	69
Table 29 - Production by Governorate in tons, 2012 – 2013 .....	70
Table 30 - Production by Governorate in tons, 2014 – 2015 .....	70
Table 31 - Production by Governorate in tons, 2015 – 2016 .....	71
Table 32 - Supply and Demand in Optimum Conditions in kcal/capita/day .....	85
Table 33 - Net Production vs Demand in Optimum Conditions in kcal/capita/day .....	85

## List of Figures

Figure 1 – Map of Lebanon and Neighboring Countries .....	12
Figure 2 - Lebanon's Governorates and Districts (LCRP, 2017) .....	14
Figure 3 - Lebanon's Most Vulnerable Localities (LCRP, 2017) .....	19
Figure 4 - Distribution of Informal Settlements on Agricultural Areas (FAO, 2014) .....	20
Figure 5 - Percentage of Households with Food Insecurity in 2016, (LCRP, 2017) .....	21
Figure 6 - Prevalence of Undernourishment as a Percent of Population (FAO) .....	24
Figure 7- Total Area Harvested in Hectares .....	34
Figure 8 – Total Area Harvested per Governorate in Hectares .....	34
Figure 9 - ESA Map Land Cover, 2008 .....	35
Figure 10 - ESA Map Cropland, Irrigated and Rainfed, 2008 .....	35
Figure 11 - Cropland Rainfed, 2008 .....	36
Figure 12 - Aggregate Cropland Rainfed, 2008 .....	36
Figure 13 - Wheat Polygon to Raster, 2008 .....	37
Figure 14 - Wheat Area Harvested in Hectares per Pixel, 2008 .....	37
Figure 15 - Total Area Harvested in Hectares per Pixel, 2008 .....	38
Figure 16 - Total Water Required in Km <sup>3</sup> .....	40
Figure 17 - Total Water Required in Km <sup>3</sup> per Pixel, 2008 .....	40
Figure 18 - Lebanon's Population Count, 2008 .....	41
Figure 19 - Water Availability, 2008 .....	41
Figure 20 - Wheat Production in tons per Pixel, 2008 .....	42

Figure 21 - Spatial Distribution of the Syrian Refugees by District, 2011 .....	43
Figure 22 – Graphical Summary of the Production .....	52
Figure 23 - ESA Land Cover Maps, 2009 –2016 .....	71
Figure 24 - Cropland Rainfed Maps, 2009 – 2016 .....	72
Figure 25 - Aggregate Cropland Rainfed Maps, 2009 – 2016.....	72
Figure 26 - Almonds' Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	73
Figure 27 – Apples’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	73
Figure 28 – Apricots’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	74
Figure 29 – Bananas’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	74
Figure 30 - Barley’s Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	75
Figure 31 – Beans’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	75
Figure 32 – Cherries’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	76
Figure 33 – Cucumbers’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016 .....	76
Figure 34 - Grapes' Area Harvested in Hectares per Pixel Maps, 2008 – 2016 .....	77
Figure 35 – Lemons’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	77
Figure 36 – Olives’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	78
Figure 37 – Onions’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	78
Figure 38 – Oranges’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	79
Figure 39 – Peaches’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	79
Figure 40 – Potatoes’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	80
Figure 41 – Tomatoes’ Area Harvested in Hectares per Pixel Maps, 2008 – 2016.....	80

Figure 42 – Wheat’s Area Harvested in Hectares per Pixel Maps, 2008 – 2016 .....	81
Figure 43 - Total Area Harvested in Hectares per Pixel Maps, 2009 – 2016.....	81
Figure 44 - Snippet of the MATLAB Code .....	82
Figure 45 - Total Water Required in Km3 per Pixel Maps, 2009 – 2016.....	83
Figure 46 - Lebanon's Population Count Maps, 2009 – 2016 .....	83
Figure 47 - Water Availability Maps, 2009 – 2016 .....	84
Figure 48 - Spatial Distribution of the Syrian Refugees by District Maps, 2012 – 2016.....	84

## Acronyms

CCI LC	Climate Change Initiative Land Cover
CFS	United Nation's Committee on World Food Security
ESA	European Space Agency
FAO	The Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GFSAD	Global Food Security-Support Analysis Data
HDX	Humanitarian Data Exchange
ICPE	Independent Country Program Evaluation
IAMP	Inter-Agency Mapping Platform
ITC	International Trade Center
LC CCI CRDP	Land Cover Climate Change Initiative Climate Research Data Package
LCRP	Lebanon Crisis Response Plan
MoA	Ministry of Agriculture of Lebanon
MoE	Ministry of Environment of Lebanon
MEW	Ministry of Energy and Water of Lebanon
NSSF	National Social Security Fund
UN	United Nations
UNDP	United Nations Development Program
UNHCR	United Nations High Commissioner for Refugees
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
US	United States
USDA	United States Department of Agriculture
WFP	World Food Program

## 1. Introduction

Poverty, hunger, and malnutrition still exist severely in our world today. Almost one in three people in the world did not have access to safe nutritious food in 2020 according to the UN. Nearly 700 million people were going to bed hungry. This reality is further challenged by continuous conflict, economic disruptions, political displacement, and the global pandemic. (Global Issues, Food, UN)

Human experience on earth has included countless migrations. Nowadays, people are fleeing their lands out of a sudden need for a safer haven. Hosting large numbers of displaced people has a political, economic, and social cost, particularly on the countries that are barely standing on their own. The massive movement of entire populations to low-income countries can affect their development and sustainability.

This was the case of Syria. The Syrian civil war began in March 2011, as a part of a broader Arab Spring Protests all over the Arab world. Now in its eleventh year, it is the world's largest refugee and humanitarian crisis. Since 2011, almost seven million Syrian have fled their country and almost the same number of people were internally displaced. Most of the displaced Syrians fled to Turkey, Lebanon, Jordan, Iraq, and Egypt. Over the last ten years, Turkey has taken in more refugees than any other country however, no country comes close to Lebanon in terms of refugee population as a percentage of the total population. (UNDP, 2014)

In this context, the necessity to consider this issue is undeniable. This study will focus on the case of Lebanon, more particularly, the impact of the presence of the Syrian refugees on the food security in Lebanon. How can a country as small as Lebanon sustain its resources in the face of a massive political displacement?

Lebanon welcomed more than 1.2 million Syrian refugees within the span of three years. With a current population of 6.79 million people, the registered Syrian refugees make-up about a quarter of the Lebanese population.

This increase in the population translates in a rise in basic needs required to sustain a healthy life. This study focuses on the impact of the displaced Syrians on food security as per its pillars: availability, access, and utilization, as well as the impact on other natural resources such as water, ecosystems, and woodlands.

In this research paper an overview of the current literature considering each element of the research independently is presented. Lebanon's geopolitical and environmental context, the Syrian war and refugees' movements, and the concept of food security. It is then followed by literature that considers an intersection between the three different elements, exploring the available data on the impact of the Syrian crisis on food security and agricultural livelihoods.

The literature however lacks proper mathematical studies. The absence of resources and statistical data about the agricultural sector in Lebanon explains the lack of numerical-based studies in the literature. It is challenging to conclusively say whether the displaced Syrian refugees negatively impacted Lebanon's food security based on words alone rather than numbers.

This research study considers the literature found in the reports coupled with a mathematical reasoning to fill the gap in the literature by presenting tangible calculations on the harvest and food production as compared to the demand.

## 2. Literature Review

This study analyzes the impact of the presence of the Syrian refugees on food security in Lebanon. It is necessary to address the research question to study how to sustain a nation's resources in the face of political displacement. The following section is a detailed overview of the current literature considering each element of the research independently: Lebanon's geopolitical and environmental context, the Syrian war and refugees' movements, and the concept of food security. Then it is followed by literature that considers an intersection between the three different elements.

### 2.1. Lebanon Overview

The following section describes Lebanon's profile, history, geography, and agricultural sector.

#### I. Lebanon's Profile

Lebanon is a country in Western Asia, the Middle East, officially known as the Lebanese Republic. Figure one below illustrates how Lebanon shares its north and east borders with Syria and its South borders with Israel. All of Lebanon's westside is a coastline on the Mediterranean Sea. (FAO AQUASTAT Report, 2008)



Figure 1 – Map of Lebanon and Neighboring Countries



Lebanon has a land area of 10,452 square kilometers and a current population of almost 6.79 million inhabitants from which more than 1.2 million are Syrian refugees. Lebanon is also home to 50,000 Palestinian refugees from Syria, as well as about 300,000 pre-existing Palestinian refugees. (ICPE Lebanon, 2020)

## II. Lebanon's History

The first signs of civilization date back to more than 7,000 years. Lebanon was ruled by the Roman Empire and then later in the sixteenth century by the Ottoman Empire. Following the Ottoman Empire's collapse after World War I, Lebanon was under the French mandate until it gained its independence in 1943. With the establishment of Israel in 1948, thousands of Palestinians sought refuge in Lebanon. Since then, Lebanon passed through periods of political stability and economic prosperity up until the eruption of the civil war in 1975 which ended in 1990, lasting for fifteen years. Shortly after the civil war began, the Syrian and Israeli army invaded Lebanon in 1976 and 1985, respectively. The Israeli occupation ended in 2000 while the Syrian occupation ended in 2005. In 2011 the Syrian war erupted causing a lot of spillover into Lebanon in terms of political stability, safety, and additional pressure on its already scarce resources.

Since October 2019, Lebanon has been experiencing its worst financial crisis. The Lebanese pound which was fixed at a rate of 1,507 Lebanese pounds per one United States dollar now stands at 28,000 which is still increasing by the day.

## III. Lebanon's Geography

Lebanon is a mountainous country that extends about sixty kilometers from west to east and 225 kilometers from north to south along the Mediterranean coast.

The country is divided into eight governorates: Beirut, Mount Lebanon, North, Akkar, South, Nabatiyeh, Bekaa, and Baalbek El Hermel. (FAO AQUASTAT, 2008)



Figure 2 - Lebanon's Governorates and Districts (LCRP, 2017)

With regards to topography, Lebanon has four parallel homogeneous areas along its north-south orientation. The first area, on the far west, is a flat and narrow coastal strip parallel to the Mediterranean Sea. The second longitudinal strip is the Lebanon Mountains, also known as Mount Lebanon, which consists of a chain of medium and high mountains ranging from 1,000 to 3,088 meters above sea level. The third major region is the Bekaa Valley, Lebanon's main agricultural area having the most arable land. And finally, on the far east, the Anti-Lebanon mountain range, with mountains that rise up to 2,800 meters and spread across the eastern Syrian border. Anti-Lebanon is mostly arid, making it less productive and more sparsely populated. (Jeanmougin, 2017)

Lebanon has a Mediterranean climate, with mildly cold and rainy winters from December until March, and hot and dry summers, from June until September. The temperature on the coast

ranges from thirteen degrees Celsius in winter to thirty-five degrees Celsius in summer, while in the Bekaa valley it ranges from five degrees Celsius in winter to thirty-three degrees Celsius in summer. (FAO AQUASTAT, 2008)

On the coast, the average annual rainfall ranges between 700 and 1,000 millimeters. About seventy percent of the country's rainfall falls between November and March during only a few days of heavy cloudbursts or violent storms. Inland the average precipitation is higher, about 1,600 millimeters, with snow in the mountains. Rain and snowfall are the country's primary renewable source of water, providing water for both rainfed and irrigated crops. Less than one-third of the available surface water is used for irrigation. (FAO AQUASTAT, 2008)

#### IV. Lebanon's Agricultural Sector

Jeanmougin examines the evolution of the agricultural sector in the Middle East. Her article "You Reap What They Sow" focuses on inquiries related to Lebanon in particular. Lebanon is divided into five major agricultural zones. First is Mount Lebanon, which is high in altitude and receive a significant amount of precipitation, making it suitable for the cultivation of apples. The slopes are ideal for growing olive, almond trees, and grapes. The Bekaa Valley, a vast fertile plateau located between the two mountain chains, is ideal to produce vegetables, fruits, and cereals. In the north potatoes and cereals are cultivated, while in the south, which is a less irrigated area, potatoes and tobacco are grown. Finally, despite its narrowness, the coastal strip is an agricultural area producing citrus and bananas. (Jeanmougin, 2017)

According to FAO, sixty-four percent of the Lebanese territory is covered by agricultural land. Thirty-nine percent of the agricultural land is cropland, and nineteen percent of the agricultural land is under permanent crops. The two main agricultural regions though are the Bekaa Valley and Baalbek El Hermel, which represent forty-two percent of the total cultivated area, and North Lebanon and Akkar, which accounts for twenty-six percent. (FAO AQUASTAT, 2008)

The major agricultural products of Lebanon can be classified into six categories: vegetables, fruits, live animals and animal products, cereals, and unmanufactured tobacco.

Fruits make up about forty-two percent of all agricultural production in Lebanon. The main fruit products cultivated are citrus fruits such as orange and lemon, as well as grapes, apples, and bananas. Vegetables come in second, accounting for thirty percent of the total agricultural output, primarily producing potatoes, tomatoes, and cucumbers. Livestock products, which are mainly dairy products, account for eleven percent of the Lebanese agricultural products. Traditional Lebanese dairy products, made from goat and cow milk, represent a significant portion of the country's livestock production, since these products are popular protein sources in the Lebanese cuisine and are usually eaten daily by most. Livestock, mainly chicken, cattle meat, sheep, and goats, is another important agricultural product accounting for ten percent of the total agricultural production. And finally, the last seven percent of Lebanon's agricultural products include cereals such as wheat and maize, and tobacco. (Hamade, 2020)

Agriculture has always been an important sector of the Lebanese economy, contributing to food production and exporting a variety of agricultural goods. However local and regional socioeconomic and political dynamics have always had a strong negative influence on agricultural development in Lebanon. The government lacks a policy vision for agriculture, since it always comes second to more important issues like the lack of basic infrastructure such as electricity, water supply, and waste management. The agricultural sector, which is often neglected, relies on interventions from international donors. As a result, agricultural services have been limited, having insufficient funds, primitive practices, and outdated techniques.

The agricultural sector's budget has never exceeded one percent of the annual national budget. Even though the compound annual growth rate between 2010 and 2018 of the agricultural sector was relatively low, about two percent, having a sustained agricultural growth is critical to improve living standards and generate high revenues. According to the MoA's agriculture

census of 2010, approximately 170,000 small and large-scale farmers, require assistance to improve the agricultural sustainable production, assets, and infrastructure, as well as support the agricultural labor market and national institutions; however, as it was already mentioned, the MoA receives less than one percent of the government budget. (MoA, 2010)

The farming community in Lebanon is highly vulnerable, and the sector in general is informal. According to the MoA census of 2010, seventy percent of agricultural holdings are classified as small-scale farmers, having eighteen percent of cultivated lands. Forty-two percent of farmers are older than fifty-five, and seventy-five percent are not registered with the NSSF, making them one of the most vulnerable working groups. Nonetheless, the sector provides a significant source of income for about twenty percent of Lebanon's working population, including full-time and part-time workers as well as seasonal family labor. (MoA, 2010)

According to the WFP, the Lebanese food sector has managed to fulfil the additional demand of 1.2 million refugees, not through its own neglected agricultural sector but mainly through imports. With its weak industrial and agricultural production, Lebanon relies heavily on imports and has a trade balance that is significantly in deficit. (WFP, 2015)

As per the Lebanese customs, food imports increased by about twenty-five percent between 2010 and 2014, which is almost proportional to the rise in Lebanon's population during the same time period.

HS Code	Product Label	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	Live Animals	115,052	184,789	244,637	217,583	222,660	220,485	276,599	322,324	280,696
2	Meat & Edible Meat Offal	91,828	124,956	145,409	125,507	123,762	120,881	136,780	138,945	123,884
3	Fish, Crustaceans & Molluscs	35,019	47,667	54,660	60,217	60,746	62,822	71,544	76,069	84,583
4	Dairy Produce	153,800	181,750	205,105	215,099	231,073	264,485	302,388	276,771	264,136
7	Edible Vegetables, Roots & Tubers	89,678	80,649	101,099	100,374	98,683	102,938	110,436	115,977	129,149
8	Edible Fruit & Nuts	57,667	71,995	81,350	82,818	101,964	112,746	119,674	162,991	162,591
9	Coffee, Tea & Spices	48,693	46,446	59,420	72,080	85,673	84,980	83,116	97,162	91,331
10	Cereals	214,048	173,668	201,922	251,250	272,854	272,867	271,371	284,129	259,673
16	Preparations of Meat & Fish	51,880	52,667	68,909	64,134	79,672	86,084	87,538	89,980	93,796
17	Sugars & Sugar Confectionery	57,483	75,087	107,472	126,403	126,727	127,283	124,020	158,940	183,306
18	Cocoa & Cocoa Preparations	37,083	45,092	55,849	52,179	63,286	69,609	72,078	85,170	83,140
19	Preparations of Cereals, Flour & Starch	82,843	104,381	124,215	134,544	161,961	182,536	183,460	251,077	246,344
20	Preparations of Vegetables, Fruits & Nuts	38,549	40,064	47,141	53,724	56,905	67,637	66,629	78,053	80,177
Total Food Import Value (1,000 €)		1,073,623	1,229,211	1,497,188	1,555,912	1,685,966	1,775,353	1,905,633	2,137,588	2,082,806

Table 1 - Food Import Value in Thousand Euros (ITC, Trade Map)

This statement is confirmed by examining table one above, computed from Trade Map which reports the value of food imports in thousands of euros. Looking at the numbers it is obvious that Lebanon relies heavily on food imports rather than harvesting and producing its own food produce. Live animals, cereals, and dairy produce are the main food imports. (ITC)

## 2.2. Syrian War and Refugee Status Overview

The Syrian civil war began on the fifteenth of March 2011, as a part of a broader Arab Spring Protests all over the Arab world. Now in its eleventh year, it is the world's largest refugee and humanitarian crisis. Since 2011, more than 6.6 million Syrian have fled their country to neighboring territories, Europe, and other parts of the world; and almost the same number of people were internally displaced. Most of the displaced Syrians, approximately 5.5 million, fled to Turkey, Lebanon, Jordan, Iraq, and Egypt. Over the last ten years, Turkey has taken in more refugees than any other country with over 3.6 million registered Syrian refugees. However, no country comes close to Lebanon in terms of refugee population as a percentage of its total population. (UNDP, 2014)

Lebanon, which has a population of 6.79 million people, is currently hosting an estimated 1.2 million registered Syrian refugees, which is almost twenty per cent of the total population. The actual value is most likely even higher since in mid-2014 the national authorities demanded that the UNHCR halt the registration of new refugees, which resulted in having a lot of illegal and undocumented Syrian refugees. Due to the lack of official camps, Syrian refugees are dispersed throughout Lebanon. Eighty-seven percent of the refugees live in 251 known localities, same as sixty-seven percent of the poor Lebanese population. These are the most vulnerable cadasters of Lebanon. In some municipalities, Syrian refugees even outnumber the locals (UNDP, 2020).

Figure three below reports Lebanon's most vulnerable localities with the percentage of deprived Lebanese and refugees by cadaster, as well as the pressure on the resources to highlight the potential degree of population pressure in services and resources. (UN, Lebanon Crisis Response Plan, 2017)

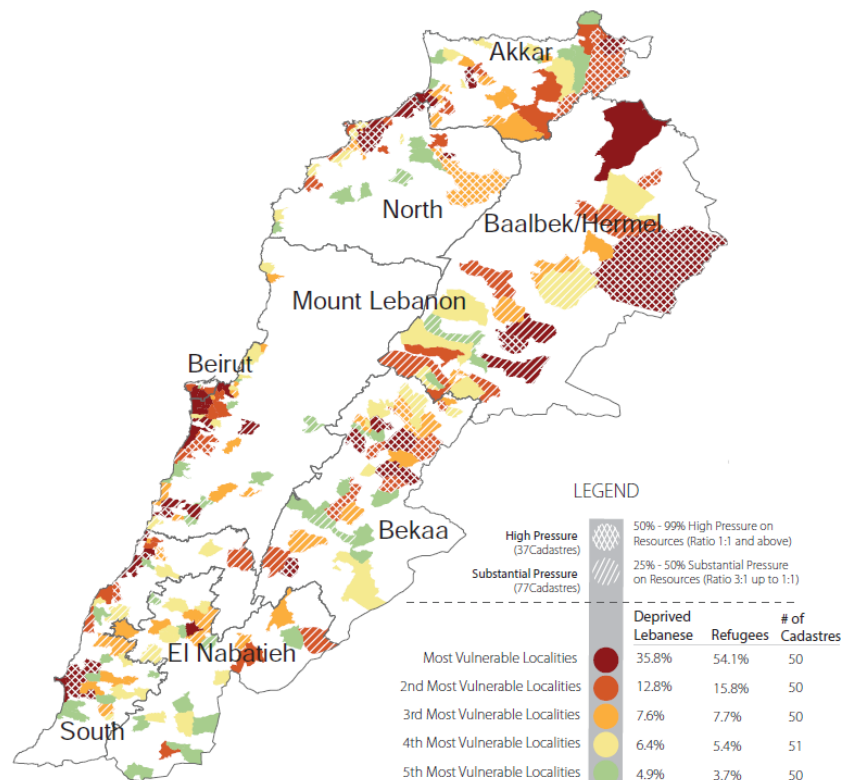


Figure 3 - Lebanon's Most Vulnerable Localities (LCRP, 2017)

Thirty-four percent of the Syrian refugees live in the governorate of Bekaa, scattered in the districts of Hermel, Baalbek El Hermel, Zahle, and West Bekaa. Twenty-nine percent are settled in the North and Akkar governorates, mainly in Halba. Twenty-five percent reside between Beirut and Mount Lebanon specifically in southern suburbs of Beirut. And finally, twelve percent are in the South mainly in the districts of Saida and Sour.

The concentration of the Syrian refugees in Lebanon is linked to geographic and economic factors. As previously stated, the largest concentration of refugees is in the Bekaa Valley, which shares an extended border with Syria, making it an expected and logical point for those fleeing the conflict. Also, as mentioned earlier, the Bekaa Valley is the main agricultural area of

Lebanon, having forty-two percent of the country's total cultivated land. Since the government has legal restrictions on Syrians' employment, restricting them from working in industries other than construction, cleaning, and agriculture, the Lebanese agricultural industry is severely reliant on low-wage labor force to reduce costs and boost profits. As a result, farmers in the Bekaa have employed and benefited from Syrian workers. Having limited options and no legal protection, many Syrians have settled in the Bekaa region, Baalbek El Hermel and in Akkar in informal tented settlements made up of temporary tents near and on agricultural fields where there are some work opportunities.

According to data from IAMP, which collects basic information for all informal settlements on a quarterly basis, and as seen in figure four below, the largest concentration of informal settlements is found in the Bekaa, and in the North, which represent Lebanon's two largest agricultural regions.

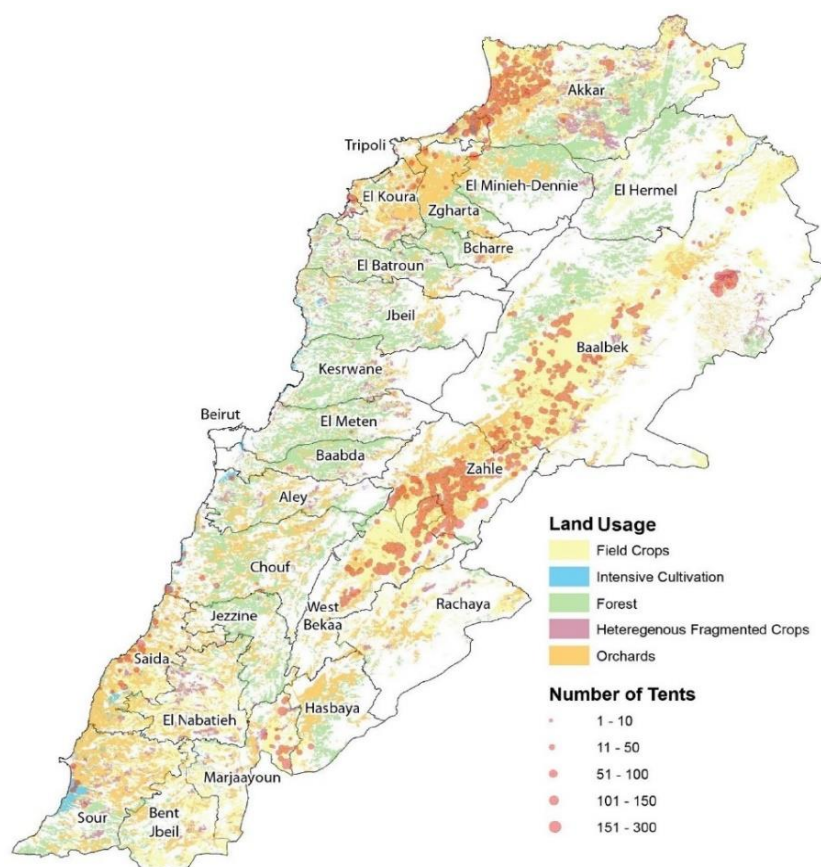


Figure 4 - Distribution of Informal Settlements on Agricultural Areas (FAO, 2014)



### 2.3. Food Security

According to the CFS, food security implies that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences to have an active and healthy life. FAO distinguished four pillars of food security: availability, access, utilization, and stability. (FAO, 1996)

### 2.4. Intersection and Impact of the Syrian Crisis on Lebanon

The following section delves into the available data on the impact of the Syrian crisis on food security and agricultural livelihoods by studying the impact on its pillars.

#### I. Impact on the Food Security

The effects of the lengthy Syrian crisis have had a significant impact on food security in Lebanon over the last ten years, particularly in the East and North of the country as seen in figure five below. In Zahle and Baalbek, the two districts with the highest number of registered Syrian refugees, more than fifty percent of the households are food insecure. (LCRP, 2017)

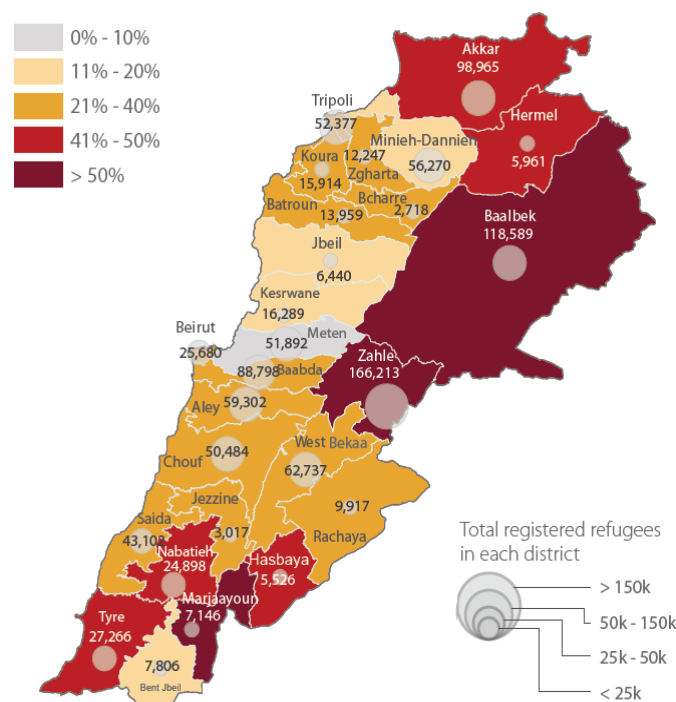


Figure 5 - Percentage of Households with Food Insecurity in 2016, (LCRP, 2017)

## II. Impact on Food Availability

As per FAO, food availability is achieved when enough food is always available to all individuals within a country. Food can be obtained through household production, other domestic outputs, commercial imports, or food assistance. (FAO, 1996)

According to a study done by the UNDP in 2012 on the impact of the Syrian crisis on the socioeconomic situation in the North and Bekaa regions, it was found that the conflicts in areas bordering Syria have however harmed Lebanon's agricultural production. Farmers cannot always access their cultivations or move freely in their croplands, sometimes missing critical stages of crop development and harvest. Many farmers had to abandon or sell their lands, while others go to their farmland less often, resulting in a lot of losses.

The growing number of informal settlements on and near agricultural land is yet another aspect affecting land use and thus food availability. Syrians living in informal settlements occupy more land than those living outside informal settlements, putting those lands out of production.

The Syrian crisis also had a significant impact on the import and the cost of agricultural inputs. Prior to the crisis, Lebanese farmers, especially those near the borders, used to buy pesticides, seeds, fertilizers, and diesel for their machinery from Syria since they were much cheaper than the Lebanese products. The Syrian products were obtained through informal trade and smuggling routes which were no longer possible after the crisis due to how unsafe the situation and area were. As a result, farmers were forced to seek alternative sources of inputs at higher costs, which not everyone could afford.

As previously mentioned, the food imports increased proportionally with the influx of refugees diminishing the pressure on food availability.

### III. Impact on Access to Food

As per FAO, food access is ensured when individuals have both physical and economical access to adequate resources to obtain appropriate foods for a nutritious diet. (FAO, 1996)

The Syrian crisis jeopardizes the economic access to food of the Lebanese, especially the vulnerable Lebanese host communities where most of the Syrian refugees are located, by increasing competition for jobs, and hence increasing unemployment. (LCRP,2017)

Even before the Syrian crisis, Lebanon's job market conditions were unfavorable, with high unemployment rates, and huge gaps between labor supply and demand. According to the UNHCR, more than ten percent of the Syrian refugees used to work in agriculture related jobs in Syria; and according to the International Labor Organization, they are mainly unskilled laborers with limited education who are willing to work under difficult conditions. Syrian refugees are therefore being hired for agricultural jobs at the expense of Lebanese workers.

Since 2012 WFP started supporting the Syrian refugees in Lebanon through a market-based food assistance program that gives electronic cards that are recharged monthly and can be spent on food in certain shops. In 2014 the voucher value per individual was 30 US dollars, however with the extent of the crisis in terms of the duration and the number of refugees, coupled with uncertainty over its conclusion, the WFP had to reduce its value to 19 US dollars a year later. In 2015 the humanitarian aid program was serving 871,307 Syrian refugees. (WFP, 2015)

Even though humanitarian assistance to Syrian refugees can be considered as a stabilizing factor, it decreases social cohesion between the refugees and the host communities. According to a report done by the humanitarian aid organization, World Vision International, many Lebanese are frustrated with the fact that Syrian refugees benefit a lot from national and international assistance while countless of Lebanese live in similar unfavorable conditions and do not receive any help. (World Vision, 2013)

#### IV. Impact on Food Utilization

As per FAO, food utilization is the proper biological use of food which necessitates a diet rich in essential nutrients and provided enough energy, safe drinking water, and adequate sanitation. It is mainly determined by people's health. (FAO, 1996)

Figure six below, from FAO, shows that in 2012, following the arrival of the Syrian refugees, Lebanon experienced a spike in the percentage of undernourished people reaching in all time high of 14.9 percent.

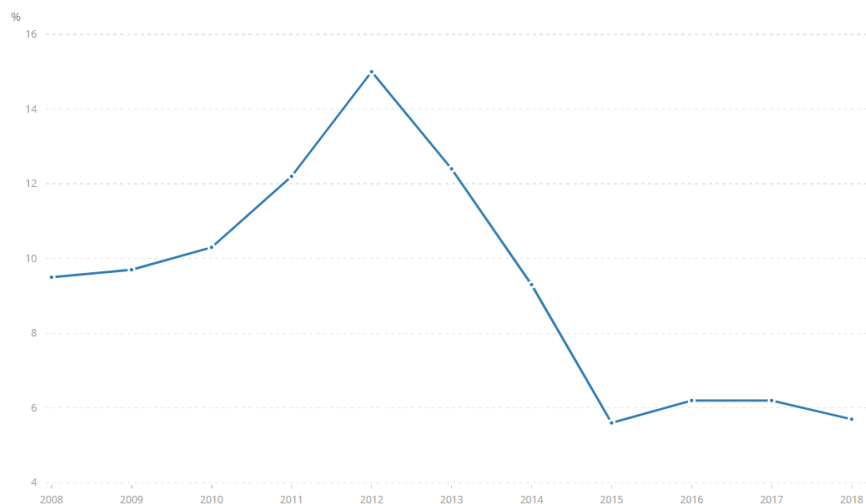


Figure 6 - Prevalence of Undernourishment as a Percent of Population (FAO)

As per a study made by the MoE in 2014, the Syrian refugees increased the soil and water contamination and therefore directly impacting and degrading the quality of agricultural produce, and therefore threatening people's health and hence food utilization. (MoE, 2014)

Also, Wastewater is very poorly managed in Lebanon, and most of the time remains untreated. As the number of Syrian refugees was increasing, the untreated wastewater levels increased, which resulted in an increase in pollution levels, which contaminates agricultural crops, fish, and wildlife populations, jeopardizing again people's health and hence food utilization.

## V. Impact on Water Resources

Prior to the Syrian crisis, Lebanon's water resources gave the country a competitive advantage over its neighbors. However, because of the crisis, this resource is being strained due to the increased demand. According to Bertassello, the influx of Syrian refugees doubled the blue water demand between 2005 and 2016. While the effects on water stress can be minor in most countries, they tend to be more significant in vulnerable countries that are facing water crises such as Lebanon.

In terms of water supply and quality, the increase in domestic water supply, mainly in the Bekaa, is estimated to be up to seventy million cubic meters, representing a twelve percent increase in national water consumption. (MEW, 2016)

In his paper Bertassello states that the water stress has increased from thirty-five percent in 2005 to fifty-nine percent in 2015. Out of this twenty-four percent increase, one third is due to food related blue water demand consumed by the refugees. (Bertassello, 2022)

According to a report by the MEW, this increase has worsened an already stressed water situation, resulting in lower groundwater tables in wells across the country ranging from one to twenty meters between April 2013 and April 2014. (MEW, 2016)

Depletion of water resources is a threat to agricultural production especially since farmers in Lebanon continue to use inefficient irrigation techniques, such as flood irrigation methods fed by open water channels. (MEW, 2010)

According to a report by the UNDP, the consumption of contaminated water, as well as poor sanitation and hygiene among refugees, has increased the prevalence of diarrheal and other communicable diseases. The pollution load from wastewater discharge has increased significantly as a result, especially since wastewater treatment plants in Lebanon are very limited.

## VI. Impact on Other Natural Resources

As for the solid waste management, the additional amount of municipal solid waste generated by the refugees is estimated to be 325,000 tons per year, which is an increase of about sixteen percent of municipal solid waste generation. While some waste is managed in existing facilities, more than half ends up in open dumps, which pollute the land, soil, and water and poses serious health hazards.

The land use and ecosystems were also affected. The influx of refugees has increased Lebanon's population density from 470 persons per square kilometers in 2010 to 570 in 2013. This urban densification causes many environmental and social stresses, generating more waste, water, and sanitation problems, noise pollution, and overcrowding. Refugees who have settled in informal tented settlements in rural area have invaded agricultural land, cutting down trees, and weakening sensitive ecosystems. (MoE, & UNDP, 2014)

As mentioned previously, the areas next to the Lebanese – Syrian border endured many negative consequences of the Syrian crisis. Another outcome of the hostilities is fire in woodlands in the areas near the border.

Also, the presence of refugees increases the demand for wood, especially in winter. The increase of forest fires and demand for wood contribute to the depletion of wood resources and forest degradation in Lebanon. (FAO AQUASTAT Report, 2008)

### 3. Methods

After looking into the available literature, I realized that there is a lack of studies based on the actual numerical data of the change in the yearly harvested agricultural areas and the yearly crop production to know if they were affected by the displaced Syrians.

This research study considers the literature found in the reports coupled with mathematical reasoning. The differentiator between this paper and the rest of the available rhetoric to this day is that it fills the gap in the literature by presenting tangible calculations on the harvest and food production as compared to the demand.

To study the impact of the Syrian refugees on Lebanon's food security I worked on a timeframe of nine years from 2008 till 2016. Three years before the Syrian war, from 2008 until 2010, three years of refugee influx into Lebanon, from 2011 until 2013, and three years after the Lebanese government issued a decision to prevent the entry of any additional displaced Syrians, from 2014 until 2016.

The first approach was to try and find satellite images of Lebanon from 2008 until 2016 to see how the agricultural area changed during the years and extract the needed information from them. However, after an extensive online search, and back and forth calls and emails with the MoA and different units of the Lebanese army, I was able to find only two satellite images of Lebanon, one in 2005 and another in 2016.

The second approach was to generate the maps myself, but unfortunately, very minimal data exist about Lebanon. According to FAOSTAT, sixty-two different crops are cultivated in Lebanon. From the FAOSTAT database, I downloaded the total area harvested of every crop from 2008 till 2016.

Eighteen crops cover ninety percent of the total area harvested and forty-four crops cover the remaining ten percent. The eighteen crops covering ninety percent of Lebanon's harvested area

are Almonds, Apples, Apricots, Bananas, Barley, Beans, Cherries, Cucumbers, Grapes, Lemons and limes, Olives, Onions, Oranges, Peaches and nectarines, Potatoes, Tobacco, Tomatoes, Wheat. Although tobacco is the seventh most cultivated crop in Lebanon, I chose to omit it from the calculations as it is not a food and hence all the calculation were done for the other seventeen crops.

The FAOSTAT database however only provides the area harvested in all of Lebanon and not on a governorate level. I found a report done in collaboration between FAO and MoA on Lebanon's agriculture statistics in 2010. In this report, the percentages of the area harvested of each crop, cultivated in each governorate, in 2010 were provided. Even though this method might not be as accurate as of the first approach it was the only feasible way to move forward. Having the percentages of the area harvested of each crop, cultivated in each governorate, in 2010, and the total area harvested, of each crop, also in 2010, I got the area harvested, in hectares, of each crop in each governorate in 2010. Using the 2010 values, I projected the results onto the other years and got the area harvested, of each crop, in each governorate, in each year. Next, I computed the fraction of each crop in each governorate in each year, by dividing the area harvested of each crop by the total area harvested of each governorate.

The following step was to generate, using ArcGIS, yearly crop-specific, area harvested per pixel maps. First, I needed a map showing the land cover of Lebanon. As a first trial, I wanted to use the Crop Dominance product of the Global Food Security-Support Analysis Data at 1 km resolution which provides cropland extent, irrigated versus rainfed, and crop dominance. This dataset was created by the National Aeronautics and Space Administration and the United States Geological Survey, to provide global cropland data that contributes towards global food security in the twenty-first century. The GCE 1 km Crop Dominance however has a lot of limitations. Firstly, it only provides the spatial distribution of the five major global cropland types: wheat, rice, corn, barley, and soybeans. Secondly, it has uncertainties in differentiating



irrigated areas from rainfed areas. And thirdly, it has significant uncertainties in areas, locations, and detail due to the coarse resolution nature of the maps. With that being said, I could not proceed with using the GFSAD dataset and had to find another land cover map. I then moved to ESA which provides the LC CCI CRDP, which has annual global land cover maps at 300 m spatial resolution. From the dataset, I downloaded and used the land cover maps of Lebanon from 2008 until 2016 as tiff files.

Moving to the ArcGIS software, after uploading the landcover map it was clear that most of Lebanon's cropland was rainfed rather than irrigated. The CCI LC maps attribute a class to each type of land cover. As per the legend, the values ten and twenty respectively represent the rainfed and irrigated cropland. Looking at the attribute table of the land cover map the value ten had a count of 45,349 while the value 20 had only 213. I decided to proceed with the rainfed cropland only and therefore generated a new map, using the raster calculation tool, eliminating all the values greater than ten. To resample the input raster to a rougher resolution, I generated an aggregate map of the latter based on the mean. The aggregate function multiplies the cell resolution of the input raster by a cell factor of thirty.

From HDX's platform of the UN OCHA, I downloaded a dataset that includes shapefiles of Lebanon's subnational administrative boundaries, dividing Lebanon into governorates, districts, and cadastral. On ArcGIS, I proceeded by adding the shapefile of Lebanon's eight governorates and joined it to the pre-calculated crop fractions. I then converted each crop fraction from polygon to raster to get a map showing the crop fractions per governorate.

The final step on ArcGIS was to generate a map per crop showing the area harvested per pixel. To do so I multiplied the crop fraction polygon to raster map by the aggregated rainfed cropland map and by a text file that converts the cell area to hectare pixel. The same procedure was repeated for the eighteen crops and the nine years.

I then added all the crop specific area harvested per pixel maps of each year, using the raster calculator tool, to get maps showing the total area harvested per pixel per year.

The next step was to compute the blue and green water required by each crop in each year based on the harvested area per pixel maps that were just generated. To do so I moved to MATLAB, but some data had to be computed before writing and running the model. From FAO's irrigation and drainage paper on crop evapotranspiration, guidelines for computing crop water requirements, I got the initial, mid, and end crop coefficient, the lengths of the development stages, and the planting and harvesting dates of all the crops. All the values were chosen for a temperate Mediterranean climate. By adding the information just mentioned and the harvested area per pixel maps onto a code on MATLAB I got the crop water requirement in cubic kilometers.

Going back to ArcGIS, using the raster calculator tool I added the water required by each crop to get a map showing the total water required per year. The next step was to compute the water availability per capita. To do so, first I added a map from WorldPop with the aggregated spatial distribution of the population in Lebanon, it reports the estimated total number of people per grid-cell. Using the raster calculator tool again, I divided the map of the total water required per year by the population counts map. The output raster was a map of the water availability per person per grid cell. Again, all the steps were repeated for all the years.

The following step was to compute maps of the production in tons of all the crops. First, I had to find the yield of each crop. I download a dataset from EarthStat that includes crop-specific data representing the average yield for each crop in tons per hectare. After uploading the Geotiff maps into ArcGIS, using the raster calculator tool again, I multiplied each area harvested per pixel map by the corresponding yield map. The output raster was a map of the production of each crop in tons per pixel. The same procedure was repeated for all the crops and all the years. Using the database from EarthStat however has some drawbacks. The main issue was its spatial

resolution. The data is reported with a resolution of 10 kilometers by 10 kilometers which is too coarse for a country as small as Lebanon. Another concern was the temporal resolution since the yield is reported for the year 2000.

To compare the location of the Syrian refugees with the agricultural area and understand whether they impacted Lebanon's food security, I needed to have maps showing the spatial distribution of the Syrian refugees in Lebanon through the years. However, no such Geotiff maps existed. The only data I was able to find was the total number of registered Syrian refugees per year and a map indicating the approximate number of Syrian refugees per governorate and per district in 2020. Having the total number per year I projected the 2020 district values onto the other years and generated yearly spatial distribution maps of the Syrian refugees' location on a district level.

Since Lebanon is a very small country, the crops cultivated in the agricultural regions serve the entire country and population. I could not therefore use the maps of the production that I previously generated to understand whether there is a shortage or surplus in terms of required calories per capita per day. All of Lebanon's wheat, for example, is cultivated in the Bekaa district but consumed in all of Lebanon. If I were to compare the production by district versus the demand, there will be a shortage in most of the crops since most of Lebanon's population does not live in the agricultural districts. However, looking back at figure five it is noticeable that in 2016 the agricultural districts, so where most of the production occurs, have the highest percent of households with food insecurity. The excel sheets detailing the production by district can be found in the appendix.

To compare the production, so in other words the supply, to the demand, I tabulated the yearly production and the yearly export and import quantities of each crop on Microsoft Excel. I also calculated the share of the Lebanese people versus the Syrian refugees of the net production of each crop, to understand how the produce is divided among the population.

From the FoodData Central, an integrated data system by the USDA that provides expanded nutrient profile data on all the foods, I got the recommended daily serving size of each crop in grams and in kilocalories to sustain a balanced and healthy lifestyle. I considered the latter as the daily demand. The point was to deduce the demand from the supply.

As I previously mentioned, Lebanon relies heavily on food imports, therefore, to estimate the actual supply, I had to include the trades to get the correct net produce mass. I calculated the net production by subtracting the export quantities from the total production and adding the import quantities. Then I divided the yearly net production by 365 and by the total number of people living in Lebanon, so the Lebanese and the Syrian refugees, to get the supply of each crop in grams per capita per day. I then subtracted the demand from the supply. A negative value implied there was a daily shortage and a positive value indicated there was a daily surplus of the crop.

To get the supply of each crop in kilocalories per capita per day, almost the same procedure was done with just one extra step at the beginning. First, I calculated the kilocalories per one gram of each crop, which I then multiplied by the daily supply in g per capita per day to get the supply in kilocalories per capita per day. I also multiplied the kilocalories per one gram by the required daily mass to get the needed daily demand per capita kilocalories of each crop to sustain a balanced and healthy lifestyle. I then subtracted the demand from the calculated supply. A negative value implied there was a daily shortage and a positive value indicated there was a daily surplus of the crop.

To better understand the magnitude of the Syrian refugees on the production I computed the net production per capita considering there are no Syrian refugees in Lebanon; so, dividing the net production by the number of Lebanese people. I calculated the production in optimum conditions in grams per capita per day and in kcal per capita per day. The same procedure mentioned above was repeated to know whether a shortage or surplus of each crop was present.

## 4. Results

As per table two below, having the percentages of the area harvested of all the crops cultivated in Lebanon, in each governorate, in 2010, and the total area harvested, of each crop, also in 2010, I got the area harvested, in hectares, of each crop in each governorate in 2010.

	Area Harvested (%)							Area Harvested	Area Harvested (ha)						
	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South		Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South
Almonds	23%	50%	14%	3%	3%	6%	1%	5427	1,248	2,714	760	163	163	326	54
Apples	13%	22%	12%	26%	2%	23%	2%	12425	1,615	2,734	1,491	3,231	249	2,858	249
Apricot	1%	88%	2%	1%	1%	7%	0%	4516	45	3,974	90	45	45	316	0
Artichokes	14%	56%	23%	2%	5%	0%	0%	116	16	65	27	2	6	0	0
Avocado	4%	0%	0%	12%	32%	8%	44%	664	27	0	0	80	212	53	292
Bananas	0%	0%	0%	6%	0%	0%	94%	3011	0	0	0	181	0	0	2,830
Barley	6%	81%	7%	0%	4%	1%	1%	10685	641	8,655	748	0	427	107	107
Beans	27%	15%	30%	11%	3%	9%	5%	3196	863	479	959	352	96	288	160
Cabbages	19%	11%	48%	6%	2%	5%	9%	1116	212	123	536	67	22	56	100
Carobs	8%	0%	0%	6%	19%	12%	55%	241	19	0	0	14	46	29	133
Cauliflower	19%	9%	52%	3%	2%	5%	10%	763	145	69	397	23	15	38	76
Cherries	1%	65%	26%	4%	1%	3%	0%	6173	62	4,012	1,605	247	62	185	0
Chickpeas	19%	46%	20%	0%	8%	6%	1%	2873	546	1,322	575	0	230	172	29
Cucumbers	13%	41%	16%	8%	7%	9%	6%	4175	543	1,712	668	334	292	376	251
Eggplants	38%	38%	5%	4%	3%	5%	7%	2072	787	787	104	83	62	104	145
Figs	9%	22%	9%	21%	24%	10%	5%	1714	154	377	154	360	411	171	86
Grapes	9%	39%	33%	9%	4%	3%	3%	10609	955	4,138	3,501	955	424	318	318
Lemons & Limes	6%	0%	0%	3%	10%	4%	77%	2909	175	0	0	87	291	116	2,240
Lentils	0%	58%	14%	0%	23%	0%	5%	1126	0	653	158	0	259	0	56
Lettuce	10%	15%	61%	2%	2%	6%	4%	2592	259	389	1,581	52	52	156	104
Melons	10%	27%	21%	1%	33%	0%	8%	1031	103	278	217	10	340	0	82
Olives	18%	8%	5%	10%	21%	23%	15%	53647	9,656	4,292	2,682	5,365	11,266	12,339	8,047
Onions	14%	38%	40%	2%	3%	2%	1%	3246	454	1,233	1,298	65	97	65	32
Oranges	16%	0%	0%	3%	4%	16%	61%	5518	883	0	0	166	221	883	3,366
Peaches & Nectarines	4%	27%	23%	17%	9%	18%	2%	3559	142	961	819	605	320	641	71
Pears	9%	6%	17%	12%	4%	51%	1%	1809	163	109	308	217	72	923	18
Peas	14%	46%	12%	2%	10%	5%	11%	1825	256	840	219	37	183	91	201
Plums	6%	13%	15%	21%	5%	39%	1%	1921	115	250	288	403	96	749	19
Potatoes	27%	19%	51%	1%	1%	1%	0%	11131	3,005	2,115	5,677	111	111	111	0
Sesame seed	1%	0%	0%	0%	68%	0%	31%	67	1	0	0	0	46	0	21
Spinach	66%	2%	23%	1%	1%	1%	6%	379	250	8	87	4	4	4	23
Tomatoes	18%	22%	16%	17%	10%	8%	9%	4383	789	964	701	745	438	351	394
Walnuts	23%	35%	16%	12%	6%	5%	3%	1205	277	422	193	145	72	60	36
Watermelons	3%	55%	10%	0%	28%	0%	4%	2105	63	1,158	211	0	589	0	84
Wheat	22%	14%	44%	0%	12%	2%	6%	29840	6,565	4,178	13,130	0	3,581	597	1,790

Table 2 - Area Harvested by Governorate, 2010

Using the 2010 values and the yearly total area harvested of every crop, I projected the results onto the other years and got the area harvested, of each crop, in each governorate, in each year. As seen in figure seven below the total yearly harvested areas did not change much throughout the years. In 2008 a total of 238,047 hectares was harvested. By 2010, the number decreased by about 16.8 percent arriving to 198,069 hectares. In 2011 it increased to 206,789 hectares then to 218,555 in 2012, then decreased by 1.2 percent in 2013 arriving to 215,944 hectares. The value kept increasing in the following years. Figure eight shows the total area harvested in each governorate from 2008 until 2016. Tables detailing the area harvested of each crop in each governorate per year can be found in the appendix.

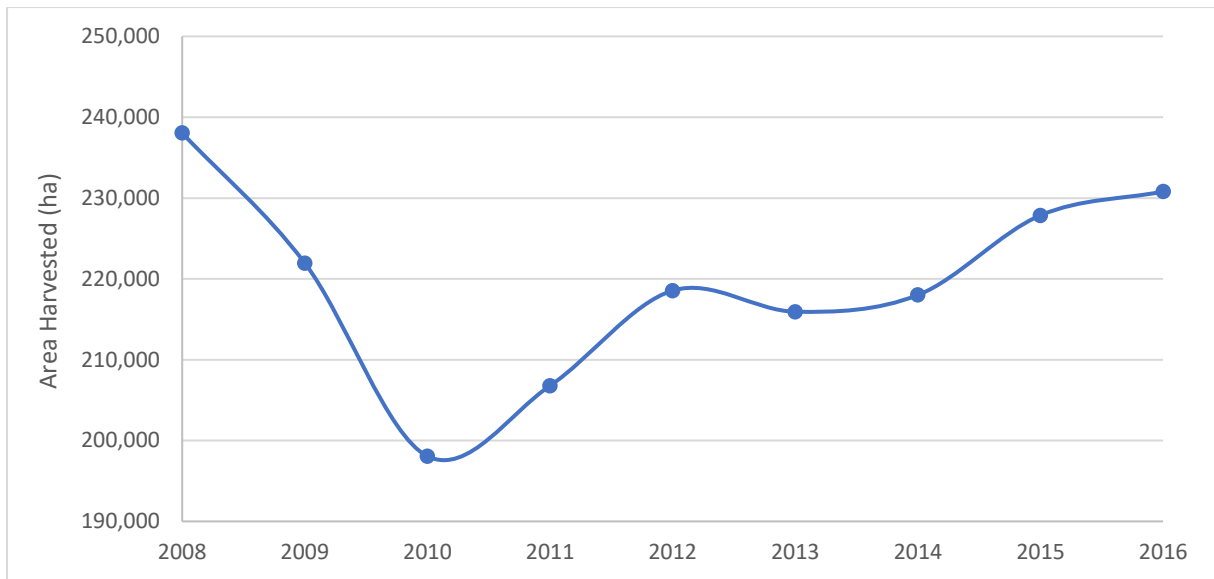


Figure 7- Total Area Harvested in Hectares

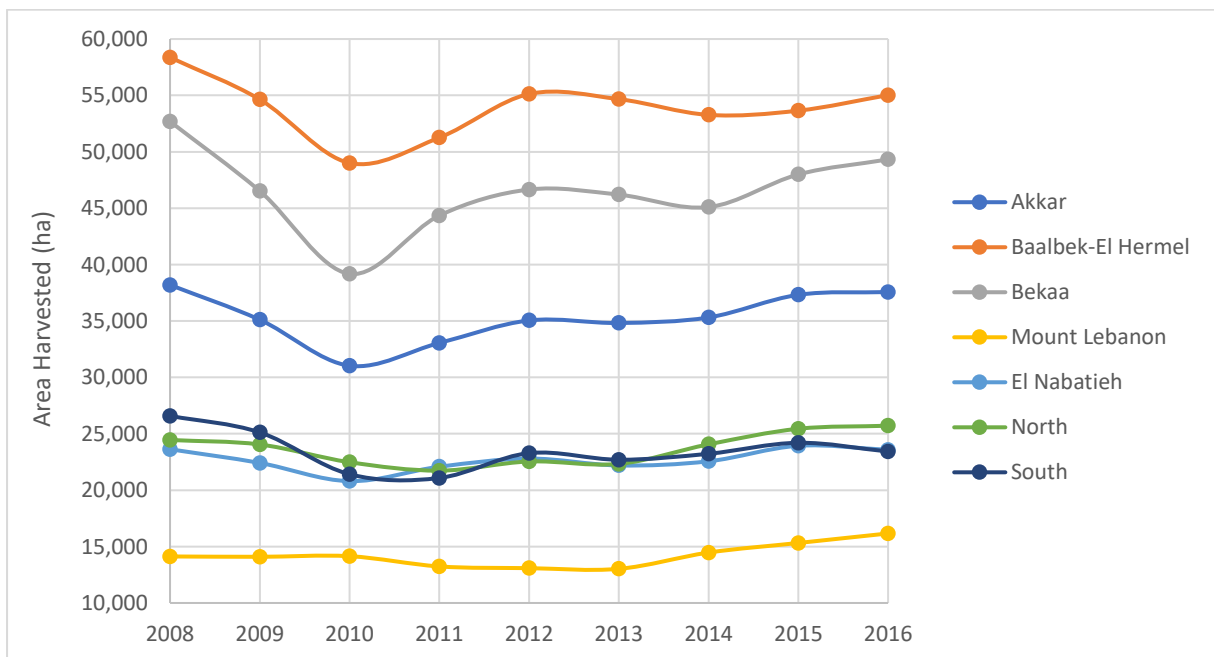


Figure 8 – Total Area Harvested per Governorate in Hectares

The following step was to generate, using ArcGIS, yearly crop-specific, area harvested per pixel maps. Figure nine shows the land cover of Lebanon in 2008, downloaded from ESA. As per the CCI LC legend, the values ten, eleven, and one hundred and twenty respectively represent the rainfed cropland, the herbaceous cover and the shrubland. They cover most of Lebanon's land. The land cover maps of the following years can be found in the appendix.

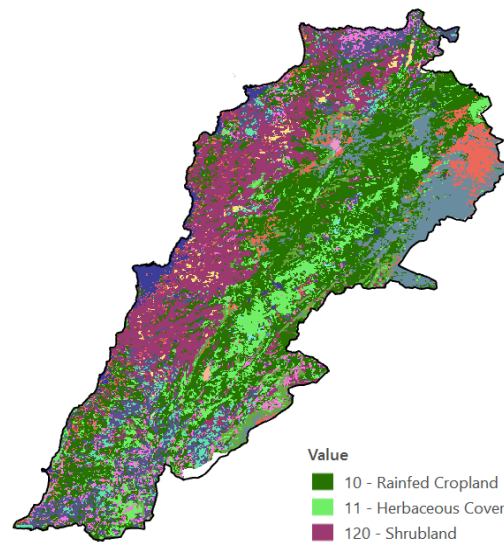


Figure 9 - ESA Map Land Cover, 2008

As I already stated, the values ten and twenty respectively represent the rainfed and irrigated cropland. Looking at figure ten below, the cropland areas under irrigation can be considered negligible with respect to the rainfed cropland.

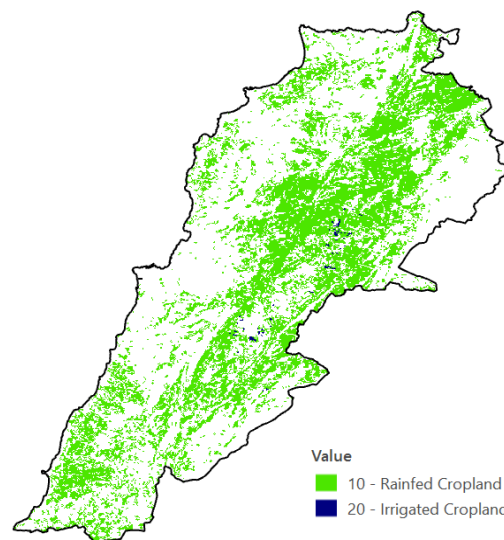


Figure 10 - ESA Map Cropland, Irrigated and Rainfed, 2008

As seen in figure eleven below, a new map was hence generated reporting only the rainfed cropland. The rainfed cropland maps of the following years can be found in the appendix.

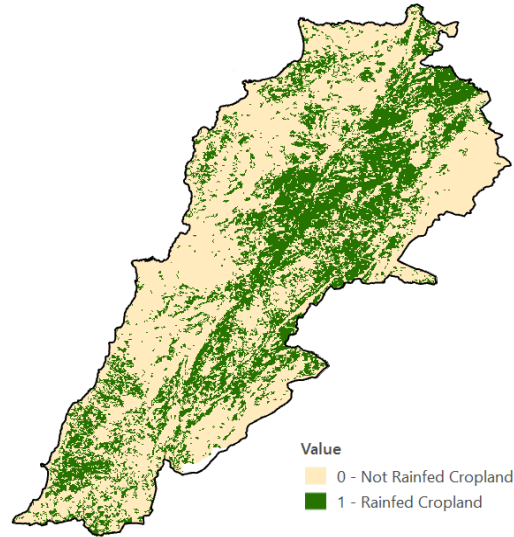


Figure 11 - Cropland Rainfed, 2008

An aggregate map of the latter was then generated to resample the input raster to a coarser resolution. Again, the aggregate maps of the following years can be found in the appendix.

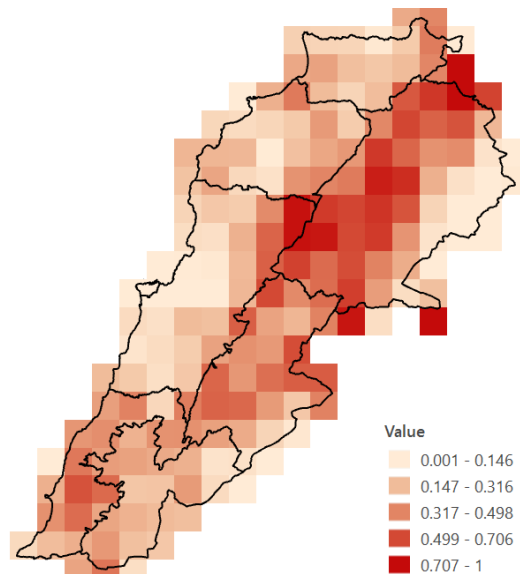


Figure 12 - Aggregate Cropland Rainfed, 2008

The following step was to convert each crop fraction from polygon to raster to get a map showing the crop fractions per governorate. Figure thirteen shows the fraction of wheat in each governorate in 2008. Wheat is one of the most important crops as it constitutes a dominant



portion of the standard diet. This staple produce is mainly cultivated in the Bekaa, Lebanon's main agricultural governorate and in Akkar.

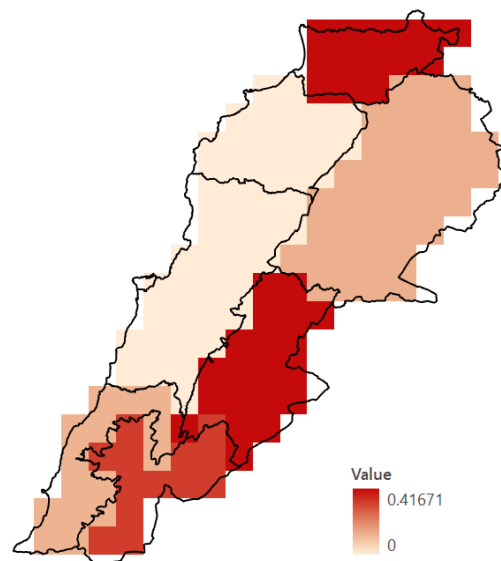


Figure 13 - Wheat Polygon to Raster, 2008

Figure fourteen below shows the area harvested of wheat per pixel in 2008. Olives and wheat are the two main crops cultivated in Akkar. Wheat and potatoes are mostly grown in the Bekaa, and barley and olives make most of the gravest in Baalbek El Hermel. The maps of the remaining crops in each year can be found in the appendix.

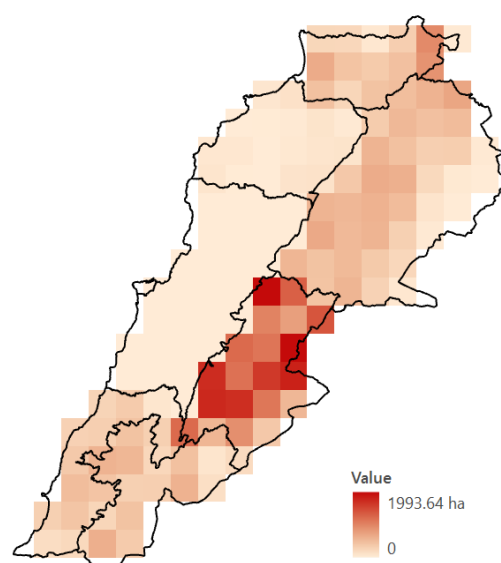


Figure 14 - Wheat Area Harvested in Hectares per Pixel, 2008

Figure fifteen below displays the pixelated total area harvested of all the crops in 2008. It is evident that Lebanon's main agricultural areas are the Bekaa Valley and Baalbek El Hermel as it was stated in the literature. The maps of the remaining years can be found in the appendix.

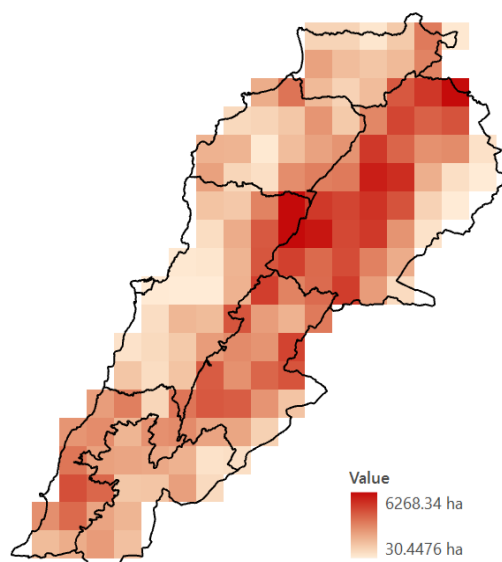


Figure 15 - Total Area Harvested in Hectares per Pixel, 2008

The next step was to compute the green and blue water required by each crop in each year based on the harvested area per pixel maps that were just generated. First, as per table three below, the initial, mid, and end crop coefficient, the lengths of the development stages, and the planting and harvesting dates of all the crops were collected and reported.

Crop Codes	Crop Name	Kc ini	Kc mid	Kc end	Initial Stage	Development Stage	Mid-Season Stage	Late Stage	Total	Planting Date	Harvesting Date
1	Almonds	40	90	65	20	10	130	30	190	4	10
2	Apples	60	95	75	30	40	35	40	145	6	10
3	Apricots	50	115	90	30	40	35	40	145	2	6
4	Bananas	50	110	100	120	90	120	60	390	3	4
5	Barley	30	115	25	30	140	40	30	240	10	5
6	Beans	40	115	35	15	25	25	10	75	8	10
7	Cherries	60	95	75	30	40	35	40	145	6	10
8	Cucumbers	60	100	75	25	35	50	20	130	2	6
9	Grapes	30	80	30	20	40	120	60	240	4	11
10	Lemons & Limes	80	80	80	60	90	120	95	365	1	12
11	Olives	65	70	70	30	90	60	90	270	3	11
12	Onions	70	115	75	15	25	70	40	150	4	9
13	Oranges	80	80	80	60	90	120	95	365	11	10
14	Peaches & Nectarines	50	115	90	30	40	35	40	145	2	6
15	Potatoes	35	115	50	20	30	60	40	150	2	6
17	Tomatoes	60	115	80	30	40	45	30	145	4	9
18	Wheat	40	115	30	30	140	40	30	240	11	6

Table 3 - Crop Characteristics (FAO)

By adding the information above and the harvested area per pixel maps onto a code on MATLAB, I got each crop's green and blue water requirement in cubic kilometers. The results are reported in tables four and five. A snippet of the MATLAB code can be found in the appendix.

	Water Required (Km <sup>3</sup> )									
	2008		2009		2010		2011		2012	
	Green Water	Blue Water	Green Water	Blue Water	Green Water	Blue Water	Green Water	Blue Water	Green Water	Blue Water
Almonds	0.0029	0.0132	0.0040	0.0143	0.0032	0.0138	0.0038	0.0117	0.0034	0.0150
Apples	0.0021	0.0288	0.0033	0.0350	0.0033	0.0412	0.0046	0.0316	0.0028	0.0319
Apricots	0.0053	0.0140	0.0057	0.0124	0.0042	0.0115	0.0039	0.0066	0.0059	0.0124
Bananas	0.0007	0.0002	0.0008	0.0001	0.0009	0.0002	0.0008	0.0001	0.0005	0.0001
Barley	0.0148	0.0083	0.0180	0.0049	0.0137	0.0065	0.0186	0.0044	0.0203	0.0075
Beans	0.0001	0.0020	0.0001	0.0017	0.0002	0.0039	0.0002	0.0034	0.0002	0.0031
Cherries	0.0021	0.0241	0.0025	0.0225	0.0019	0.0215	0.0031	0.0193	0.0023	0.0206
Cucumbers	0.0017	0.0034	0.0012	0.0020	0.0027	0.0054	0.0030	0.0036	0.0019	0.0038
Grapes	0.0087	0.0387	0.0099	0.0364	0.0081	0.0382	0.0082	0.0276	0.0078	0.0342
Lemons & Limes	0.0026	0.0077	0.0032	0.0080	0.0021	0.0066	0.0029	0.0068	0.0024	0.0101
Olives	0.0874	0.2834	0.1030	0.2880	0.0879	0.3202	0.1092	0.2665	0.0845	0.3677
Onions	0.0018	0.0092	0.0037	0.0150	0.0038	0.0185	0.0045	0.0159	0.0038	0.0140
Oranges	0.0134	0.0291	0.0118	0.0226	0.0079	0.0184	0.0066	0.0112	0.0094	0.0337
Peaches & Nectarines	0.0089	0.0186	0.0089	0.0149	0.0096	0.0200	0.0108	0.0132	0.0089	0.0186
Potatoes	0.0559	0.0824	0.0649	0.0690	0.0396	0.0546	0.0467	0.0362	0.0250	0.0035
Tomatoes	0.0052	0.0482	0.0055	0.0373	0.0065	0.0604	0.0080	0.0448	0.0061	0.0445
Wheat	0.1450	0.1660	0.1447	0.1155	0.1124	0.1265	0.1692	0.1104	0.1761	0.1168

Table 4 - Green and Blue Water Required per Crop in Km<sup>3</sup>, 2008 – 2012

	Water Required (Km <sup>3</sup> )									
	2012		2013		2014		2015		2016	
	Green Water	Blue Water	Green Water	Blue Water	Green Water	Blue Water	Green Water	Blue Water	Green Water	Blue Water
Almonds	0.0034	0.0150	0.0038	0.0122	0.0034	0.0110	0.0030	0.0105	0.0024	0.0093
Apples	0.0028	0.0319	0.0037	0.0288	0.0041	0.0328	0.0039	0.0355	0.0038	0.0471
Apricots	0.0059	0.0124	0.0062	0.0110	0.0051	0.0101	0.0046	0.0090	0.0045	0.0095
Bananas	0.0005	0.0001	0.0006	0.0001	0.0007	0.0001	0.0006	0.0001	0.0007	0.0001
Barley	0.0203	0.0075	0.0191	0.0068	0.0175	0.0064	0.0160	0.0057	0.0176	0.0088
Beans	0.0002	0.0031	0.0002	0.0030	0.0002	0.0025	0.0001	0.0030	0.0001	0.0029
Cherries	0.0023	0.0206	0.0026	0.0187	0.0022	0.0165	0.0020	0.0151	0.0014	0.0146
Cucumbers	0.0019	0.0038	0.0023	0.0033	0.0024	0.0034	0.0023	0.0032	0.0027	0.0040
Grapes	0.0078	0.0342	0.0076	0.0265	0.0086	0.0286	0.0086	0.0328	0.0073	0.0314
Lemons & Limes	0.0024	0.0101	0.0031	0.0076	0.0029	0.0067	0.0026	0.0064	0.0025	0.0068
Olives	0.0845	0.3677	0.1052	0.2743	0.1100	0.2759	0.1121	0.2936	0.0925	0.3005
Onions	0.0038	0.0140	0.0044	0.0163	0.0038	0.0150	0.0038	0.0145	0.0034	0.0143
Oranges	0.0094	0.0337	0.0111	0.0212	0.0105	0.0179	0.0091	0.0172	0.0072	0.0160
Peaches & Nectarines	0.0089	0.0186	0.0103	0.0149	0.0107	0.0166	0.0114	0.0159	0.0123	0.0197
Potatoes	0.0250	0.0035	0.0574	0.0606	0.0653	0.0677	0.0697	0.0679	0.0793	0.0857
Tomatoes	0.0061	0.0445	0.0078	0.0448	0.0084	0.0558	0.0085	0.0550	0.0089	0.0616
Wheat	0.1761	0.1168	0.1519	0.1411	0.1386	0.1120	0.1334	0.1124	0.1410	0.1313

Table 5 - Green and Blue Water Required per Crop in Km<sup>3</sup>, 2012 – 2016

Since the total area harvested did not change much during the years, it only makes sense that, as it reported in figure sixteen below, the total water required by the crops remained almost the same throughout the years.

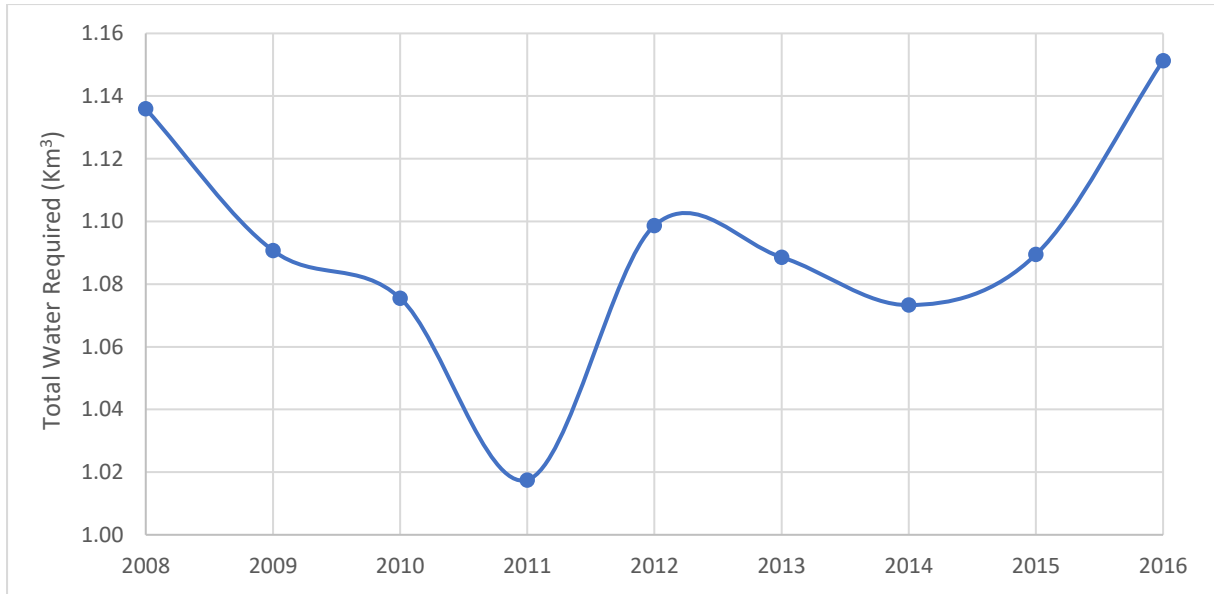


Figure 16 - Total Water Required in Km<sup>3</sup>

In the following step, I added all the water required by each crop to get a map showing the total cubic kilometer of water required per year per pixel, as seen in figure seventeen below. The maps of the following years can be found in the appendix.

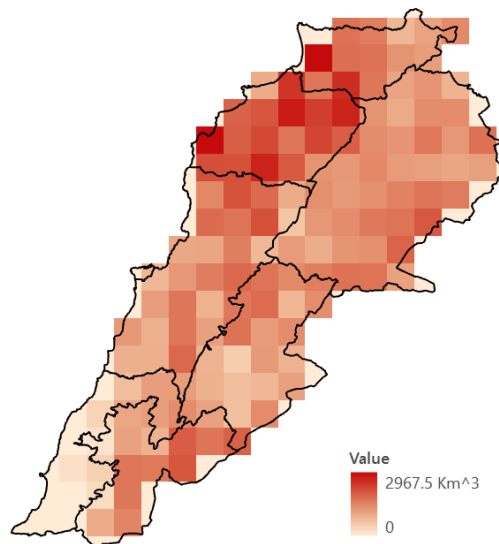


Figure 17 - Total Water Required in Km<sup>3</sup> per Pixel, 2008

The next step was to compute the green water availability per capita but to do so, first I added a map from WorldPop with the aggregated spatial distribution of the population in Lebanon, as seen in figure eighteen. The maps of the following years can be found in the appendix.

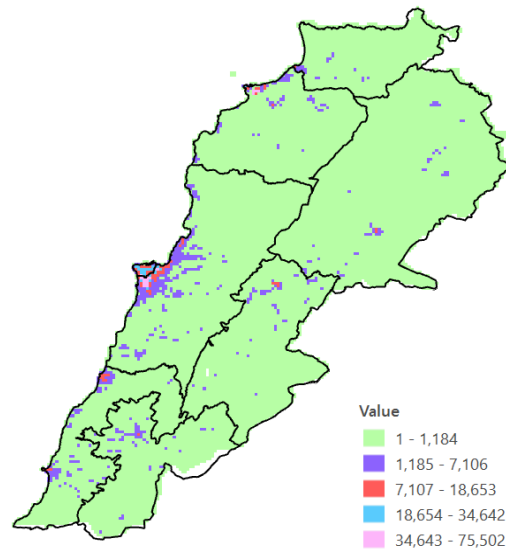


Figure 18 - Lebanon's Population Count, 2008

Finally, figure nineteen correspond to the water availability in 2008 per capita per grid cell map. Again, the maps of the following years can be found in the appendix.

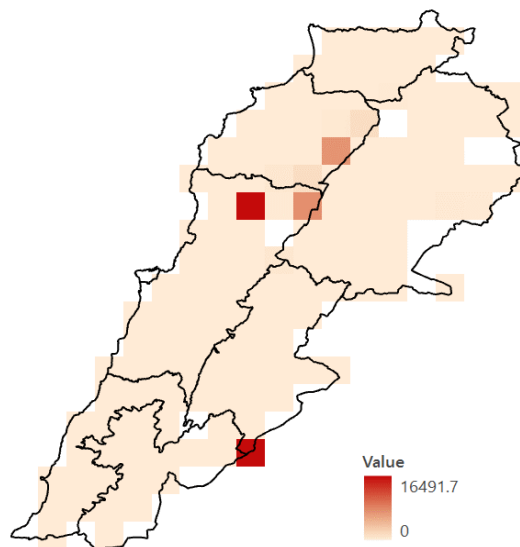


Figure 19 - Water Availability, 2008

The following step was to compute maps of the production in tons per pixel of each crop. Figure twenty below shows the production of wheat per pixel in 2008. The production per pixel maps of the remaining crops in each year can be found in the appendix. As it was previously

reported all Lebanon's wheat is mainly cultivated in the Bekaa district. Therefore, it is obvious that in the production map most of the wheat is also produced in the Bekaa area.

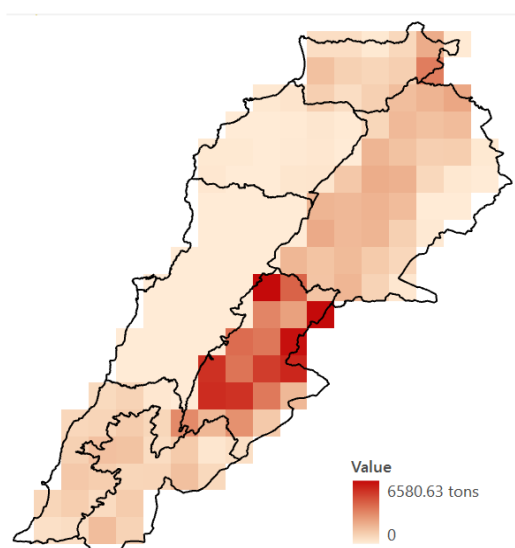


Figure 20 - Wheat Production in tons per Pixel, 2008

I also generated yearly spatial distribution maps of the Syrian refugees in each district. To do so, I first projected the 2020 values onto to the other years as seen in table six below.

District	Number of Syrian Refugees							
	2011	2012	2013	2014	2015	2016	2017	2020
Akkar	622	14,833	99,324	134,113	124,205	117,534	115,975	106,163
El Hermel	39	929	6,218	8,396	7,775	7,358	7,260	6,646
El Minieh-Dennie	315	7,507	50,266	67,872	62,858	59,481	58,693	53,727
Tripoli	234	5,573	37,316	50,386	46,663	44,157	43,571	39,885
Zgharta	87	2,073	13,883	18,746	17,361	16,428	16,210	14,839
Baalbek	667	15,900	106,468	143,759	133,138	125,987	124,317	113,799
El Koura	85	2,032	13,603	18,368	17,011	16,097	15,884	14,540
El Batroun	61	1,447	9,687	13,080	12,114	11,463	11,311	10,354
Bcharre	9	223	1,491	2,014	1,865	1,765	1,741	1,594
Jbeil	33	779	5,215	7,041	6,521	6,171	6,089	5,574
Kesrwane	64	1,518	10,167	13,728	12,714	12,031	11,871	10,867
El Meten	160	3,819	25,570	34,527	31,976	30,258	29,857	27,331
Zahle	908	21,667	145,086	195,904	181,430	171,685	169,409	155,076
Beirut	95	2,263	15,151	20,457	18,946	17,928	17,691	16,194
Baabda	401	9,565	64,051	86,485	80,095	75,794	74,788	68,461
Aley	292	6,963	46,625	62,957	58,305	55,174	54,442	49,836
West Bekaa	357	8,506	56,954	76,903	71,221	67,396	66,502	60,876
Chouf	262	6,243	41,803	56,444	52,274	49,467	48,811	44,681
Rachaya	45	1,064	7,125	9,621	8,910	8,432	8,320	7,616
Jezzine	14	329	2,201	2,972	2,753	2,605	2,570	2,353
Saida	226	5,391	36,100	48,745	45,143	42,719	42,152	38,586
El Nabatieh	113	2,690	18,012	24,321	22,524	21,314	21,031	19,252
Hasbaya	21	501	3,355	4,530	4,195	3,970	3,917	3,586
Marjaayoun	46	1,092	7,313	9,875	9,145	8,654	8,539	7,817
Sour	142	3,397	22,750	30,718	28,448	26,920	26,563	24,316
Bent Jbeil	37	878	5,882	7,942	7,355	6,960	6,868	6,287
Total	5,332	127,181	851,616	1,149,904	1,064,948	1,007,749	994,385	910,256

Table 6 - Number of Syrian Refugees per District

The values were then added into ArcGIS and figure twenty-one below represents the distribution of the Syrian refugees on a district level, in 2011. The maps of the following years can be found in the appendix. From the generated maps we can see that the Syrian refugees are mainly in the Bekaa, Baalbek El Hermel, and Akkar as it was mentioned in the literature.

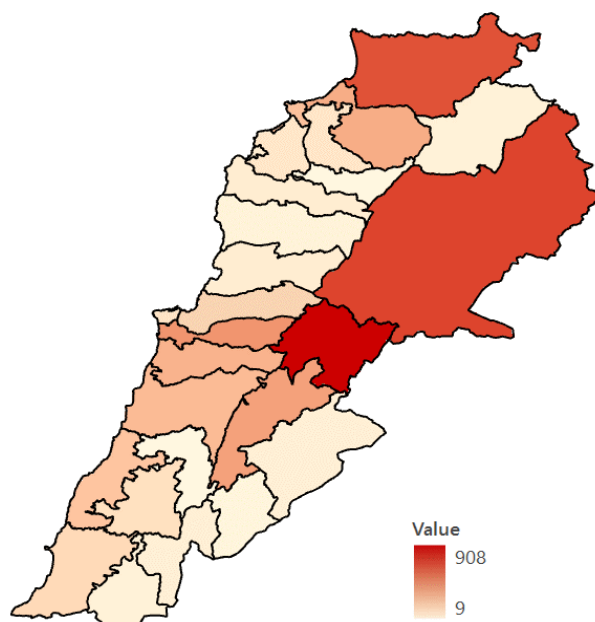


Figure 21 - Spatial Distribution of the Syrian Refugees by District, 2011

In tables seven and eight below, the yearly total population in Lebanon, the number of Syrian refugees and the number of Lebanese people as well as their respective percentages are reported.

	2008		2009		2010		2011		2012	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Lebanese People	4,764,745	100	4,813,026	100	4,952,859	99.996	5,196,690	99.898	5,410,439	97.703
Syrian Refugees	0	0	0	0	205	0.004	5,332	0.102	127,181	2.297
Total Population	4,764,745		4,813,026		4,953,064		5,202,022		5,537,620	

Table 7 - Lebanon's Population, 2008 – 2012

	2012		2013		2014		2015		2016	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Lebanese People	5,410,439	97.703	5,061,400	85.598	5,111,142	81.634	5,467,733	83.698	5,706,532	84.991
Syrian Refugees	127,181	2.297	851,616	14.402	1,149,904	18.366	1,064,948	16.302	1,007,749	15.009
Total Population	5,537,620		5,913,016		6,261,046		6,532,681		6,714,281	

Table 8 - Lebanon's Population, 2012 – 2016

Moving to the following section of the work, I wanted to compare the production, so in other words the supply, to the demand.

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Almonds	30,000	34,300	27,165	26,485	30,100	29,656	28,754	27,913	25,862
Apples	125,200	138,100	154,429	135,807	125,714	126,485	180,565	210,424	344,469
Apricots	32,500	29,000	20,972	15,041	24,920	24,952	28,856	33,238	39,801
Bananas	89,700	96,000	87,180	79,925	63,544	59,650	78,022	85,991	109,675
Barley	29,000	29,700	22,110	30,000	35,000	35,000	33,000	37,101	48,790
Beans	16,700	16,200	27,780	25,988	27,429	25,600	21,129	19,993	17,031
Cherries	31,000	30,800	24,161	21,235	23,021	21,816	24,632	26,939	32,432
Cucumbers	131,010	87,200	197,815	181,042	144,151	146,691	134,376	127,618	98,350
Grapes	118,900	108,000	92,495	78,093	79,699	77,358	91,932	105,752	118,754
Lemons & Limes	114,000	121,400	79,491	90,987	103,706	103,844	104,773	106,332	115,740
Olives	85,000	79,000	80,000	88,000	70,000	106,200	113,700	132,500	157,646
Onions	50,900	86,500	91,649	87,297	86,328	86,731	90,490	98,699	109,765
Oranges	228,700	177,000	118,508	88,182	170,050	165,764	171,273	176,678	188,844
Peaches & Nectarines	42,000	30,500	30,592	32,162	33,213	33,512	42,997	52,119	63,337
Potatoes	514,600	425,000	264,888	275,000	280,000	412,000	451,860	524,265	631,973
Tomatoes	305,300	194,500	274,793	282,501	284,823	287,814	325,110	281,810	249,877
Wheat	143,700	111,400	83,000	125,000	150,000	140,000	140,000	139,000	129,037

Table 9 - Production in tons

Table nine above reports the production in tons of each crop. Values in blue indicate that the amount has increased from the previous year and values in red imply that the amount has decreased. Between 2010 and 2011, the production of a bit more than half the crops decreased, however the decreases are minimal. Focusing on the values between 2012 and 2014 it is evident that for most of the crops the production actually increased after the influx of Syrian refugees into Lebanon. It is also imported to mention that the production of staple crops such as barley, potato and wheat increased throughout the years.

Since Lebanon depends on severely on food imports, I estimated the actual supply, which includes the trades. I calculated the net production by subtracting the export quantities from the total production and adding the import quantities as reported in table ten, eleven and twelve below. Clearly, the most imported crop in terms of mass and in contrast with the local production is wheat.



	2008				2009				2010			
	Production	Export	Import	Net	Production	Export	Import	Net	Production	Export	Import	Net
Almonds	30,000	134	942	30,808	34,300	102	972	35,170	27,165	124	245	27,286
Apples	125,200	59,387	382	66,195	138,100	63,072	735	75,763	154,429	79,168	462	75,723
Apricots	32,500	2,099	412	30,813	29,000	1,558	537	27,979	20,972	1,184	269	20,057
Bananas	89,700	59,181	538	31,057	96,000	53,783	149	42,366	87,180	40,504	244	46,920
Barley	29,000	4,037	62,962	87,925	29,700	2,914	73,145	99,931	22,110	244	72,016	93,882
Beans	16,700	370	8,187	24,517	16,200	585	8,064	23,679	27,780	301	7,756	35,235
Cherries	31,000	3,640	6	27,366	30,800	2,150	107	28,757	24,161	3,420	52	20,793
Cucumbers	131,010	519	7,281	137,772	87,200	643	6,161	92,718	197,815	944	5,959	202,830
Grapes	118,900	23,749	528	95,679	108,000	25,628	698	83,070	92,495	19,264	977	74,208
Lemons & Limes	114,000	39,167	759	75,592	121,400	32,359	451	89,492	79,491	25,020	891	55,362
Olives	85,000	0	0	85,000	79,000	0	0	79,000	80,000	0	0	80,000
Onions	50,900	19,752	13,966	45,114	86,500	19,370	10,900	78,030	91,649	18,394	16,315	89,570
Oranges	228,700	88,169	480	141,011	177,000	103,412	250	73,838	118,508	81,156	174	37,526
Peaches & Nectarines	42,000	13,704	4	28,300	30,500	9,258	52	21,294	30,592	12,066	32	18,558
Potatoes	514,600	151,643	92,282	455,239	425,000	91,837	82,273	415,436	264,888	108,949	113,203	269,142
Tomatoes	305,300	6,202	18,326	317,424	194,500	1,551	18,080	211,029	274,793	1,939	18,680	291,534
Wheat	143,700	29,611	418,863	532,952	111,400	13,478	537,692	635,614	83,000	33,744	506,183	555,439

Table 10 - Net Production Including Trade in tons, 2008 – 2010

	2011				2012				2013			
	Production	Export	Import	Net	Production	Export	Import	Net	Production	Export	Import	Net
Almonds	26,485	155	144	26,474	30,100	145	206	30,161	29,656	302	865	30,219
Apples	135,807	61,455	1,104	75,456	125,714	88,077	955	38,592	126,485	71,483	1,567	56,569
Apricots	15,041	2,632	210	12,619	24,920	3,856	45	21,109	24,952	3,058	253	22,147
Bananas	79,925	42,858	185	37,252	63,544	39,698	422	24,268	59,650	48,705	251	11,196
Barley	30,000	4,185	87,204	113,019	35,000	5,119	69,700	99,581	35,000	1,783	72,644	105,861
Beans	25,988	508	7,407	32,887	27,429	801	7,549	34,177	25,600	822	7,492	32,270
Cherries	21,235	2,611	31	18,655	23,021	1,555	1	21,467	21,816	1,571	1	20,246
Cucumbers	181,042	393	4,641	185,290	144,151	707	6,073	149,517	146,691	737	2,718	148,672
Grapes	78,093	17,414	2,211	62,890	79,699	19,218	3,938	64,419	77,358	21,795	2,867	58,430
Lemons & Limes	90,987	24,663	616	66,940	103,706	13,407	821	91,120	103,844	19,027	4,516	89,333
Olives	88,000	0	0	88,000	70,000	28	3,523	73,495	106,200	52	3,753	109,901
Onions	87,297	16,670	14,214	84,841	86,328	12,336	15,239	89,231	86,731	28,135	14,854	73,450
Oranges	88,182	83,502	197	4,877	170,050	74,507	115	95,658	165,764	46,177	3,306	122,893
Peaches & Nectarines	32,162	15,465	18	16,715	33,213	12,792	30	20,451	33,512	16,771	28	16,769
Potatoes	275,000	118,727	99,828	256,101	280,000	98,509	69,534	251,025	412,000	192,143	72,440	292,297
Tomatoes	282,501	1,257	18,541	299,785	284,823	2,703	25,335	307,455	287,814	5,126	22,205	304,893
Wheat	125,000	7,245	446,120	563,875	150,000	1,585	529,818	678,233	140,000	2,530	603,301	740,771

Table 11 - Net Production Including Trade in tons, 2011 – 2013

	2014				2015				2016			
	Production	Export	Import	Net	Production	Export	Import	Net	Production	Export	Import	Net
Almonds	28,754	349	1,285	29,690	27,913	304	2,757	30,366	25,862	460	17	25,419
Apples	180,565	53,068	1,337	128,834	210,424	56,915	1,692	155,201	344,469	58,515	1,217	287,171
Apricots	28,856	902	84	28,038	33,238	1,803	404	31,839	39,801	1,622	4	38,183
Bananas	78,022	27,634	154	50,542	85,991	19,801	411	66,601	109,675	32,372	121	77,424
Barley	33,000	7	73,995	106,988	37,101	0	83,173	120,274	48,790	349	156,997	205,438
Beans	21,129	919	8,470	28,680	19,993	1,044	5,589	24,538	17,031	3,826	7,074	20,279
Cherries	24,632	1,688	2	22,946	26,939	2,169	45	24,815	32,432	3,974	8	28,466
Cucumbers	134,376	547	5,504	139,333	127,618	489	4,941	132,070	98,350	154	2,554	100,750
Grapes	91,932	23,084	92	68,940	105,752	16,729	140	89,163	118,754	19,054	122	99,822
Lemons & Limes	104,773	17,195	721	88,299	106,332	8,595	534	98,271	115,740	1,732	121	114,129
Olives	113,700	4	2,039	115,735	132,500	3	894	133,391	157,646	29	43	157,660
Onions	90,490	26,381	12,819	76,928	98,699	6,038	13,022	105,683	109,765	6,274	24,219	127,710
Oranges	171,273	53,456	4,760	122,577	176,678	25,767	3,605	154,516	188,844	27,519	5	161,330
Peaches & Nectarines	42,997	6,515	56	36,538	52,119	7,131	224	45,212	63,337	5,959	6	57,384
Potatoes	451,860	234,408	87,761	305,213	524,265	140,878	67,909	451,296	631,973	134,674	84,359	581,658
Tomatoes	325,110	3,728	19,017	340,399	281,810	2,306	19,938	299,442	249,877	303	5,131	254,705
Wheat	140,000	19,039	615,416	736,377	139,000	45,819	625,661	718,842	129,037	16,583	538,985	651,439

Table 12 - Net Production Including Trade in tons, 2014 – 2016

I then calculated the share of the Lebanese people versus the Syrian refugees of the net production of each crop to understand how the produce is divided among the population. The values are reported in tables thirteen, fourteen and fifteen below.

The yearly share as a percentage is obviously the same for all the crops since the number of Syrian refugees is considered constant in a year. It is the same as the percentage of Syrian refugees in the total population in each year. In 2012, a year after the Syrian war erupted, the Syrian refugees made-up about 2.3 percent of the total population. By 2014 almost one in every six people living in Lebanon was a Syrian refugee. In 2015, the number started to decrease and by 2016 they represented fifteen percent of the total population.

	2008				2009				2010			
	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)
Almonds	30,808	0.0065	30,808	0	35,170	0.0073	35,170	0	27,286	0.0055	27,285	1
Apples	66,195	0.0139	66,195	0	75,763	0.0157	75,763	0	75,723	0.0153	75,720	3
Apricots	30,813	0.0065	30,813	0	27,979	0.0058	27,979	0	20,057	0.0040	20,056	1
Bananas	31,057	0.0065	31,057	0	42,366	0.0088	42,366	0	46,920	0.0095	46,918	2
Barley	87,925	0.0185	87,925	0	99,931	0.0208	99,931	0	93,882	0.0190	93,878	4
Beans	24,517	0.0051	24,517	0	23,679	0.0049	23,679	0	35,235	0.0071	35,234	1
Cherries	27,366	0.0057	27,366	0	28,757	0.0060	28,757	0	20,793	0.0042	20,792	1
Cucumbers	137,772	0.0289	137,772	0	92,718	0.0193	92,718	0	202,830	0.0410	202,822	8
Grapes	95,679	0.0201	95,679	0	83,070	0.0173	83,070	0	74,208	0.0150	74,205	3
Lemons & Limes	75,592	0.0159	75,592	0	89,492	0.0186	89,492	0	55,362	0.0112	55,360	2
Olives	85,000	0.0178	85,000	0	79,000	0.0164	79,000	0	80,000	0.0162	79,997	3
Onions	45,114	0.0095	45,114	0	78,030	0.0162	78,030	0	89,570	0.0181	89,566	4
Oranges	141,011	0.0296	141,011	0	73,838	0.0153	73,838	0	37,526	0.0076	37,524	2
Peaches & Nectarines	28,300	0.0059	28,300	0	21,294	0.0044	21,294	0	18,558	0.0037	18,557	1
Potatoes	455,239	0.0955	455,239	0	415,436	0.0863	415,436	0	269,142	0.0543	269,131	11
Tomatoes	317,424	0.0666	317,424	0	211,029	0.0438	211,029	0	291,534	0.0589	291,522	12
Wheat	532,952	0.1119	532,952	0	635,614	0.1321	635,614	0	555,439	0.1121	555,416	23

Table 13 - Share of the Net Production Between the Population, 2008 – 2010

	2011				2012				2013			
	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)
Almonds	26,474	0.0051	26,447	27	30,161	0.0054	29,468	693	30,219	0.0051	25,867	4,352
Apples	75,456	0.0145	75,379	77	38,592	0.0070	37,706	886	56,569	0.0096	48,422	8,147
Apricots	12,619	0.0024	12,606	13	21,109	0.0038	20,624	485	22,147	0.0037	18,957	3,190
Bananas	37,252	0.0072	37,214	38	24,268	0.0044	23,711	557	11,196	0.0019	9,584	1,612
Barley	113,019	0.0217	112,903	116	99,581	0.0180	97,294	2,287	51,861	0.0088	44,392	7,469
Beans	32,887	0.0063	32,853	34	34,177	0.0062	33,392	785	32,270	0.0055	27,622	4,648
Cherries	18,655	0.0036	18,636	19	21,467	0.0039	20,974	493	20,246	0.0034	17,330	2,916
Cucumbers	185,290	0.0356	185,100	190	149,517	0.0270	146,083	3,434	148,672	0.0251	127,260	21,412
Grapes	62,890	0.0121	62,826	64	64,419	0.0116	62,940	1,479	58,430	0.0099	50,015	8,415
Lemons & Limes	66,940	0.0129	66,871	69	91,120	0.0165	89,027	2,093	89,333	0.0151	76,467	12,866
Olives	88,000	0.0169	87,910	90	73,495	0.0133	71,807	1,688	109,901	0.0186	94,073	15,828
Onions	84,841	0.0163	84,754	87	89,231	0.0161	87,182	2,049	73,450	0.0124	62,871	10,579
Oranges	4,877	0.0009	4,872	5	95,658	0.0173	93,461	2,197	122,893	0.0208	105,193	17,700
Peaches & Nectarines	16,715	0.0032	16,698	17	20,451	0.0037	19,981	470	16,769	0.0028	14,354	2,415
Potatoes	256,101	0.0492	255,839	262	251,025	0.0453	245,260	5,765	292,297	0.0494	250,199	42,098
Tomatoes	299,785	0.0576	299,478	307	307,455	0.0555	300,394	7,061	304,893	0.0516	260,981	43,912
Wheat	563,875	0.1084	563,297	578	678,233	0.1225	662,656	15,577	740,771	0.1253	634,082	106,689

Table 14 - Share of the Net Production Between the Population, 2011 – 2013

	2014				2015				2016			
	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)	Net Production (t)	Produce per Capita (t/capita/year)	Share of Lebanese People (t)	Share of Syrian Refugees (t)
Almonds	29,690	0.0047	24,237	5,453	30,366	0.0046	25,416	4,950	25,419	0.0038	21,604	3,815
Apples	128,834	0.0206	105,172	23,662	155,201	0.0238	129,900	25,301	287,171	0.0428	244,069	43,102
Apricots	28,038	0.0045	22,889	5,149	31,839	0.0049	26,649	5,190	38,183	0.0057	32,452	5,731
Bananas	50,542	0.0081	41,259	9,283	66,601	0.0102	55,744	10,857	77,424	0.0115	65,803	11,621
Barley	94,988	0.0152	77,542	17,446	120,274	0.0184	100,667	19,607	205,438	0.0306	174,604	30,834
Beans	28,680	0.0046	23,413	5,267	24,538	0.0038	20,538	4,000	20,279	0.0030	17,235	3,044
Cherries	22,946	0.0037	18,732	4,214	24,815	0.0038	20,770	4,045	28,466	0.0042	24,194	4,272
Cucumbers	139,333	0.0223	113,743	25,590	132,070	0.0202	110,540	21,530	100,750	0.0150	85,628	15,122
Grapes	68,940	0.0110	56,278	12,662	89,163	0.0136	74,628	14,535	99,822	0.0149	84,840	14,982
Lemons & Limes	88,299	0.0141	72,082	16,217	98,271	0.0150	82,251	16,020	114,129	0.0170	96,999	17,130
Olives	115,735	0.0185	94,479	21,256	133,391	0.0204	111,646	21,745	157,660	0.0235	133,997	23,663
Onions	76,928	0.0123	62,799	14,129	105,683	0.0162	88,455	17,228	127,710	0.0190	108,542	19,168
Oranges	122,577	0.0196	100,065	22,512	154,516	0.0237	129,327	25,189	161,330	0.0240	137,116	24,214
Peaches & Nectarines	36,538	0.0058	29,827	6,711	45,212	0.0069	37,842	7,370	57,384	0.0085	48,771	8,613
Potatoes	305,213	0.0487	249,158	56,055	451,296	0.0691	377,726	73,570	581,658	0.0866	494,357	87,301
Tomatoes	340,399	0.0544	277,881	62,518	299,442	0.0458	250,627	48,815	254,705	0.0379	216,476	38,229
Wheat	736,377	0.1176	601,134	135,243	718,842	0.1100	601,657	117,185	651,439	0.0970	553,664	97,775

Table 15 - Share of the Net Production Between the Population, 2014 – 2016

To get the demand I first tabulated the recommended daily serving size, to sustain a balanced and healthy lifestyle, of each crop in grams and in kilocalories, as reported in the table below.

	Recomended Serving (g)	Calories per Serving (kcal)	kcal/g
Almonds	30	183	6.070
Apples	93	53	0.570
Apricots	40	100	2.500
Bananas	20	36	1.809
Barley	45	159	3.540
Beans	130	111	0.850
Cherries	140	90	0.640
Cucumbers	158	21	0.130
Grapes	122	243	2.002
Lemons & Limes	212	64	0.300
Olives	15	25	1.670
Onions	85	28	0.323
Oranges	20	50	2.498
Peaches & Nectarines	150	83	0.556
Potatoes	111	143	1.285
Tomatoes	164	34	0.210
Wheat	179	934	5.219

Table 16 - Recommended Serving of Each Crop (FoodData Central)

I then got the supply of each crop in grams per capita per day by dividing the yearly net production by 365 and by the total number of people living in Lebanon; and subtracted the demand from the supply, as seen in table seventeen below. In table eighteen, a negative or red value implies there was a shortage, and a positive or blue value indicates there was a surplus of the crop. As a first look it is obvious that most of the crops are in shortage.

	Supply (g/capita/day)									Demand (g/capita/day)
	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Almonds	17.71	20.02	15.09	13.94	14.92	14.00	12.99	12.74	10.37	30.18
Apples	38.06	43.13	41.89	39.74	19.09	26.21	56.38	65.09	117.18	93.33
Apricots	17.72	15.93	11.09	6.65	10.44	10.26	12.27	13.35	15.58	40.00
Bananas	17.86	24.12	25.95	19.62	12.01	5.19	22.12	27.93	31.59	20.00
Barley	50.56	56.88	51.93	59.52	49.27	49.05	46.82	50.44	83.83	45.00
Beans	14.10	13.48	19.49	17.32	16.91	14.95	12.55	10.29	8.27	130.00
Cherries	15.74	16.37	11.50	9.82	10.62	9.38	10.04	10.41	11.62	140.00
Cucumbers	79.22	52.78	112.19	97.59	73.97	68.89	60.97	55.39	41.11	158.00
Grapes	55.02	47.29	41.05	33.12	31.87	27.07	30.17	37.39	40.73	121.50
Lemons & Limes	43.47	50.94	30.62	35.25	45.08	41.39	38.64	41.21	46.57	212.00
Olives	48.87	44.97	44.25	46.35	36.36	50.92	50.64	55.94	64.33	15.00
Onions	25.94	44.42	49.54	44.68	44.15	34.03	33.66	44.32	52.11	85.47
Oranges	81.08	42.03	20.76	2.57	47.33	56.94	53.64	64.80	65.83	20.00
Peaches & Nectarines	16.27	12.12	10.27	8.80	10.12	7.77	15.99	18.96	23.42	150.00
Potatoes	261.76	236.48	148.87	134.88	124.19	135.43	133.56	189.27	237.34	111.49
Tomatoes	182.52	120.12	161.26	157.89	152.11	141.27	148.95	125.58	103.93	164.00
Wheat	306.45	361.81	307.23	296.97	335.55	343.23	322.23	301.47	265.82	179.00

Table 17 - Supply and Demand in grams/capita/day

	Surplus or Shortage (g/capita/day)								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Almonds	-12.46	-10.16	-15.09	-16.24	-15.26	-16.18	-17.19	-17.44	-19.81
Apples	-55.27	-50.21	-51.45	-53.59	-74.24	-67.12	-36.96	-28.24	23.85
Apricots	-22.28	-24.07	-28.91	-33.35	-29.56	-29.74	-27.73	-26.65	-24.42
Bananas	-2.14	4.12	5.95	-0.38	-7.99	-14.81	2.12	7.93	11.59
Barley	5.56	11.88	6.93	14.52	4.27	4.05	1.82	5.44	38.83
Beans	-115.90	-116.52	-110.51	-112.68	-113.09	-115.05	-117.45	-119.71	-121.73
Cherries	-124.26	-123.63	-128.50	-130.18	-129.38	-130.62	-129.96	-129.59	-128.38
Cucumbers	-78.78	-105.22	-45.81	-60.41	-84.03	-89.11	-97.03	-102.61	-116.89
Grapes	-66.48	-74.21	-80.45	-88.38	-89.63	-94.43	-91.33	-84.11	-80.77
Lemons & Limes	-168.53	-161.06	-181.38	-176.75	-166.92	-170.61	-173.36	-170.79	-165.43
Olives	33.87	29.97	29.25	31.35	21.36	35.92	35.64	40.94	49.33
Onions	-59.53	-41.05	-35.93	-40.79	-41.32	-51.44	-51.81	-41.15	-33.36
Oranges	61.08	22.03	0.76	-17.43	27.33	36.94	33.64	44.80	45.83
Peaches & Nectarines	-133.73	-137.88	-139.73	-141.20	-139.88	-142.23	-134.01	-131.04	-126.58
Potatoes	150.28	124.99	37.39	23.39	12.71	23.95	22.07	77.78	125.86
Tomatoes	18.52	-43.88	-2.74	-6.11	-11.89	-22.73	-15.05	-38.42	-60.07
Wheat	127.45	182.81	128.23	117.97	156.55	164.23	143.23	122.47	86.82

Table 18 - Net Production vs Demand in grams/capita/day

I also got the supply of each crop in kilocalories per capita per day and subtracted the demand from it, as seen in table nineteen below. In table twenty, a negative or red value implies there was a shortage, and a positive or blue value indicates there was a surplus of the crop. Clearly the same crops that were in red are still in red, and the one in blue remain in blue, since the last step was just a change of units.



	(kcal/g)	Supply (kcal/capita/day)									Demand (kcal/capita/day)
		2008	2009	2010	2011	2012	2013	2014	2015	2016	
Almonds	6.07	107.53	121.52	91.61	84.63	90.58	84.99	78.86	77.30	62.96	183.18
Apples	0.57	21.70	24.58	23.87	22.65	10.88	14.94	32.13	37.10	66.79	53.20
Apricots	2.50	44.29	39.82	27.74	16.61	26.11	25.65	30.67	33.38	38.95	100.00
Bananas	1.81	32.30	43.62	46.94	35.49	21.72	9.38	40.00	50.52	57.14	36.17
Barley	3.54	178.97	201.37	183.83	210.71	174.41	173.64	165.73	178.56	296.75	159.30
Beans	0.85	11.98	11.46	16.57	14.72	14.37	12.71	10.67	8.75	7.03	110.50
Cherries	0.64	10.07	10.48	7.36	6.29	6.80	6.00	6.43	6.66	7.43	89.60
Cucumbers	0.13	10.30	6.86	14.59	12.69	9.62	8.96	7.93	7.20	5.34	20.54
Grapes	2.00	110.14	94.67	82.18	66.31	63.81	54.20	60.39	74.86	81.55	243.24
Lemons & Limes	0.30	13.04	15.28	9.19	10.58	13.52	12.42	11.59	12.36	13.97	63.60
Olives	1.67	81.62	75.10	73.90	77.40	60.72	85.04	84.57	93.42	107.43	25.05
Onions	0.32	8.37	14.33	15.99	14.42	14.24	10.98	10.86	14.30	16.81	27.58
Oranges	2.50	202.50	104.97	51.84	6.41	118.20	142.21	133.96	161.84	164.41	49.95
Peaches & Nectarines	0.56	9.04	6.73	5.70	4.89	5.62	4.32	8.88	10.53	13.01	83.33
Potatoes	1.28	336.33	303.85	191.28	173.30	159.57	174.01	171.60	243.19	304.96	143.25
Tomatoes	0.21	38.33	25.23	33.86	33.16	31.94	29.67	31.28	26.37	21.83	34.44
Wheat	5.22	1,599.31	1,888.25	1,603.42	1,549.87	1,751.22	1,791.27	1,681.66	1,573.36	1,387.26	934.18

Table 19 - Supply and Demand in kcal/capita/day

	Surplus or Shortage (g/capita/day)								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Almonds	-12.46	-10.16	-15.09	-16.24	-15.26	-16.18	-17.19	-17.44	-19.81
Apples	-55.27	-50.21	-51.45	-53.59	-74.24	-67.12	-36.96	-28.24	23.85
Apricots	-22.28	-24.07	-28.91	-33.35	-29.56	-29.74	-27.73	-26.65	-24.42
Bananas	-2.14	4.12	5.95	-0.38	-7.99	-14.81	2.12	7.93	11.59
Barley	5.56	11.88	6.93	14.52	4.27	4.05	1.82	5.44	38.83
Beans	-115.90	-116.52	-110.51	-112.68	-113.09	-115.05	-117.45	-119.71	-121.73
Cherries	-124.26	-123.63	-128.50	-130.18	-129.38	-130.62	-129.96	-129.59	-128.38
Cucumbers	-78.78	-105.22	-45.81	-60.41	-84.03	-89.11	-97.03	-102.61	-116.89
Grapes	-66.48	-74.21	-80.45	-88.38	-89.63	-94.43	-91.33	-84.11	-80.77
Lemons & Limes	-168.53	-161.06	-181.38	-176.75	-166.92	-170.61	-173.36	-170.79	-165.43
Olives	33.87	29.97	29.25	31.35	21.36	35.92	35.64	40.94	49.33
Onions	-59.53	-41.05	-35.93	-40.79	-41.32	-51.44	-51.81	-41.15	-33.36
Oranges	61.08	22.03	0.76	-17.43	27.33	36.94	33.64	44.80	45.83
Peaches & Nectarines	-133.73	-137.88	-139.73	-141.20	-139.88	-142.23	-134.01	-131.04	-126.58
Potatoes	150.28	124.99	37.39	23.39	12.71	23.95	22.07	77.78	125.86
Tomatoes	18.52	-43.88	-2.74	-6.11	-11.89	-22.73	-15.05	-38.42	-60.07
Wheat	127.45	182.81	128.23	117.97	156.55	164.23	143.23	122.47	86.82

Table 20 - Net Production vs Demand in kcal/capita/day

To better understand the magnitude of the Syrian refugees on the production I computed the net production per capita considering there are no Syrian refugees in Lebanon; so, dividing the net production by the number of Lebanese people only. I calculated the latter in grams per capita per day, as seen in table twenty-one.

	Supply (g/capita/day)									Demand (g/capita/day)
	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Almonds	17.71	20.02	15.09	13.96	15.27	16.36	15.91	15.22	12.20	30
Apples	38.06	43.13	41.89	39.78	19.54	30.62	69.06	77.77	137.87	93
Apricots	17.72	15.93	11.09	6.65	10.69	11.99	15.03	15.95	18.33	40
Bananas	17.86	24.12	25.95	19.64	12.29	6.06	27.09	33.37	37.17	20
Barley	50.56	56.88	51.93	59.58	50.43	57.30	57.35	60.27	98.63	45
Beans	14.10	13.48	19.49	17.34	17.31	17.47	15.37	12.30	9.74	130
Cherries	15.74	16.37	11.50	9.84	10.87	10.96	12.30	12.43	13.67	140
Cucumbers	79.22	52.78	112.20	97.69	75.71	80.48	74.69	66.18	48.37	158
Grapes	55.02	47.29	41.05	33.16	32.62	31.63	36.95	44.68	47.92	122
Lemons & Limes	43.47	50.94	30.62	35.29	46.14	48.36	47.33	49.24	54.79	212
Olives	48.87	44.97	44.25	46.39	37.22	59.49	62.04	66.84	75.69	15
Onions	25.94	44.42	49.55	44.73	45.18	39.76	41.24	52.95	61.31	85
Oranges	81.08	42.03	20.76	2.57	48.44	66.52	65.70	77.42	77.46	20
Peaches & Nectarines	16.27	12.12	10.27	8.81	10.36	9.08	19.59	22.65	27.55	150
Potatoes	261.76	236.48	148.88	135.02	127.11	158.22	163.60	226.13	279.26	111
Tomatoes	182.52	120.12	161.27	158.05	155.69	165.04	182.46	150.04	122.28	164
Wheat	306.45	361.81	307.25	297.28	343.44	400.98	394.72	360.19	312.76	179

Table 21 – Supply and Demand in Optimum Conditions in g/capita/day

Again, I subtracted the demand from the supply. In table twenty-two numbers in green represent amounts that became sufficient after considering there are no Syrian Refugees in Lebanon. It is evident that most of the crops are still in shortage. Only the amount of tomatoes in 2013 and 2014 increased. The net production of tomatoes, assuming there are no Syrian refugees, increased by 16.8 percent in 2013 and 22.5 percent in 2014. The same was also calculated in kilocalorie per capita per day, and the tables can be found in the appendix.

	Surplus or Shortage (g/capita/day)								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Almonds	-12.46	-10.16	-15.09	-16.22	-14.91	-13.82	-14.26	-14.96	-17.97
Apples	-55.27	-50.21	-51.45	-53.55	-73.79	-62.71	-24.27	-15.57	44.54
Apricots	-22.28	-24.07	-28.91	-33.35	-29.31	-28.01	-24.97	-24.05	-21.67
Bananas	-2.14	4.12	5.95	-0.36	-7.71	-13.94	7.09	13.37	17.17
Barley	5.56	11.88	6.93	14.58	5.43	12.30	12.35	15.27	53.63
Beans	-115.90	-116.52	-110.51	-112.66	-112.69	-112.53	-114.63	-117.70	-120.26
Cherries	-124.26	-123.63	-128.50	-130.16	-129.13	-129.04	-127.70	-127.57	-126.33
Cucumbers	-78.78	-105.22	-45.80	-60.31	-82.29	-77.52	-83.31	-91.82	-109.63
Grapes	-66.48	-74.21	-80.45	-88.34	-88.88	-89.87	-84.55	-76.82	-73.58
Lemons & Limes	-168.53	-161.06	-181.38	-176.71	-165.86	-163.64	-164.67	-162.76	-157.21
Olives	33.87	29.97	29.25	31.39	22.22	44.49	47.04	51.84	60.69
Onions	-59.53	-41.05	-35.93	-40.74	-40.29	-45.71	-44.24	-32.52	-24.16
Oranges	61.08	22.03	0.76	-17.43	28.44	46.52	45.70	57.42	57.46
Peaches & Nectarines	-133.73	-137.88	-139.73	-141.19	-139.64	-140.92	-130.41	-127.35	-122.45
Potatoes	150.28	124.99	37.39	23.53	15.63	46.73	52.12	114.65	167.77
Tomatoes	18.52	-43.88	-2.73	-5.95	-8.31	1.04	18.46	-13.96	-41.72
Wheat	127.45	182.81	128.25	118.28	164.44	221.98	215.72	181.19	133.76

Table 22 - Net Production vs Demand in Optimum Conditions in g/capita/day

In summary, looking at the total yearly harvested area, it is evident that it did not change much throughout the years. We can see from the results that the main decrease in the total area harvested occurred prior to 2010 so before the Syrian war erupted. After the start of the influx of the displaced refugees into Lebanon, the total area harvested actually increased. A slight decrease was recorded in 2013 followed by an incremental increase until 2016.

While the area harvested of most crops increased after 2010, the yearly production of some crops decreased between 2010 and 2011. Looking at the yearly production between 2012 and 2014 though, it is clear that for most of the crops the production actually increased.

Comparing the demand to the net production, including the trade, it is evident that almost all the crops are in shortage and do not meet their recommended daily intake, even with all the imports. Even when considering a best-case scenario where no Syrian refugees live in Lebanon most of the crops were still in shortage.

Figure twenty-two below graphically summarizes the production of the top six crops: apples, bananas, barley, potatoes, tomatoes, and wheat. In each map the density of the colors of the governorates indicates the amount of production of each crop. The red color corresponds to the governorate with the most production and the white color to a governorate that does not produce the crop in question. The intensity of the blue color of the arrows indicates the amounts needed in each governorate. The darker the blue, the scarcer the crop in the governorate that the arrow points to. And finally, the thickness of the import and export arrows represents how little or how large the import and export quantities are with respect to each other.

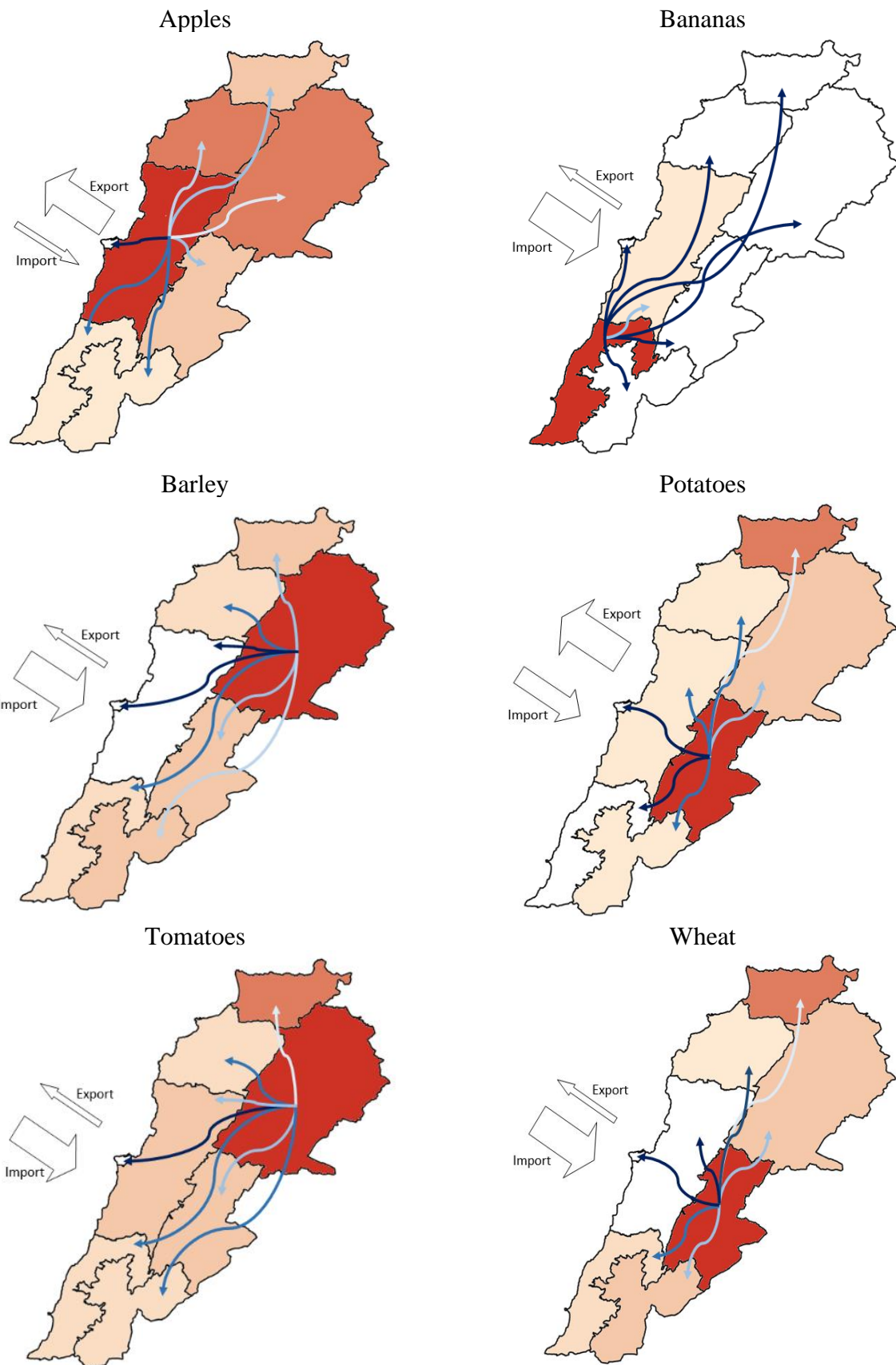


Figure 22 – Graphical Summary of the Production



## 5. Discussion

This study analyzes the impact of the presence of the Syrian refugees on Lebanon's food security. Based on the literature review, the Syrian refugees' influx had a significant impact on Lebanon's food security. However no actual numerical study existed to prove this hypothesis. My thesis represents the missing mathematical model to interpret whether the hypothesis stands or not.

To do so I examined the yearly change in the harvested area of each crop as well as the total harvested areas, the water required and the production. I then analyzed the yearly demand versus the supply to assess if the Syrian refugees caused a shortage of a crop. These calculations help examine the impact on the first pillar of food security, the food availability.

As mentioned in the literature many Syrians have settled in the Bekaa region, Baalbek El Hermel and in Akkar in informal tented settlements made up of temporary tents on and near agricultural fields affecting land use, decreasing the areas prone to harvest, and thus impacting food availability.

However, looking at the total yearly harvested area, it is obvious that it did not change much throughout the years. We can see from the results that the main decrease in the total area harvested occurred prior to 2010 so before the Syrian war erupted. Between 2011 and 2012, immediately after the refugees started coming into Lebanon, the total area harvested actually increased by about 10.3 percent. A slight decrease of 1.2 percent was recorded in 2013 followed by an incremental increase until 2016.

If we focus only on the Bekaa region, Baalbek El Hermel and Akkar, the areas with the most Syrian refugees and informal settlements we can also see an increase in the total area harvested between 2010 and 2012. The total area harvested in the Bekaa increased by 19 percent, in Baalbek El Hermel by 12.5 percent and in Akkar by 12.9 percent. Between 2012 and 2014, the

Bekaa and Baalbek El Hermel underwent a small decrease of 3.3 percent each followed by an incremental increase. The total area harvested in Akkar decreased by less than 230 hectares between 2012 and 2013, which is less than a one percent, then increased incrementally in the following years as well. These decreases are very minimal to be directly linked to the settlement of the Syrian refugees as it was mentioned in the literature. Hence, based on the calculations and the numbers, the Syrian refugees did not affect the amount of areas harvested but on the contrary the total amount increased incrementally between 2013 and 2016.

According to the literature reviewed, the water challenges in Lebanon preceded the arrival of the Syrian refugees. The influx of refugees increased the stress on Lebanon's already scarce water resources, and a recorded increase of eight percent on water stress was found to be due to a rise in food-related water demand. According to the calculations and as previously seen in figure sixteen, the total water required by the analyzed crops has increased by about eight percent between 2011 and 2012 following the sudden arrival of the Syrian refugees. A slight decrease of two percent is observed between 2012 and 2014, followed by an increase of more than seven percent in the two following years. These increases commensurate with the documented increase in area harvested and the increase in food demand following the arrival of more than 1.2 million displaced Syrians. The results validate what was documented in the literature.

According to the literature, farmers could not always access their cultivations or move freely in their croplands, sometimes missing critical stages of crop development and harvest resulting in a lot of losses in the production. This is evident when looking at the yearly production between 2010 and 2011, where the production of some crops decreased. Looking at the yearly production between 2012 and 2014 though, it is clear that for most of the crops the production actually increased.

However, it is important to focus on staple crops such as barley, olives, potatoes, and wheat, which are mainly grown in the three critical areas, Bekaa, Baalbek El Hermel and Akkar. Between 2010 and 2014 the production of barley increased by fifty percent, olives' production increased by forty-two percent, the production of potatoes increased by seventy-one percent and wheat's production increased by sixty-nine percent. The increases in the production of these crops aligns with the increase of the area harvested and is a logical response to accommodate the increase in demand. The massive increase in the production of potatoes and wheat can be linked to the fact that they are easy crops that do not require much care, they are easy to grow and produce abundant harvests. However even with the substantial increase, wheat remains the mostly imported food since an average of 150,000 tons per year is not sufficient to feed more than six million people.

The arrival of more than one million people to the country in three years was definitely a challenge for the stability of national food availability but given that Lebanon is highly reliant on food imports and due to the flexibility of the external supply the influx of refugees has been correlated with a proportional increase in food imports. According to the ITC, cereals, vegetables, and fruits are mainly imported from Ukraine, Egypt, and Iran, respectively.

However, comparing the demand to the net production, including the trade, it is evident that almost all the crops are in shortage and do not meet their recommended daily intake, even with all the imports. These shortages, however, do not mean that Lebanon is food insecure for numerous reasons.

Barley, olives, potatoes, and wheat, the staple crops, are sufficient and meet the daily recommended intake every year. The remaining fruits and vegetables were however found to be in shortage. The deficiencies are however very minimal and do not exceed a few grams per day. If we consider a more realistic scenario: a person will most likely not eat all of the mentioned fruits and vegetables on a daily basis but alternate between them; and so, the

quantities will probably accumulate and be sufficient. Also, even though these crops represent ninety percent of the crops harvested in Lebanon, the daily Lebanese diet is made-up of many other foods such as dairy, animal products and various other fruits and vegetables. The latter confirms again that even though some crops appear to be slightly insufficient the diversity of the Lebanese diet should compensate for it.

Circling back to figure five it was reported that in Baalbek and Zahle, in 2016, more than fifty percent of the households were food insecure. Even though most of the production occurs in these districts, they are still considered as Lebanon's most vulnerable regions with about seventy percent of the poor Lebanese population and most of the Syrian refugees residing there. While having physical access to food these underprivileged communities lack the economical access and hence experience from food insecurity.

Nevertheless, to better understand the magnitude of the Syrian refugees on the shortage I computed the net production per capita considering there are no Syrian refugees in Lebanon, so in other words, in a best-case scenario and in optimum conditions.

Even when considering that no Syrian refugees live in Lebanon most of the crops were still in shortage. Only the amount of tomatoes in 2013 and 2014 increased and became sufficient for the population. The net production of tomatoes in 2013 and 2014 increased by seventeen percent and twenty-three percent, respectively. This again proves that the influx of Syrian refugees did not impact the food availability in terms of decreasing the production.

It is crucial to mention that the study encountered a lot of limitations. Finding papers, articles, and publications on Lebanon and the Syrian refugees was not an easy task. My resources were mainly reports done by the UN or one of its agencies and the FAO. Even websites of governmental entities in Lebanon such as the MoA, MoE and the Lebanese army had very limited information.

The yearly yield and production used as a basis for all these calculations and interpretations are from FAOSTAT rather than from a credible source in Lebanon such as the MoA. This limits the accuracy of all the computations and analysis, but it was the only way to move forward as no data was published nor was available. Multiple emails were sent to the ministry however none were received. I then reached out to Ms. Sonia El Abiad, the head of the studies department in the MoA, who confirmed that there are no additional data other than the published report done in 2010. The emails can be found in the appendix.

## 6. Conclusion

Lebanon, a small country in the Middle East, has a land area of 10,452 square kilometers and a current population of almost 6.79 million inhabitants from which more than 1.2 million are Syrian refugees. The outbreak of the civil war in Syria in 2011 has had an impact on Lebanon on multiple levels. According to the literature, the influx of Syrian refugees impacted Lebanon's food availability, access to food, food utilization as well as its other natural resources such as water, ecosystems, and woodlands.

This research study considers the literature found in the reports coupled with mathematical reasoning, to analyze the impact of the presence of the Syrian refugees on Lebanon's food security. The differentiator between this paper and the rest of the available rhetoric to this day is that it fills the gap in the literature by presenting tangible calculations, which are missing in the literature, to interpret whether the hypothesis stands or not.

To do so I examined the yearly change in the harvested area of each crop as well as the total harvested areas, the water required and the production. I then analyzed the yearly demand versus the supply to assess if the Syrian refugees caused a shortage of a crop. These calculations help examine the impact on the first pillar of food security, the food availability.

As mentioned in the literature many Syrians have settled in the Bekaa, Baalbek El Hermel and in Akkar in informal settlements made up of temporary tents on and near agricultural fields affecting land use, decreasing the areas prone to harvest, and thus impacting food availability. Farmers could not always access their cultivations or move freely in their croplands, sometimes missing critical stages of crop development and harvest resulting in a lot of losses in the production, again impacting food availability and thus food security.

The total yearly harvested area did not change much throughout the years though. Based on the calculations and the numbers, the Syrian refugees did not affect the amount of areas harvested

but on the contrary the total amount increased incrementally between 2013 and 2016. The same goes for the production, between 2012 and 2014 for most of the crops the yearly production increased as well. Staple crops such as barley, olives, potatoes, and wheat, which are mainly grown in the three critical areas, Bekaa, Baalbek El Hermel and Akkar, also increased with the increase in demand.

As seen in the literature reviewed, the water challenges in Lebanon preceded the arrival of the Syrian refugees. The influx of refugees however, increased the stress on Lebanon's already scarce water resources. According to the calculations the total water required by the crops used in the study has increased throughout the years. These increases commensurate with the documented increase in area harvested and the increase in food demand.

Comparing the demand to the net production demonstrated that the quantities of the staple crops, barley, olives, potatoes, and wheat, are sufficient and meets the daily recommended intake. However, the production of the other crops proved to be in shortage. But, after considering a best-case scenario, far from reality, in which no Syrian refugees reside in Lebanon, most of the crops were still in shortage, and hence their scarcity was not linked to the influx of the Syrian refugees.

The arrival of more than one million people to the country in three years was definitely a challenge for the stability of national food availability but given that Lebanon is highly reliant on food imports and due to the flexibility of the external supply the influx of refugees has been correlated with a proportional increase in food imports. Wheat is one of the main food imported to Lebanon, primarily from Ukraine. With the port explosion in Beirut in 2020 destroying Lebanon's wheat silos, the war in Ukraine in 2022, and Lebanon's high dependance on wheat import, the country's future with respect to having a sufficient amount of wheat as in the past is extremely at risk.

The absence of resources and statistical data about the agricultural sector in Lebanon explains the lack of numerical-based studies in the literature. It is challenging to conclusively say whether the displaced Syrian refugees negatively impacted Lebanon's food security based on these findings alone. However, it is safe to say that despite the tremendous stress on the local demand that an influx of over one million people is likely to place in a small country like Lebanon, the predicted stress on the harvest and yield did not occur.

In my study I only focused on the agriculture and certain crops, however, one can widen the research and examine the changes in all the crops harvested in Lebanon as well as the dairy and animal products. It is crucial that in the future the agricultural sector in Lebanon is not as neglected as it is in the present, and that the MoA is given more funding to be able to support local harvest and production and accommodate the increasing demand without being so reliant on imports.



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## 8. Appendix

	2008								2009							
	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South
Almonds	6,300	1,449	3,150	882	189	189	378	63	6,600	1,518	3,300	924	198	198	396	66
Apples	10,100	1,313	2,222	1,212	2,626	202	2,323	202	11,800	1,534	2,596	1,416	3,068	236	2,714	236
Apricots	6,500	65	5,720	130	65	65	455	0	5,900	59	5,192	118	59	59	413	0
Artichokes	61	9	34	14	1	3	0	0	64	9	36	15	1	3	0	0
Avocados	450	18	0	0	54	144	36	198	610	24	0	0	73	195	49	268
Bananas	3,000	0	0	0	180	0	0	2,820	3,325	0	0	0	200	0	0	3,126
Barley	14,500	870	11,745	1,015	0	580	145	145	14,400	864	11,664	1,008	0	576	144	144
Beans	2,080	562	312	624	229	62	187	104	1,635	441	245	491	180	49	147	82
Cabbages	1,950	371	215	936	117	39	98	176	1,244	236	137	597	75	25	62	112
Carobs	310	25	0	0	19	59	37	171	243	19	0	0	15	46	29	134
Cauliflowers	1,200	228	108	624	36	24	60	120	605	115	54	315	18	12	30	61
Cherries	8,500	85	5,525	2,210	340	85	255	0	7,510	75	4,882	1,953	300	75	225	0
Chickpeas	1,900	361	874	380	0	152	114	19	1,550	295	713	310	0	124	93	16
Cucumbers	3,100	403	1,271	496	248	217	279	186	1,896	246	777	303	152	133	171	114
Eggplants	800	304	304	40	32	24	40	56	842	320	320	42	34	25	42	59
Figs	950	86	209	86	200	228	95	48	1,088	98	239	98	228	261	109	54
Grapes	13,200	1,188	5,148	4,356	1,188	528	396	396	12,024	1,082	4,689	3,968	1,082	481	361	361
Lemons & Limes	4,100	246	0	0	123	410	164	3,157	4,321	259	0	0	130	432	173	3,327
Lentils	800	0	464	112	0	184	0	40	803	0	466	112	0	185	0	40
Lettuce	1,100	110	165	671	22	22	66	44	1,413	141	212	862	28	28	85	57
Melons	390	39	105	82	4	129	0	31	640	64	173	134	6	211	0	51
Olives	56,000	10,080	4,480	2,800	5,600	11,760	12,880	8,400	57,800	10,404	4,624	2,890	5,780	12,138	13,294	8,670
Onions	2,000	280	760	800	40	60	40	20	3,132	438	1,190	1,253	63	94	63	31
Oranges	10,400	1,664	0	0	312	416	1,664	6,344	8,240	1,318	0	0	247	330	1,318	5,026
Peaches & Nectarines	3,700	148	999	851	629	333	666	74	3,200	128	864	736	544	288	576	64
Pears	3,100	279	186	527	372	124	1,581	31	2,781	250	167	473	334	111	1,418	28
Peas	1,900	266	874	228	38	190	95	209	1,683	236	774	202	34	168	84	185
Plums	2,100	126	273	315	441	105	819	21	1,981	119	258	297	416	99	773	20
Potatoes	20,100	5,427	3,819	10,251	201	201	201	0	18,900	5,103	3,591	9,639	189	189	189	0
Sesame seed	68	1	0	0	0	46	0	21	69	1	0	0	0	47	0	21
Spinach	278	183	6	64	3	3	3	17	200	132	4	46	2	2	2	12
Tomatoes	4,060	731	893	650	690	406	325	365	3,098	558	682	496	527	310	248	279
Walnuts	1,050	242	368	168	126	63	53	32	945	217	331	151	113	57	47	28
Watermelons	2,100	63	1,155	210	0	588	0	84	1,619	49	890	162	0	453	0	65
Wheat	49,900	10,978	6,986	21,956	0	5,988	998	2,994	39,800	8,756	5,572	17,512	0	4,776	796	2,388
Total	238,047	38,197	58,369	52,689	14,124	23,629	24,452	26,586	221,961	35,110	54,642	46,522	14,095	22,417	24,051	25,124

Table 23 - Area Harvested per Governorate in Hectares, 2008 – 2009

	2011								2012							
	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South
Almonds	5,454	1,254	2,727	764	164	164	327	55	5,936	1,365	2,968	831	178	178	356	59
Apples	10,671	1,387	2,348	1,281	2,774	213	2,454	213	9,923	1,290	2,183	1,191	2,580	198	2,282	198
Apricots	3,337	33	2,937	67	33	33	234	0	5,339	53	4,698	107	53	53	374	0
Artichokes	111	16	62	26	2	6	0	0	62	9	35	14	1	3	0	0
Avocados	580	23	0	0	70	186	46	255	580	23	0	0	70	186	46	255
Bananas	2,664	0	0	0	160	0	0	2,504	2,095	0	0	0	126	0	0	1,969
Barley	14,053	843	11,383	984	0	562	141	141	16,024	961	12,979	1,122	0	641	160	160
Beans	3,132	846	470	940	345	94	282	157	3,156	852	473	947	347	95	284	158
Cabbages	1,079	205	119	518	65	22	54	97	1,464	278	161	703	88	29	73	132
Carobs	242	19	0	0	15	46	29	133	247	20	0	0	15	47	30	136
Cauliflowers	704	134	63	366	21	14	35	70	876	166	79	456	26	18	44	88
Cherries	6,485	65	4,215	1,686	259	65	195	0	6,861	69	4,460	1,784	274	69	206	0
Chickpeas	3,199	608	1,472	640	0	256	192	32	3,118	592	1,434	624	0	249	187	31
Cucumbers	3,868	503	1,586	619	309	271	348	232	3,161	411	1,296	506	253	221	284	190
Eggplants	1,532	582	582	77	61	46	77	107	1,548	588	588	77	62	46	77	108
Figs	1,773	160	390	160	372	426	177	89	1,140	103	251	103	239	274	114	57
Grapes	9,052	815	3,530	2,987	815	362	272	272	9,096	819	3,547	3,002	819	364	273	273
Lemons & Limes	3,455	207	0	0	104	346	138	2,660	3,871	232	0	0	116	387	155	2,981
Lentils	1,009	0	585	141	0	232	0	50	765	0	444	107	0	176	0	38
Lettuce	3,198	320	480	1,951	64	64	192	128	1,599	160	240	975	32	32	96	64
Melons	860	86	232	181	9	284	0	69	825	83	223	173	8	272	0	66
Olives	53,600	9,648	4,288	2,680	5,360	11,256	12,328	8,040	53,600	9,648	4,288	2,680	5,360	11,256	12,328	8,040
Onions	3,339	467	1,269	1,336	67	100	67	33	3,426	480	1,302	1,370	69	103	69	34
Oranges	3,980	637	0	0	119	159	637	2,428	7,494	1,199	0	0	225	300	1,199	4,571
Peaches & Nectarines	3,148	126	850	724	535	283	567	63	3,147	126	850	724	535	283	566	63
Pears	1,506	136	90	256	181	60	768	15	1,966	177	118	334	236	79	1,003	20
Peas	1,855	260	853	223	37	186	93	204	1,850	259	851	222	37	185	93	204
Plums	1,964	118	255	295	412	98	766	20	2,056	123	267	308	432	103	802	21
Potatoes	11,500	3,105	2,185	5,865	115	115	115	0	12,000	3,240	2,280	6,120	120	120	120	0
Sesame seed	65	1	0	0	0	44	0	20	63	1	0	0	0	43	0	20
Spinach	280	185	6	64	3	3	3	17	220	145	4	51	2	2	2	13
Tomatoes	3,694	665	813	591	628	369	296	332	3,780	680	832	605	643	378	302	340
Walnuts	1,178	271	412	188	141	71	59	35	1,185	273	415	190	142	71	59	36
Watermelons	2,110	63	1,161	211	0	591	0	84	2,075	62	1,141	208	0	581	0	83
Wheat	42,112	9,265	5,896	18,529	0	5,053	842	2,527	48,007	10,562	6,721	21,123	0	5,761	960	2,880
Total	206,789	33,051	51,258	44,346	13,240	22,079	21,732	21,083	218,555	35,049	55,128	46,655	13,088	22,803	22,545	23,288

Table 24 - Area Harvested per Governorate in Hectares, 2011 – 2012

	2013								2014							
	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South
Almonds	5,790	1,332	2,895	811	174	174	347	58	5,354	1,231	2,677	750	161	161	321	54
Apples	9,996	1,299	2,199	1,200	2,599	200	2,299	200	12,001	1,560	2,640	1,440	3,120	240	2,760	240
Apricots	5,402	54	4,754	108	54	54	378	0	4,807	48	4,230	96	48	48	336	0
Artichokes	67	9	38	15	1	3	0	0	71	10	40	16	1	4	0	0
Avocados	597	24	0	0	72	191	48	263	615	25	0	0	74	197	49	271
Bananas	1,949	0	0	0	117	0	0	1,832	2,305	0	0	0	138	0	0	2,167
Barley	15,661	940	12,685	1,096	0	626	157	157	14,000	840	11,340	980	0	560	140	140
Beans	3,010	813	452	903	331	90	271	151	2,652	716	398	796	292	80	239	133
Cabbages	1,461	278	161	701	88	29	73	131	1,401	266	154	672	84	28	70	126
Carobs	251	20	0	0	15	48	30	138	300	24	0	0	18	57	36	165
Cauliflowers	898	171	81	467	27	18	45	90	871	165	78	453	26	17	44	87
Cherries	6,555	66	4,261	1,704	262	66	197	0	5,829	58	3,789	1,516	233	58	175	0
Chickpeas	3,170	602	1,458	634	0	254	190	32	3,260	619	1,500	652	0	261	196	33
Cucumbers	3,214	418	1,318	514	257	225	289	193	3,358	437	1,377	537	269	235	302	201
Eggplants	1,545	587	587	77	62	46	77	108	1,947	740	740	97	78	58	97	136
Figs	985	89	217	89	207	236	99	49	944	85	208	85	198	227	94	47
Grapes	8,835	795	3,446	2,916	795	353	265	265	10,062	906	3,924	3,320	906	402	302	302
Lemons & Limes	3,875	233	0	0	116	388	155	2,984	3,691	221	0	0	111	369	148	2,842
Lentils	863	0	501	121	0	198	0	43	814	0	472	114	0	187	0	41
Lettuce	1,661	166	249	1,013	33	33	100	66	1,575	158	236	961	32	32	95	63
Melons	812	81	219	171	8	268	0	65	562	56	152	118	6	185	0	45
Olives	53,600	9,648	4,288	2,680	5,360	11,256	12,328	8,040	58,820	10,588	4,706	2,941	5,882	12,352	13,529	8,823
Onions	3,488	488	1,325	1,395	70	105	70	35	3,200	448	1,216	1,280	64	96	64	32
Oranges	7,238	1,158	0	0	217	290	1,158	4,415	6,820	1,091	0	0	205	273	1,091	4,160
Peaches & Nectarines	3,155	126	852	726	536	284	568	63	3,600	144	972	828	612	324	648	72
Pears	1,774	160	106	302	213	71	905	18	1,802	162	108	306	216	72	919	18
Peas	1,967	275	905	236	39	197	98	216	2,009	281	924	241	40	201	100	221
Plums	2,062	124	268	309	433	103	804	21	2,423	145	315	363	509	121	945	24
Potatoes	15,800	4,266	3,002	8,058	158	158	158	0	17,910	4,836	3,403	9,134	179	179	179	0
Sesame seed	61	1	0	0	0	41	0	19	58	1	0	0	0	39	0	18
Spinach	200	132	4	46	2	2	2	12	230	152	5	53	2	2	2	14
Tomatoes	3,748	675	825	600	637	375	300	337	4,817	867	1,060	771	819	482	385	434
Walnuts	1,192	274	417	191	143	72	60	36	1,230	283	431	197	148	74	62	37
Watermelons	2,074	62	1,141	207	0	581	0	83	1,870	56	1,029	187	0	524	0	75
Wheat	42,988	9,457	6,018	18,915	0	5,159	860	2,579	36,800	8,096	5,152	16,192	0	4,416	736	2,208
Total	215,944	34,822	54,670	46,204	13,027	22,193	22,330	22,698	218,008	35,315	53,274	45,097	14,469	22,561	24,064	23,227

Table 25 - Area Harvested per Governorate in Hectares, 2013 – 2014

	2015								2016							
	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South	Area Harvested	Akkar	Baalbek-El Hermel	Bekaa	Mount Lebanon	El Nabatieh	North	South
Almonds	5,005	1,151	2,503	701	150	150	300	50	4,298	989	2,149	602	129	129	258	43
Apples	12,646	1,644	2,782	1,518	3,288	253	2,909	253	16,573	2,154	3,646	1,989	4,309	331	3,812	331
Apricots	4,496	45	3,956	90	45	45	315	0	4,285	43	3,771	86	43	43	300	0
Artichokes	73	10	41	17	1	4	0	0	138	19	77	32	3	7	0	0
Avocados	982	39	0	0	118	314	79	432	1,642	66	0	0	197	525	131	722
Bananas	2,381	0	0	0	143	0	0	2,238	2,320	0	0	0	139	0	0	2,181
Barley	13,795	828	11,174	966	0	552	138	138	15,414	925	12,485	1,079	0	617	154	154
Beans	2,927	790	439	878	322	88	263	146	2,875	776	431	863	316	86	259	144
Cabbages	1,360	258	150	653	82	27	68	122	1,223	232	135	587	73	24	61	110
Carobs	339	27	0	0	20	64	41	186	356	28	0	0	21	68	43	196
Cauliflowers	875	166	79	455	26	18	44	88	831	158	75	432	25	17	42	83
Cherries	5,172	52	3,362	1,345	207	52	155	0	4,919	49	3,197	1,279	197	49	148	0
Chickpeas	2,701	513	1,242	540	0	216	162	27	1,914	364	880	383	0	153	115	19
Cucumbers	3,426	445	1,405	548	274	240	308	206	3,751	488	1,538	600	300	263	338	225
Eggplants	1,544	587	587	77	62	46	77	108	1,396	530	530	70	56	42	70	98
Figs	828	75	182	75	174	199	83	41	456	41	100	41	96	109	46	23
Grapes	11,170	1,005	4,356	3,686	1,005	447	335	335	10,443	940	4,073	3,446	940	418	313	313
Lemons & Limes	3,602	216	0	0	108	360	144	2,774	3,534	212	0	0	106	353	141	2,721
Lentils	731	0	424	102	0	168	0	37	902	0	523	126	0	207	0	45
Lettuce	1,422	142	213	867	28	28	85	57	1,198	120	180	731	24	24	72	48
Melons	677	68	183	142	7	223	0	54	766	77	207	161	8	253	0	61
Olives	63,170	11,371	5,054	3,159	6,317	13,266	14,529	9,476	59,780	10,760	4,782	2,989	5,978	12,554	13,749	8,967
Onions	3,119	437	1,185	1,248	62	94	62	31	3,029	424	1,151	1,212	61	91	61	30
Oranges	6,671	1,067	0	0	200	267	1,067	4,069	5,626	900	0	0	169	225	900	3,432
Peaches & Nectarines	3,926	157	1,060	903	667	353	707	79	4,231	169	1,142	973	719	381	762	85
Pears	1,871	168	112	318	225	75	954	19	1,998	180	120	340	240	80	1,019	20
Peas	2,245	314	1,033	269	45	225	112	247	2,699	378	1,242	324	54	270	135	297
Plums	2,703	162	351	405	568	135	1,054	27	3,212	193	418	482	675	161	1,253	32
Potatoes	20,106	5,429	3,820	10,254	201	201	201	0	22,101	5,967	4,199	11,272	221	221	221	0
Sesame seed	55	1	0	0	0	37	0	17	55	1	0	0	0	37	0	17
Spinach	218	144	4	50	2	2	2	13	114	75	2	26	1	1	1	7
Tomatoes	4,816	867	1,060	771	819	482	385	433	5,363	965	1,180	858	912	536	429	483
Walnuts	1,279	294	448	205	153	77	64	38	1,279	294	448	205	153	77	64	38
Watermelons	1,535	46	844	154	0	430	0	61	1,104	33	607	110	0	309	0	44
Wheat	40,000	8,800	5,600	17,600	0	4,800	800	2,400	40,977	9,015	5,737	18,030	0	4,917	820	2,459
Total	227,866	37,319	53,649	47,994	15,320	23,937	25,445	24,203	230,802	37,566	55,026	49,325	16,164	23,579	25,714	23,429

Table 26 - Area Harvested per Governorate in Hectares, 2015 – 2016



	2008										2009									
	Yield	Akkar	Baalbek-EI Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production	Yield	Akkar	Baalbek-EI Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production
Almonds	47,619	6,900	15,000	0	4,200	900	900	1,800	300	30,000	51,970	7,889	17,150	0	4,802	1,029	1,029	2,058	343	34,300
Apples	123,960	16,276	27,544	0	15,024	2,504	32,552	28,796	2,504	125,200	117,034	17,953	30,382	0	16,572	2,762	35,906	31,763	2,762	138,100
Apricots	50,000	325	28,600	0	650	325	325	2,275	0	32,500	49,153	290	25,520	0	580	290	290	2,030	0	29,000
Artichokes	107,705	92	368	0	151	33	13	0	0	657	93,750	84	336	0	138	30	12	0	0	600
Avocados	135,556	244	0	0	0	1,952	732	488	2,684	6,100	118,033	288	0	0	0	2,304	864	576	3,168	7,200
Bananas	299,000	0	0	0	0	0	5,382	0	84,318	89,700	288,722	0	0	0	0	5,760	0	90,240	96,000	
Barley	20,000	1,740	23,490	0	2,030	1,160	0	290	290	29,000	20,625	1,782	24,057	0	2,079	1,188	0	297	297	29,700
Beans	20,000	1,123	624	0	1,248	125	458	374	208	4,160	14,388	635	353	0	706	71	259	212	118	2,352
Cabbages	449,744	16,663	9,647	0	42,096	1,754	5,262	4,385	7,893	87,700	393,087	9,291	5,379	0	23,472	978	2,934	2,445	4,401	48,900
Carobs	87,645	217	0	0	0	516	163	326	1,494	2,717	90,535	176	0	0	0	418	132	264	1,210	2,200
Cauliflowers	261,667	5,966	2,826	0	16,328	628	942	1,570	3,140	31,400	213,223	2,451	1,161	0	6,708	258	387	645	1,290	12,900
Cherries	36,471	310	20,150	0	8,060	310	1,240	930	0	31,000	41,012	308	20,020	0	8,008	308	1,232	924	0	30,800
Chickpeas	6,842	247	598	0	260	104	0	78	13	1,300	7,742	228	552	0	240	96	0	72	12	1,200
Cucumbers	422,613	17,031	53,714	0	20,962	9,171	10,481	11,791	7,861	131,010	459,916	11,336	35,752	0	13,952	6,104	6,976	7,848	5,232	87,200
Eggplants	246,250	7,486	7,486	0	985	591	788	985	1,379	19,700	261,283	8,360	8,360	0	1,100	660	880	1,100	1,540	22,000
Figs	52,632	450	1,100	0	450	1,200	1,050	500	250	5,000	54,228	531	1,298	0	531	1,416	1,239	590	295	5,900
Grapes	90,076	10,701	46,371	0	39,237	4,756	10,701	3,567	3,567	118,900	89,820	9,720	42,120	0	35,640	4,320	9,720	3,240	3,240	108,000
Lemons & Limes	278,049	6,840	0	0	0	11,400	3,420	4,560	87,780	114,000	280,953	7,284	0	0	0	12,140	3,642	4,856	93,478	121,400
Lentils	10,000	0	464	0	112	184	0	0	40	800	19,925	0	928	0	224	368	0	0	80	1,600
Lettuce	254,545	2,800	4,200	0	17,080	560	560	1,680	1,120	28,000	264,685	3,740	5,610	0	22,814	748	748	2,244	1,496	37,400
Melons	217,949	850	2,295	0	1,785	2,805	85	0	680	8,500	218,750	1,400	3,780	0	2,940	4,620	140	0	1,120	14,000
Olives	15,179	15,300	6,800	0	4,250	17,851	8,500	19,551	12,750	85,002	13,668	14,220	6,320	0	3,950	16,590	7,900	18,170	11,850	79,001
Onions	254,500	7,126	19,342	0	20,360	1,527	1,018	1,018	509	50,900	276,181	12,110	32,870	0	34,600	2,595	1,730	1,730	865	86,500
Oranges	219,904	36,592	0	0	0	9,148	6,861	36,592	139,507	228,700	214,806	28,320	0	0	0	7,080	5,310	28,320	107,970	177,000
Peaches & Nectarines	113,514	1,680	11,340	0	9,660	3,780	7,140	7,560	840	42,000	95,313	1,220	8,235	0	7,015	2,745	5,185	5,490	610	30,500
Pears	109,677	3,060	2,040	0	5,780	1,360	4,080	17,340	340	34,000	127,652	3,195	2,130	0	6,035	1,420	4,260	18,105	355	35,500
Peas	63,158	1,680	5,520	0	1,440	1,200	240	600	1,320	12,000	59,756	1,408	4,626	0	1,207	1,006	201	503	1,106	10,057
Plums	119,048	1,500	3,250	0	3,750	1,250	5,250	9,750	250	25,000	120,141	1,428	3,094	0	3,570	1,190	4,998	9,282	238	23,800
Potatoes	256,020	138,942	97,774	0	262,446	5,146	5,146	5,146	0	514,600	224,868	114,750	80,750	0	216,750	4,250	4,250	4,250	0	425,001
Sesame seed	32,353	2	0	0	0	150	0	0	68	220	31,739	2	0	0	0	149	0	0	68	219
Spinach	123,273	2,262	69	0	788	34	34	34	206	3,427	110,000	1,452	44	0	506	22	22	22	132	2,200
Tobacco	12,222	1,870	4,290	0	0	3,190	0	220	1,430	11,000	12,377	1,581	3,627	0	0	2,697	0	186	1,209	9,300
Tomatoes	751,970	54,954	67,166	0	48,848	30,530	51,901	24,424	27,477	305,300	627,824	35,010	42,790	0	31,120	19,450	33,065	15,560	17,505	194,500
Walnuts	21,905	529	805	0	368	138	276	115	69	2,300	21,164	460	700	0	320	120	240	100	60	2,000
Watermelons	350,000	2,205	40,425	0	7,350	20,580	0	0	2,940	73,500	327,980	1,593	29,205	0	5,310	14,868	0	0	2,124	53,100
Wheat	28,798	31,614	20,118	0	63,229	17,244	0	2,874	8,622	143,702	27,990	24,508	15,596	0	49,016	13,368	0	2,228	6,684	111,400

Table 27 - Production by Governorate in tons, 2008 – 2009

	2010										2011									
	Yield	Akkar	Baalbek-El Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production	Yield	Akkar	Baalbek-El Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production
Almonds	50,055	6,248	13,582	0	3,803	815	815	1,630	272	27,165	48,561	6,092	13,243	0	3,708	795	795	1,589	265	26,485
Apples	124,289	20,076	33,974	0	18,531	3,089	40,152	35,519	3,089	154,429	127,267	17,655	29,877	0	16,297	2,716	35,310	31,236	2,716	135,807
Apricots	46,439	210	18,455	0	419	210	210	1,468	0	20,972	45,073	150	13,236	0	301	150	150	1,053	0	15,041
Artichokes	95,086	154	618	0	254	55	22	0	0	1,103	105,315	164	655	0	269	58	23	0	0	1,169
Avocados	134,232	357	0	0	0	2,852	1,070	713	3,922	8,913	135,569	315	0	0	0	2,516	944	629	3,460	7,863
Bananas	289,538	0	0	0	0	0	5,231	0	81,949	87,180	300,019	0	0	0	0	0	4,796	0	75,130	79,925
Barley	20,693	1,327	17,909	0	1,548	884	0	221	221	22,110	21,348	1,800	24,300	0	2,100	1,200	0	300	300	30,000
Beans	16,112	1,390	772	0	1,545	154	566	463	257	5,149	16,920	1,431	795	0	1,590	159	583	477	265	5,299
Cabbages	405,341	8,595	4,976	0	21,713	905	2,714	2,262	4,071	45,236	450,232	9,230	5,344	0	23,318	972	2,915	2,429	4,372	48,580
Carobs	87,884	169	0	0	0	402	127	254	1,165	2,118	88,430	171	0	0	0	407	128	257	1,177	2,140
Cauliflowers	178,650	2,590	1,227	0	7,088	273	409	682	1,363	13,631	245,000	3,277	1,552	0	8,969	345	517	862	1,725	17,248
Cherries	39,140	242	15,705	0	6,282	242	966	725	0	24,611	32,745	212	13,803	0	5,521	212	849	637	0	21,235
Chickpeas	8,107	443	1,071	0	466	186	0	140	23	2,329	8,734	531	1,285	0	559	224	0	168	28	2,794
Cucumbers	473,808	25,716	81,104	0	31,650	13,847	15,825	17,803	11,869	197,815	468,051	23,535	74,227	0	28,967	12,673	14,483	16,294	10,863	181,042
Eggplants	265,985	20,943	20,943	0	2,756	1,653	2,204	2,756	3,858	55,112	264,426	15,394	15,394	0	2,026	1,215	1,620	2,026	2,836	40,510
Figs	54,020	833	2,037	0	833	2,222	1,944	926	463	9,259	50,773	810	1,980	0	810	2,160	1,890	900	450	9,002
Grapes	87,185	8,325	36,073	0	30,523	3,700	8,325	2,775	2,775	92,495	86,272	7,028	30,456	0	25,771	3,124	7,028	2,343	2,343	78,093
Lemons & Limes	273,259	4,769	0	0	0	7,949	2,385	3,180	61,208	79,491	263,349	5,459	0	0	0	9,099	2,730	3,639	70,060	90,987
Lentils	15,071	0	984	0	238	390	0	0	85	1,697	13,459	0	788	0	190	312	0	0	68	1,358
Lettuce	272,724	7,069	10,604	0	43,121	1,414	1,414	4,241	2,828	70,690	269,681	8,624	12,937	0	52,609	1,725	1,725	5,175	3,450	86,244
Melons	214,471	2,211	5,970	0	4,644	7,297	221	0	1,769	22,112	191,360	1,646	4,443	0	3,456	5,431	165	0	1,317	16,457
Olives	37,281	36,000	16,000	0	10,000	42,000	20,000	46,000	30,000	200,001	16,418	15,840	7,040	0	4,400	18,480	8,800	20,240	13,200	88,000
Onions	282,344	12,831	34,827	0	36,660	2,749	1,833	1,833	916	91,649	261,447	12,222	33,173	0	34,919	2,619	1,746	1,746	873	87,297
Oranges	214,766	18,961	0	0	0	4,740	3,555	18,961	72,290	118,508	221,563	14,109	0	0	0	3,527	2,645	14,109	53,791	88,182
Peaches & Nectarines	85,957	1,224	8,260	0	7,036	2,753	5,501	5,507	612	30,592	102,166	1,286	8,684	0	7,397	2,895	5,468	5,789	643	32,162
Pears	130,818	2,130	1,420	0	4,023	947	2,840	12,069	237	23,665	118,958	1,612	1,075	0	3,046	717	2,150	9,137	179	17,915
Peas	53,778	1,374	4,515	0	1,178	981	196	491	1,080	9,814	48,287	1,254	4,120	0	1,075	896	179	448	985	8,957
Plums	114,529	1,320	2,860	0	3,300	1,100	4,620	8,580	220	22,001	114,730	1,352	2,929	0	3,380	1,127	4,732	8,788	225	22,533
Potatoes	237,973	71,520	50,329	0	135,093	2,649	2,649	0	0	264,888	239,130	74,250	52,250	0	140,250	2,750	2,750	2,750	0	275,000
Sesame seed	31,940	2	0	0	0	146	0	0	66	214	32,154	2	0	0	0	142	0	0	65	209
Spinach	93,377	2,336	71	0	814	35	35	35	212	3,539	129,250	2,389	72	0	832	36	36	36	217	3,619
Tobacco	11,745	1,666	3,822	0	0	2,842	0	196	274	9,800	11,586	1,678	3,849	0	0	2,862	0	197	1,283	9,869
Tomatoes	626,952	49,463	60,454	0	43,967	27,479	46,715	21,983	24,731	274,793	764,756	50,850	62,150	0	45,200	28,250	48,025	22,600	25,425	282,501
Walnuts	15,469	429	652	0	298	112	244	93	56	1,864	14,728	399	607	0	278	104	208	87	52	1,735
Watermelons	333,482	2,106	38,609	0	7,020	19,655	0	0	2,808	70,198	345,782	2,189	40,128	0	7,296	20,429	0	0	2,918	72,960
Wheat	27,815	18,260	11,620	0	36,520	9,960	0	1,660	4,980	83,000	29,683	27,500	17,500	0	55,000	15,000	0	2,500	7,500	125,000

	2012										2013									
	Yield	Akkar	Baalbek-EI Hermel	Beirut	Bekaa	El Nabatiah	Mount Lebanon	North	South	Total Production	Yield	Akkar	Baalbek-EI Hermel	Beirut	Bekaa	El Nabatiah	Mount Lebanon	North	South	Total Production
Almonds	50,708	6,923	15,050	0	4,214	903	903	1,806	301	30,100	51,219	6,821	14,828	0	4,152	890	890	1,779	297	29,656
Apples	126,690	16,343	27,657	0	15,086	2,514	32,686	28,914	2,514	125,714	126,536	16,443	27,827	0	15,178	2,530	32,886	29,092	2,530	126,485
Apricots	46,675	249	21,929	0	498	249	249	1,744	0	24,920	46,190	250	21,958	0	499	250	250	1,747	0	24,952
Artichokes	104,194	90	362	0	149	32	13	0	0	646	101,493	95	381	0	156	34	14	0	0	680
Avocados	136,586	317	0	0	0	2,535	951	634	3,486	7,922	135,678	324	0	0	0	2,592	972	648	3,564	8,100
Bananas	303,313	0	0	0	0	0	3,813	0	59,731	63,544	306,054	0	0	0	0	0	3,579	0	56,071	59,650
Barley	21,842	2,100	28,350	0	2,450	1,400	0	350	350	35,000	22,349	2,100	28,351	0	2,450	1,400	0	350	350	35,001
Beans	17,019	1,450	806	0	1,611	161	591	483	269	5,371	17,562	1,427	793	0	1,586	159	581	476	264	5,286
Cabbages	436,387	12,139	7,028	0	30,666	1,278	3,833	3,194	5,750	63,887	440,110	12,217	7,073	0	30,864	1,286	3,858	3,215	5,787	64,300
Carobs	89,555	177	0	0	0	420	133	265	1,217	2,212	90,080	181	0	0	0	430	136	271	1,244	2,261
Cauliflowers	240,411	4,001	1,895	0	10,951	421	632	1,053	2,106	21,060	239,967	4,094	1,939	0	11,205	431	646	1,077	2,155	21,549
Cherries	33,553	230	14,963	0	5,985	230	921	691	0	23,021	33,281	218	14,180	0	5,672	218	873	654	0	21,816
Chickpeas	9,176	544	1,316	0	572	229	0	172	29	2,861	9,590	578	1,398	0	608	243	0	182	30	3,040
Cucumbers	456,030	18,740	59,102	0	23,064	10,091	11,532	12,974	8,649	144,151	456,413	19,070	60,143	0	23,471	10,268	11,735	13,202	8,801	146,691
Eggplants	260,368	15,316	15,316	0	2,015	1,209	1,612	2,015	2,821	40,305	261,625	15,360	15,360	0	2,021	1,213	1,617	2,021	2,829	40,421
Figs	52,254	536	1,311	0	536	1,430	1,251	596	298	5,957	51,929	460	1,125	0	460	1,228	1,074	512	256	5,115
Grapes	87,620	7,173	31,083	0	26,301	3,188	7,173	2,391	2,391	79,699	87,559	6,962	30,170	0	25,528	3,094	6,962	2,321	2,321	77,358
Lemons & Limes	267,905	6,222	0	0	0	10,371	3,111	4,148	79,854	103,706	267,985	6,231	0	0	0	10,384	3,115	4,154	79,960	103,844
Lentils	14,497	0	643	0	155	255	0	0	55	1,109	14,403	0	721	0	174	286	0	0	62	1,243
Lettuce	260,694	4,168	6,253	0	25,428	834	834	2,501	1,667	41,685	262,306	4,357	6,535	0	26,577	871	871	2,614	1,743	43,569
Melons	169,127	1,395	3,767	0	2,930	4,604	140	0	1,116	13,953	158,682	1,288	3,479	0	2,706	4,252	129	0	1,031	12,885
Olives	13,060	12,600	5,600	0	3,500	14,700	7,000	16,100	10,500	70,002	19,813	19,116	8,496	0	5,310	22,302	10,620	24,425	15,930	106,198
Onions	251,979	12,086	32,805	0	34,531	2,590	1,727	1,727	863	86,328	248,655	12,142	32,958	0	34,692	2,602	1,735	1,735	867	86,731
Oranges	226,915	27,208	0	0	0	6,802	5,102	27,208	103,731	170,050	229,019	26,522	0	0	0	6,631	4,973	26,522	101,116	165,764
Peaches & Nectarines	105,539	1,329	8,968	0	7,639	2,989	5,646	5,978	664	33,213	106,219	1,340	9,048	0	7,708	3,016	5,697	6,032	670	33,512
Pears	120,855	2,138	1,426	0	4,039	950	2,851	12,118	238	23,760	121,133	1,934	1,289	0	3,653	860	2,579	10,959	215	21,489
Peas	46,209	1,197	3,932	0	1,026	855	171	427	940	8,549	41,792	1,151	3,781	0	986	822	164	411	904	8,220
Plums	116,430	1,436	3,112	0	3,591	1,197	5,027	9,336	239	23,938	115,790	1,433	3,104	0	3,581	1,194	5,014	9,312	239	23,876
Potatoes	233,333	75,600	53,200	0	142,800	2,800	2,800	2,800	0	280,000	260,759	111,240	78,280	0	210,120	4,120	4,120	4,120	0	411,999
Sesame seed	32,381	2	0	0	0	139	0	0	63	204	32,623	2	0	0	0	135	0	0	62	199
Spinach	135,773	1,971	60	0	687	30	30	30	179	2,987	143,100	1,889	57	0	658	29	29	29	172	2,862
Tobacco	11,677	1,601	3,672	0	0	2,730	0	188	1,224	9,415	11,654	1,571	3,603	0	0	2,679	0	185	1,201	9,239
Tomatoes	753,500	51,268	62,661	0	45,572	28,482	48,420	22,786	25,634	284,823	767,914	51,807	63,319	0	46,050	28,781	48,928	23,025	25,903	287,814
Walnuts	15,359	419	637	0	291	109	218	91	55	1,820	15,176	416	633	0	289	109	217	90	54	1,809
Watermelons	341,320	2,125	38,953	0	7,082	19,831	0	0	2,833	70,824	342,623	2,132	39,083	0	7,106	19,897	0	0	2,842	71,060
Wheat	31,245	33,000	21,000	0	65,999	18,000	0	3,000	9,000	149,998	32,567	30,800	19,600	0	61,600	16,800	0	2,800	8,400	139,999

Table 29 - Production by Governorate in tons, 2012 – 2013

	2014										2015									
	Yield	Akkar	Baalbek-El Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production	Yield	Akkar	Baalbek-El Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production
Almonds	53,706	6,613	14,377	0	4,026	863	863	1,725	288	28,754	55,770	6,420	13,956	0	3,908	837	837	1,675	279	27,913
Apples	150,458	23,473	39,724	0	21,668	3,611	46,947	41,530	3,611	180,565	166,396	27,355	46,293	0	25,251	4,208	54,710	48,398	4,208	210,424
Apricots	60,029	289	25,393	0	577	289	289	2,020	0	28,856	73,928	332	29,249	0	665	332	332	2,327	0	33,238
Artichokes	85,211	85	339	0	139	30	12	0	0	605	74,110	76	303	0	124	27	11	0	0	541
Avocados	127,659	314	0	0	0	2,512	942	628	3,454	7,851	125,530	493	0	0	0	3,945	1,479	986	5,424	12,327
Bananas	338,490	0	0	0	0	0	4,681	0	73,341	78,022	361,155	0	0	0	0	0	5,159	0	80,832	85,991
Barley	23,571	1,980	26,730	0	2,310	1,320	0	330	330	32,999	26,895	2,226	30,052	0	2,597	1,484	0	371	371	37,102
Beans	22,558	1,615	897	0	1,795	179	658	538	299	5,982	29,054	2,296	1,276	0	2,551	255	935	765	425	8,504
Cabbages	410,942	10,939	6,333	0	27,635	1,151	3,454	2,879	5,182	57,573	393,603	10,171	5,888	0	25,694	1,071	3,212	2,677	4,818	53,530
Carobs	97,400	234	0	0	0	555	175	351	1,607	2,922	101,386	275	0	0	0	653	206	412	1,890	3,437
Cauliflowers	224,007	3,707	1,756	0	10,146	390	585	976	1,951	19,511	212,091	3,526	1,670	0	9,650	371	557	928	1,856	18,558
Cherries	42,258	246	16,011	0	6,404	246	985	739	0	24,632	52,086	269	17,510	0	7,004	269	1,078	808	0	26,939
Chickpeas	10,245	635	1,536	0	668	267	0	200	33	3,340	8,734	448	1,085	0	472	189	0	142	24	2,359
Cucumbers	400,167	17,469	55,094	0	21,500	9,406	10,750	12,094	8,063	134,376	372,499	16,590	52,323	0	20,419	8,933	10,209	11,486	7,657	127,618
Eggplants	236,364	17,488	17,488	0	2,301	1,381	1,841	2,301	3,221	46,020	222,085	13,030	13,030	0	1,714	1,029	1,372	1,714	2,400	34,290
Figs	49,386	420	1,026	0	420	1,119	979	466	233	4,662	47,742	356	870	0	356	949	830	395	198	3,953
Grapes	91,366	8,274	35,854	0	30,338	3,677	8,274	2,758	2,758	91,932	94,675	9,518	41,243	0	34,898	4,230	9,518	3,173	3,173	105,752
Lemons & Limes	283,861	6,286	0	0	0	10,477	3,143	4,191	80,675	104,773	295,203	6,380	0	0	0	10,633	3,190	4,253	81,876	106,332
Lentils	13,157	0	621	0	150	246	0	0	54	1,071	12,927	0	548	0	132	217	0	0	47	945
Lettuce	240,705	3,791	5,687	0	23,126	758	758	2,275	1,516	37,911	225,893	3,212	4,818	0	19,594	642	642	1,927	1,285	32,122
Melons	188,612	1,060	2,862	0	2,226	3,498	106	0	848	10,600	216,913	1,469	3,965	0	3,084	4,846	147	0	1,175	14,685
Olives	19,330	20,466	9,096	0	5,685	23,877	11,370	26,151	17,055	113,699	20,975	23,850	10,600	0	6,625	27,825	13,250	30,475	19,875	132,499
Onions	282,781	12,669	34,386	0	36,196	2,715	1,810	1,810	905	90,490	316,444	13,818	37,506	0	39,480	2,961	1,974	974	98	98,699
Oranges	251,133	27,404	0	0	0	6,851	5,138	27,404	104,476	171,273	264,845	28,268	0	0	0	7,067	5,300	28,268	107,774	176,678
Peaches & Nectarines	119,436	1,720	11,609	0	9,889	3,870	7,309	7,739	860	42,997	132,753	2,085	14,072	0	11,987	4,691	8,860	9,381	1,042	52,119
Pears	125,855	2,041	1,361	0	3,855	907	2,721	11,566	227	22,679	131,288	2,211	1,474	0	4,176	983	2,948	12,528	246	24,564
Peas	52,627	1,480	4,863	0	1,269	1,057	211	529	1,163	10,573	58,616	1,842	6,053	0	1,579	1,316	263	658	1,448	13,159
Plums	117,540	1,709	3,702	0	4,272	1,424	5,981	11,107	285	28,480	119,497	1,938	4,199	0	4,845	1,615	6,783	12,597	323	32,300
Potatoes	252,295	122,002	85,853	0	230,449	4,519	4,519	4,519	0	451,860	260,751	141,552	99,611	0	267,376	5,243	5,243	5,243	0	524,266
Sesame seed	33,276	2	0	0	0	131	0	0	60	193	34,364	2	0	0	0	129	0	0	59	189
Spinach	170,391	2,587	708	0	901	39	39	235	3,919	196,147	2,822	86	0	0	983	43	43	257	4,276	
Tobacco	12,461	1,772	4,065	0	0	3,022	0	208	1,355	10,422	13,132	1,903	4,365	0	0	3,246	0	224	1,455	11,192
Tomatoes	674,922	58,520	71,524	0	52,018	32,511	55,269	26,009	29,260	325,110	585,154	50,726	61,998	0	45,090	28,181	47,908	22,545	25,363	281,810
Walnuts	16,142	457	695	0	318	119	238	99	60	1,986	17,717	521	793	0	363	136	272	113	68	2,266
Watermelons	397,433	2,230	40,876	0	7,432	20,810	0	0	2,973	74,320	435,088	2,004	36,732	0	6,679	18,700	0	0	2,671	66,786
Wheat	38,043	30,800	19,600	0	61,599	16,800	0	2,800	8,400	139,998	34,750	30,580	19,460	0	61,160	16,680	0	2,780	8,340	139,000

	2015										2016									
	Yield	Akkar	Baalbek-EI Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production	Yield	Akkar	Baalbek-EI Hermel	Beirut	Bekaa	El Nabatieh	Mount Lebanon	North	South	Total Production
Almonds	55,770	6,420	13,956	0	3,908	837	837	1,675	279	27,913	60,172	5,948	12,931	0	3,621	776	776	1,552	259	19,914
Apples	166,396	27,355	46,293	0	25,251	4,208	54,710	48,398	4,208	210,424	207,850	44,781	75,783	0	41,336	6,889	89,562	79,228	6,889	299,689
Apricots	73,928	332	29,249	0	665	332	332	2,327	0	33,238	92,884	398	35,025	0	796	398	398	2,786	0	39,403
Artichokes	74,110	76	303	0	124	27	11	0	0	541	39,203	76	303	0	124	27	11	0	0	465
Avocados	125,530	493	0	0	0	3,945	1,479	986	5,424	12,327	113,855	748	0	0	0	5,982	2,243	1,496	8,226	17,947
Bananas	361,155	0	0	0	0	0	5,159	0	80,832	85,991	472,737	0	0	0	0	0	6,580	0	103,094	109,675
Barley	26,895	2,226	30,052	0	2,597	1,484	0	371	371	37,102	31,653	2,927	39,520	0	3,415	1,952	0	488	488	45,863
Beans	29,054	2,296	1,276	0	2,551	255	935	765	425	8,504	39,470	3,064	1,702	0	3,404	340	1,248	1,021	567	8,284
Cabbages	393,603	10,171	5,888	0	25,694	1,071	3,212	2,677	4,818	53,530	341,153	7,927	4,590	0	20,027	834	2,503	2,086	3,755	33,796
Carobs	101,386	275	0	0	0	653	206	412	1,890	3,437	117,584	335	0	0	0	795	251	502	2,302	3,851
Cauliflowers	212,091	3,526	1,670	0	9,650	371	557	928	1,856	18,558	181,324	2,863	1,356	0	7,835	301	452	753	1,507	12,205
Cherries	52,086	269	17,510	0	7,004	269	1,078	808	0	26,939	65,932	324	21,081	0	8,432	324	1,297	973	0	32,108
Chickpeas	8,734	448	1,085	0	472	189	0	142	24	2,359	7,226	263	636	0	277	111	0	83	14	1,120
Cucumbers	372,499	16,590	52,323	0	20,419	8,933	10,209	11,486	7,657	127,618	262,197	12,786	40,324	0	15,736	6,885	7,868	8,852	5,901	85,565
Eggplants	222,085	13,030	13,030	0	1,714	1,029	1,372	1,714	2,400	34,290	164,885	8,747	8,747	0	1,151	691	921	1,151	1,611	14,271
Figs	47,742	356	870	0	356	949	830	395	198	3,953	46,250	190	464	0	190	506	443	211	105	1,919
Grapes	94,675	9,518	41,243	0	34,898	4,230	9,518	3,173	3,173	105,752	113,716	10,688	46,314	0	39,189	4,750	10,688	3,563	3,563	108,066
Lemons & Limes	295,203	6,380	0	0	0	10,633	3,190	4,253	81,876	106,332	327,504	6,944	0	0	0	11,574	3,472	4,630	89,120	108,796
Lentils	12,927	0	548	0	132	217	0	47	945	9,557	0	500	0	0	121	198	0	0	43	862
Lettuce	225,893	3,212	4,818	0	19,594	642	642	1,927	1,285	32,122	172,012	2,061	3,091	0	12,570	412	412	1,236	824	18,546
Melons	126,913	1,469	3,965	0	3,084	4,846	147	0	1,175	14,685	257,219	1,970	5,320	0	4,138	6,502	197	0	1,576	17,733
Olives	20,975	23,850	10,600	0	6,625	27,825	13,250	30,475	19,875	132,499	26,371	28,376	12,612	0	7,882	33,106	15,765	36,259	23,647	129,270
Onions	316,444	13,818	37,506	0	39,480	2,961	1,974	1,974	987	98,699	362,380	15,367	41,711	0	43,906	3,293	2,195	2,195	1,098	94,398
Oranges	264,845	28,268	0	0	0	7,067	5,300	28,268	107,774	176,678	335,663	30,215	0	0	0	7,554	5,665	30,215	115,195	158,629
Peaches & Nectarines	132,753	2,085	14,072	0	11,987	4,691	8,860	9,381	1,042	52,119	149,697	2,533	17,101	0	14,567	5,700	10,767	11,401	1,267	60,803
Pears	131,288	2,211	1,474	0	4,176	983	2,948	12,528	246	24,564	143,378	2,578	1,719	0	4,870	1,146	3,438	14,610	286	26,069
Peas	58,616	1,842	6,053	0	1,579	1,316	263	658	1,448	13,159	71,123	2,687	8,830	0	2,304	1,920	384	960	2,112	16,509
Plums	119,497	1,938	4,199	0	4,845	1,615	6,783	12,597	323	32,300	131,323	2,531	5,484	0	6,327	2,109	8,858	16,451	422	39,650
Potatoes	260,751	141,552	99,611	0	267,376	5,243	5,243	5,243	0	524,266	285,948	170,633	120,075	0	322,307	6,320	6,320	6,320	0	461,341
Sesame seed	34,364	2	0	0	0	129	0	59	189	34,182	2	0	0	0	0	128	0	0	58	186
Spinach	196,147	2,822	86	0	983	43	43	43	257	4,276	230,877	1,737	53	0	605	26	26	26	158	895
Tobacco	13,132	1,903	4,365	0	0	3,246	0	224	1,455	11,192	14,387	2,090	4,795	0	0	3,566	0	246	1,598	10,205
Tomatoes	585,154	50,726	61,998	0	45,090	28,181	47,908	22,545	25,363	281,810	465,928	44,978	54,973	0	39,980	24,988	42,479	19,990	22,488	204,899
Walnuts	17,717	521	793	0	363	136	272	113	68	2,266	21,744	640	973	0	445	167	334	139	83	2,141
Watermelons	435,088	2,004	36,732	0	6,679	18,700	0	0	2,671	66,786	530,815	1,758	32,231	0	5,860	16,409	0	0	2,344	56,844
Wheat	34,750	30,580	19,460	0	61,160	16,680	0	2,780	8,340	139,000	31,490	28,388	18,065	0	56,776	15,484	0	2,581	7,742	100,649

Table 31 - Production by Governorate in tons, 2015 – 2016

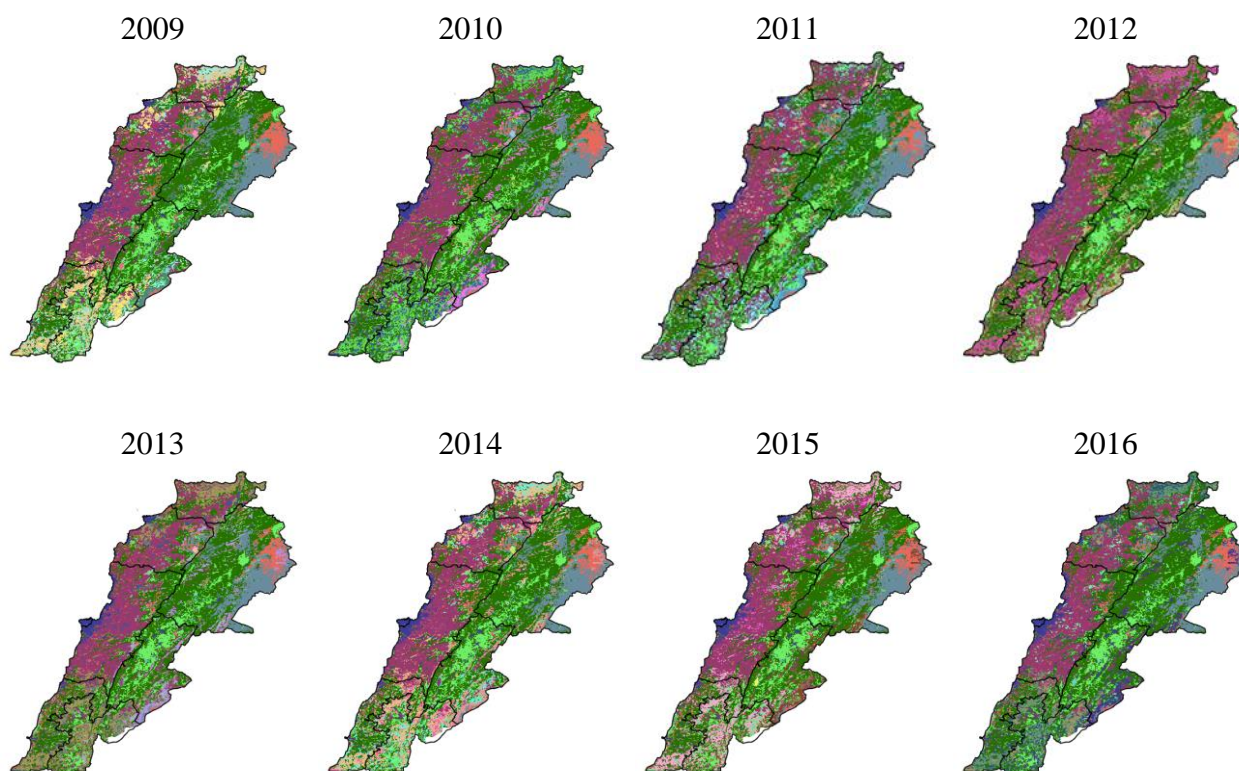


Figure 23 - ESA Land Cover Maps, 2009 –2016



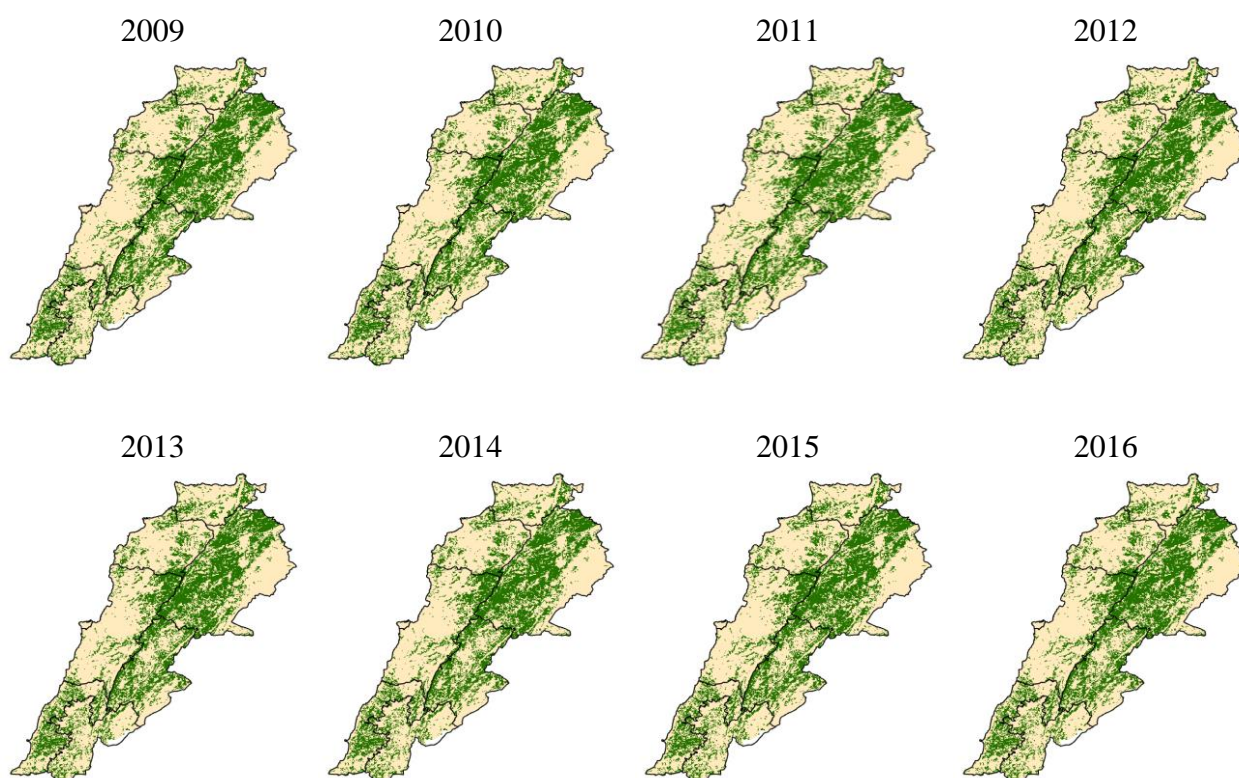


Figure 24 - Cropland Rainfed Maps, 2009 – 2016

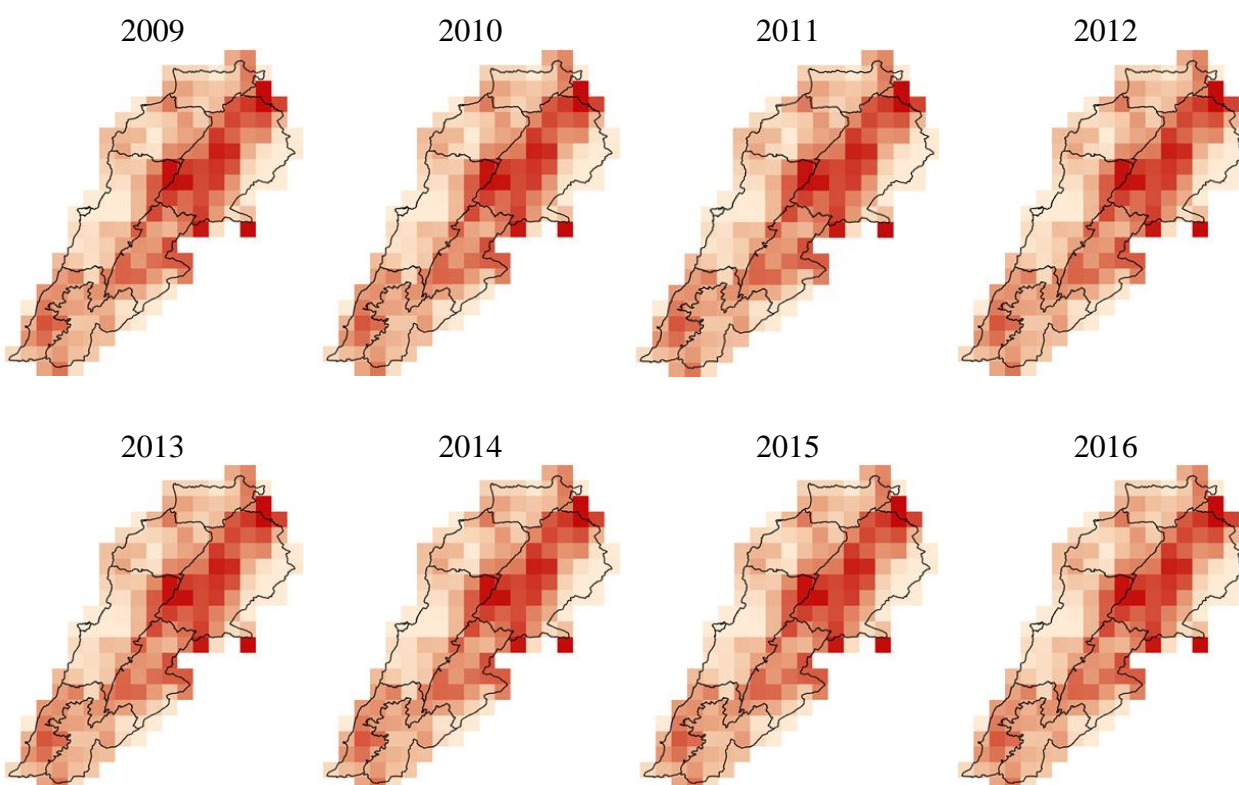


Figure 25 - Aggregate Cropland Rainfed Maps, 2009 – 2016

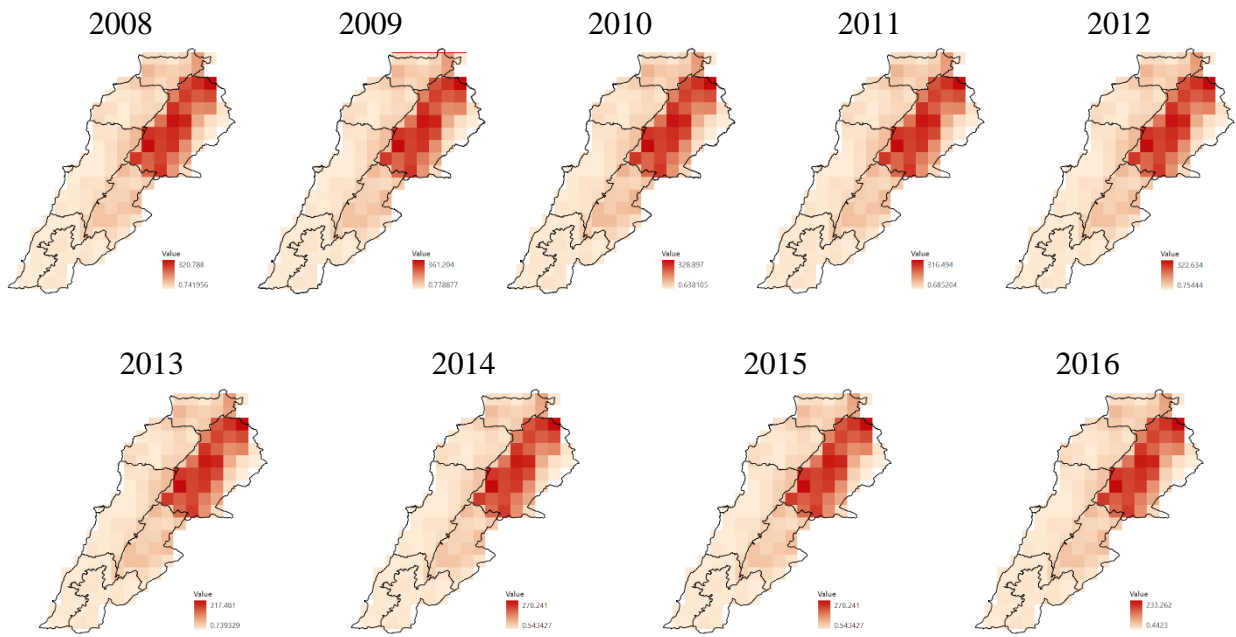


Figure 26 - Almonds' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

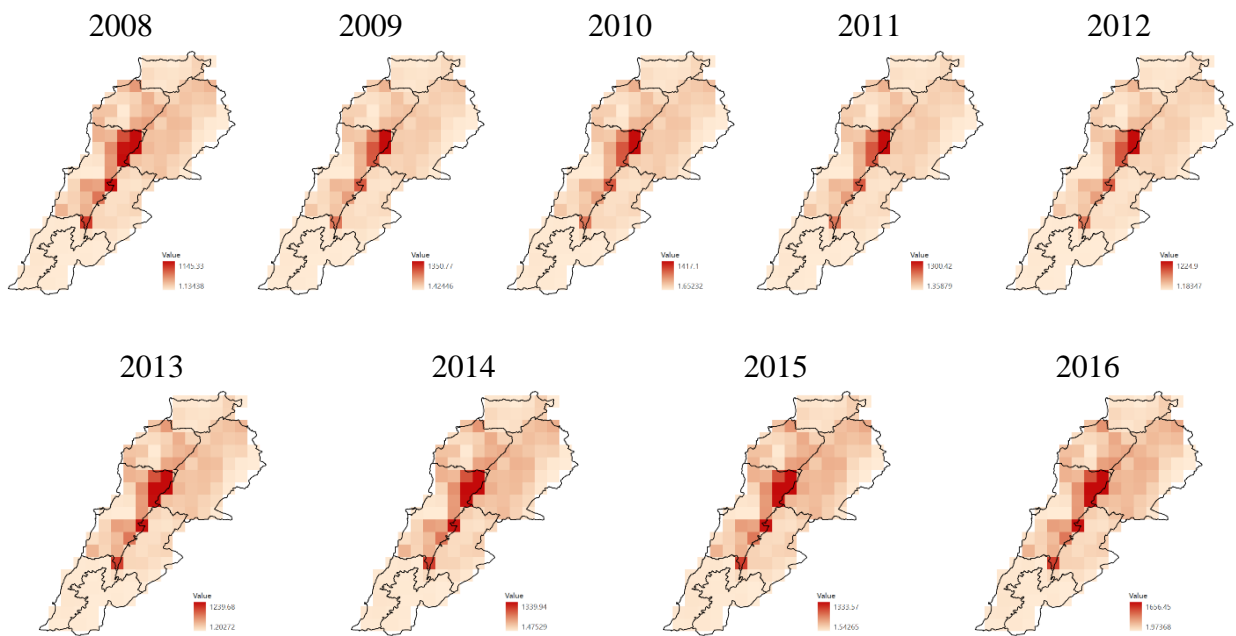


Figure 27 – Apples' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

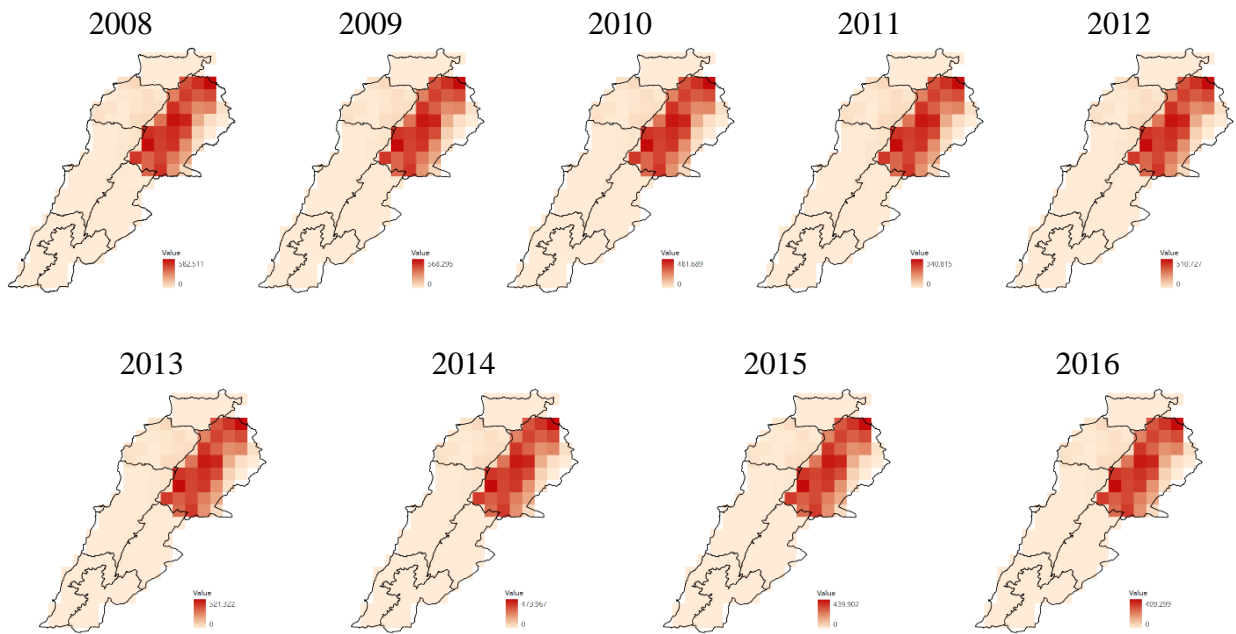


Figure 28 – Apricots' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

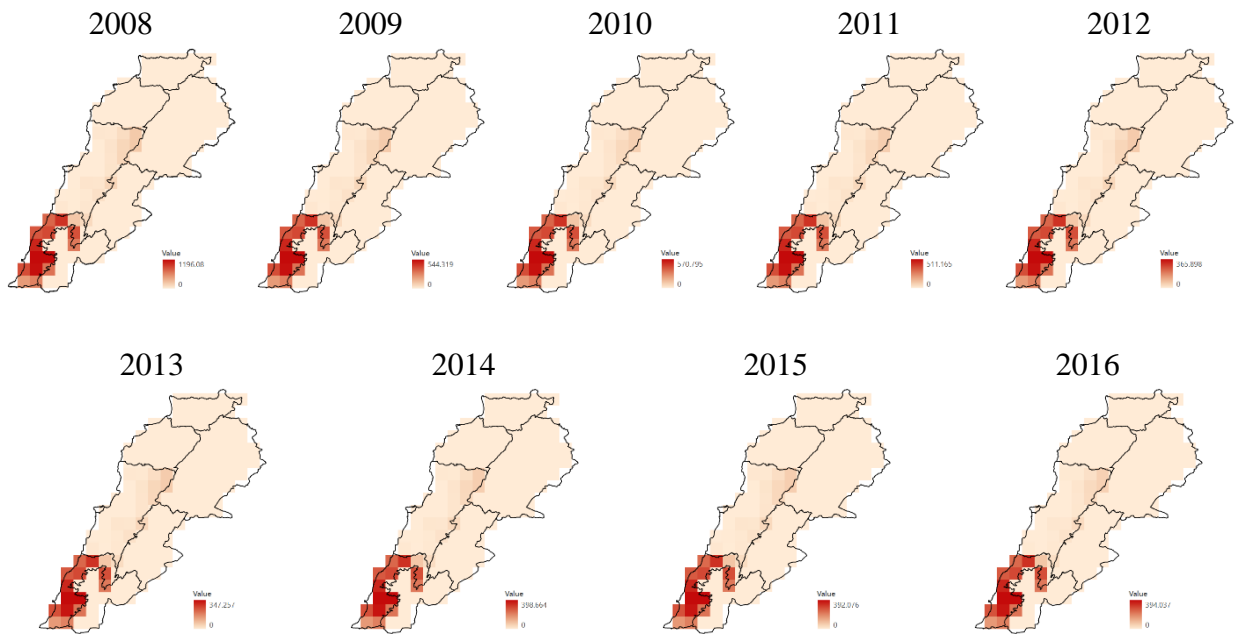


Figure 29 – Bananas' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

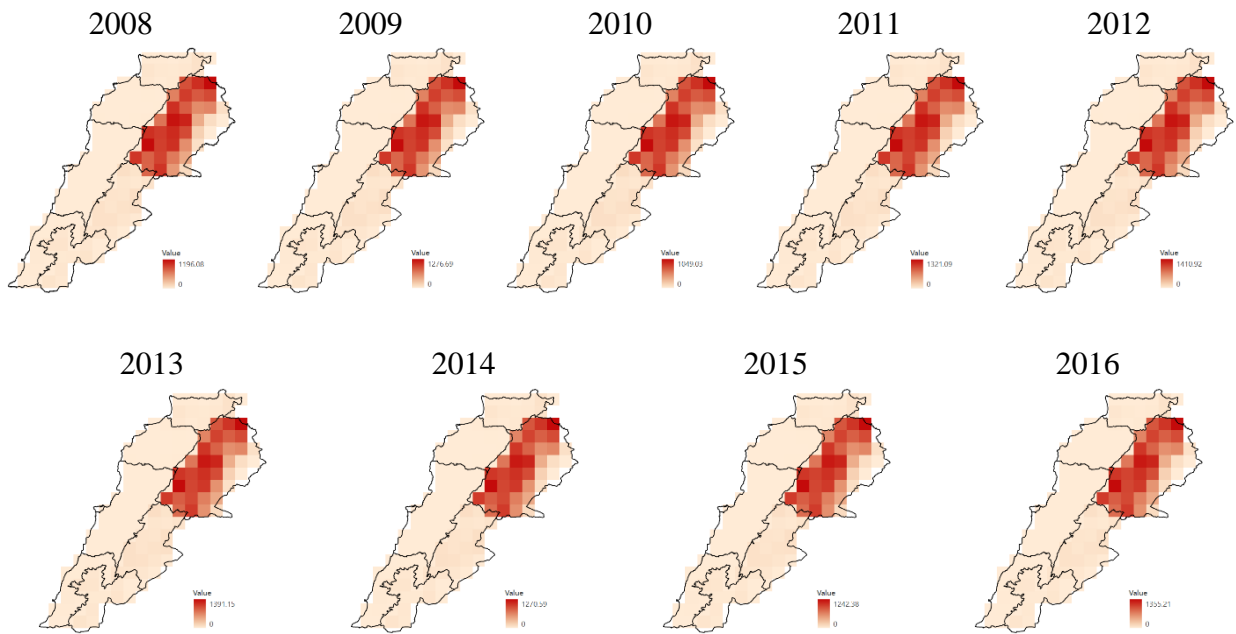


Figure 30 - Barley's Area Harvested in Hectares per Pixel Maps, 2008 – 2016

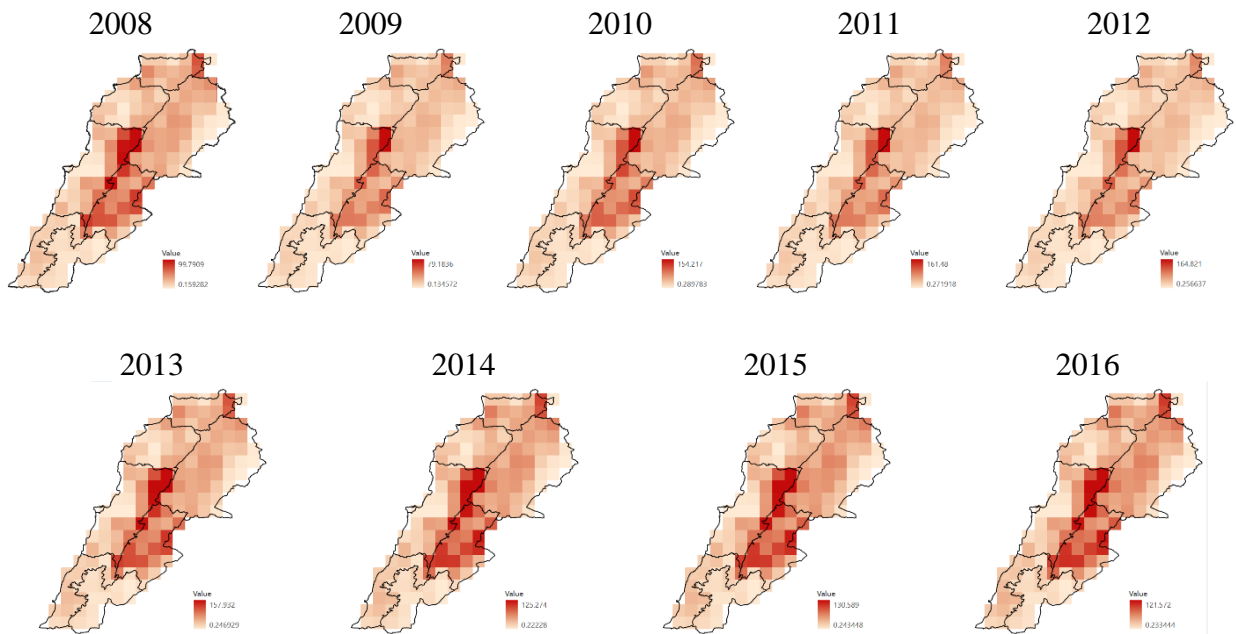


Figure 31 – Beans' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

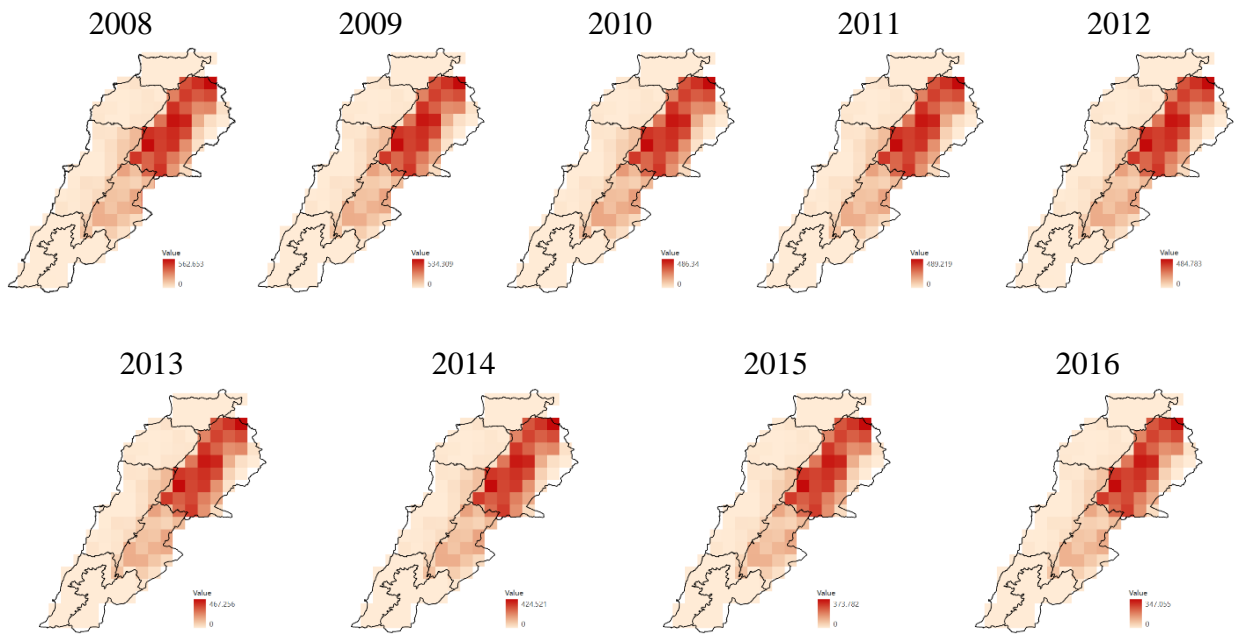


Figure 32 – Cherries' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

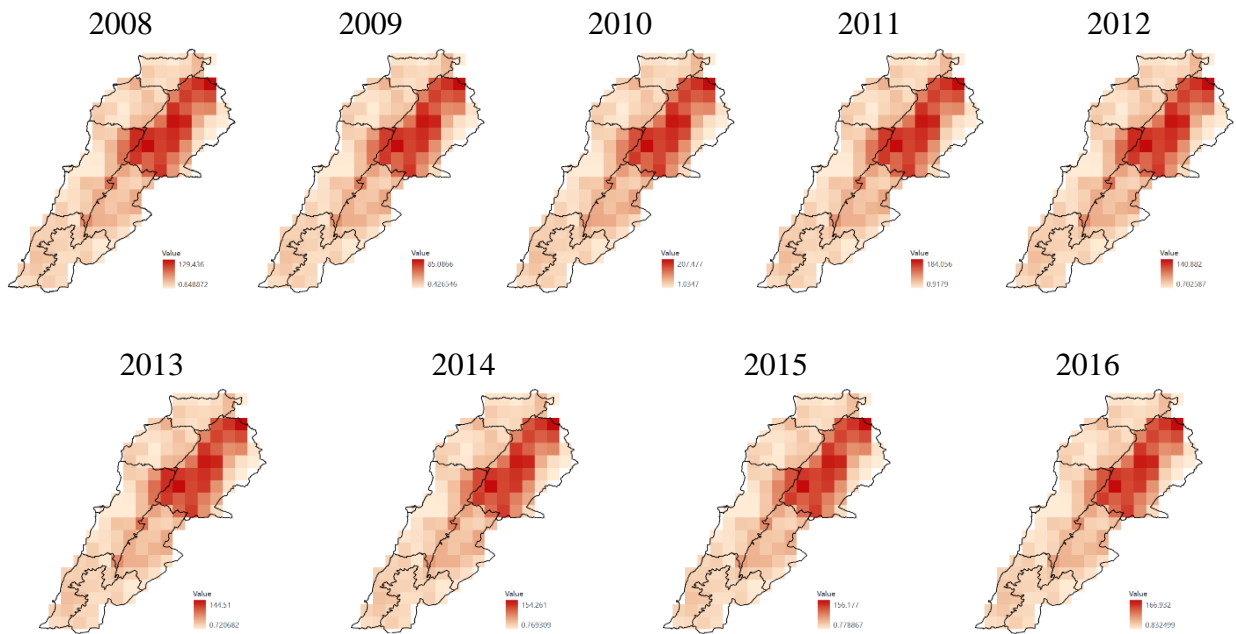


Figure 33 – Cucumbers' Area Harvested in Hectares per Pixel Maps, 2008 – 2016



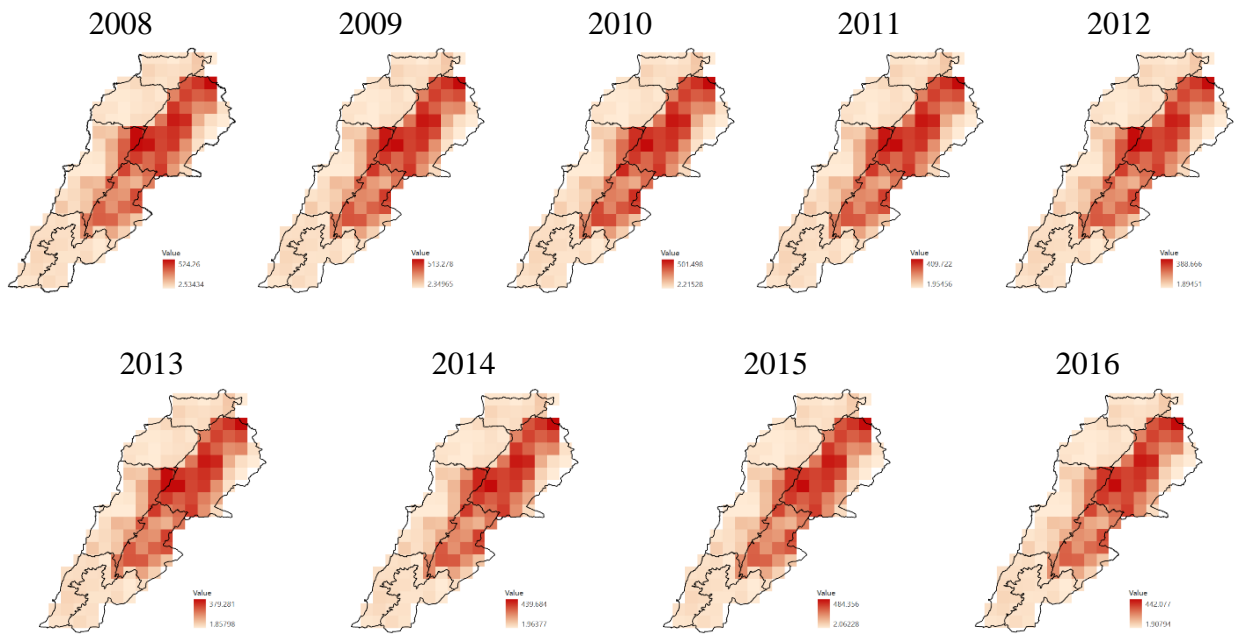


Figure 34 - Grapes' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

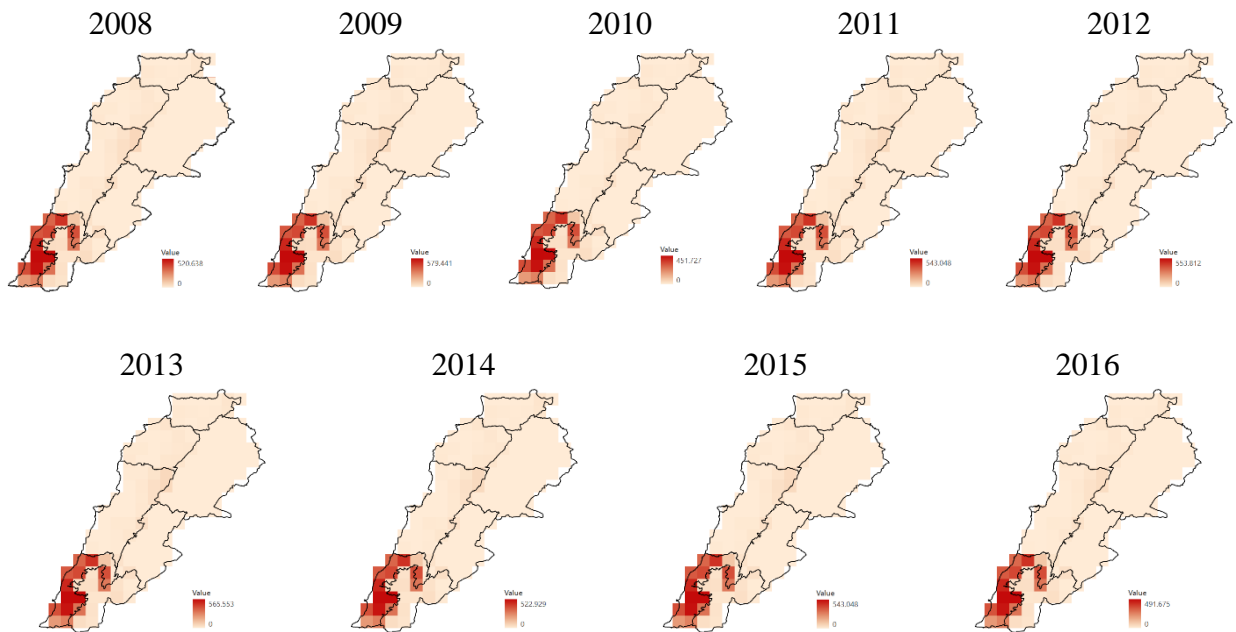


Figure 35 – Lemons' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

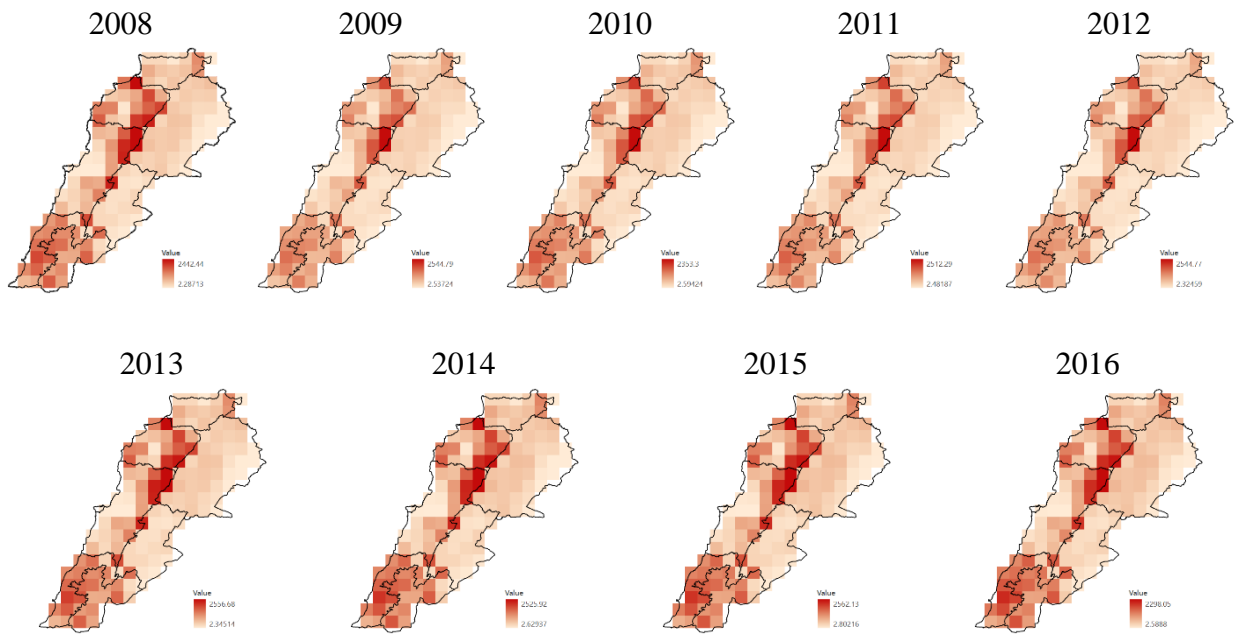


Figure 36 – Olives' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

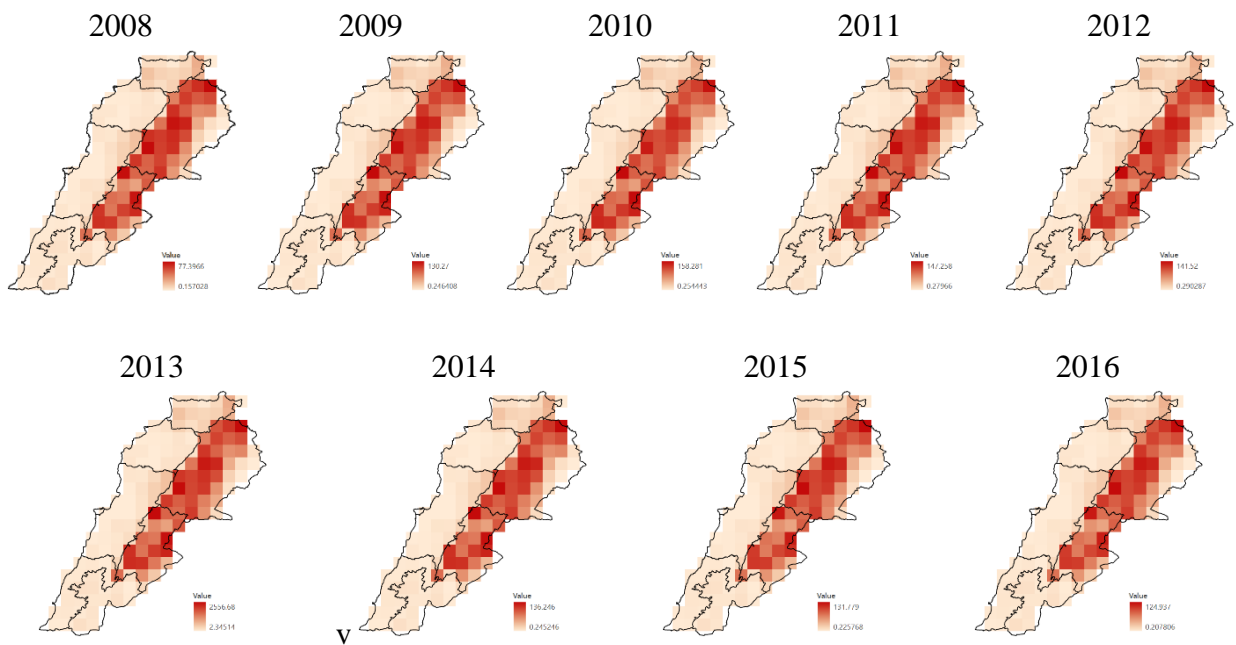


Figure 37 – Onions' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

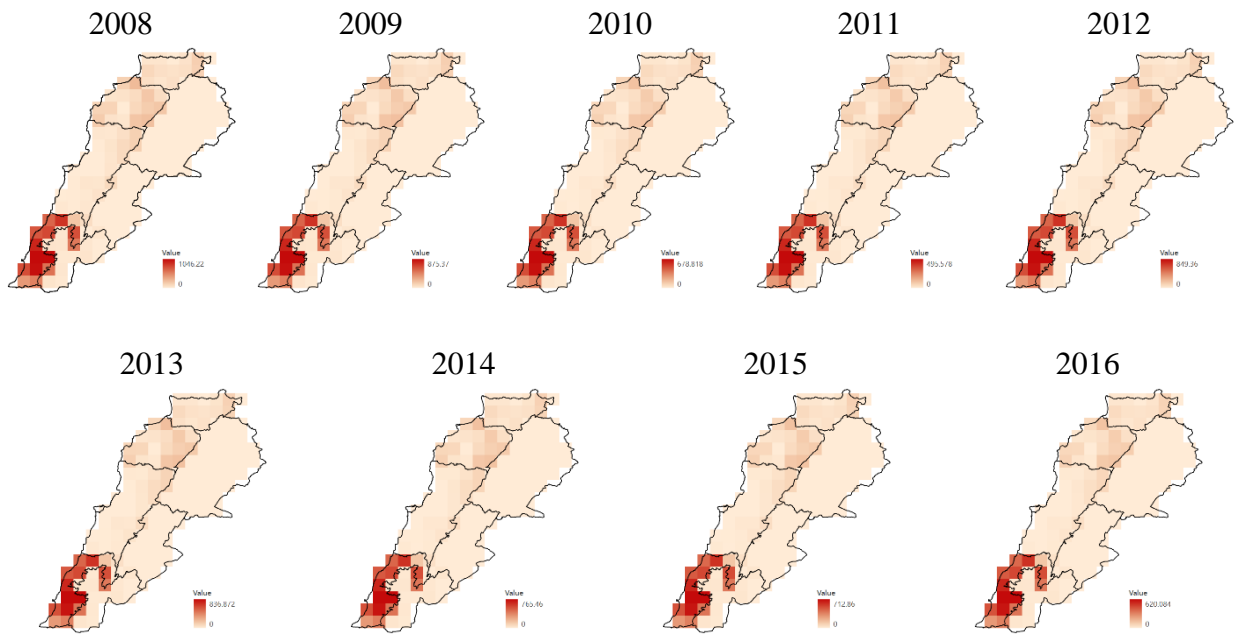


Figure 38 – Oranges' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

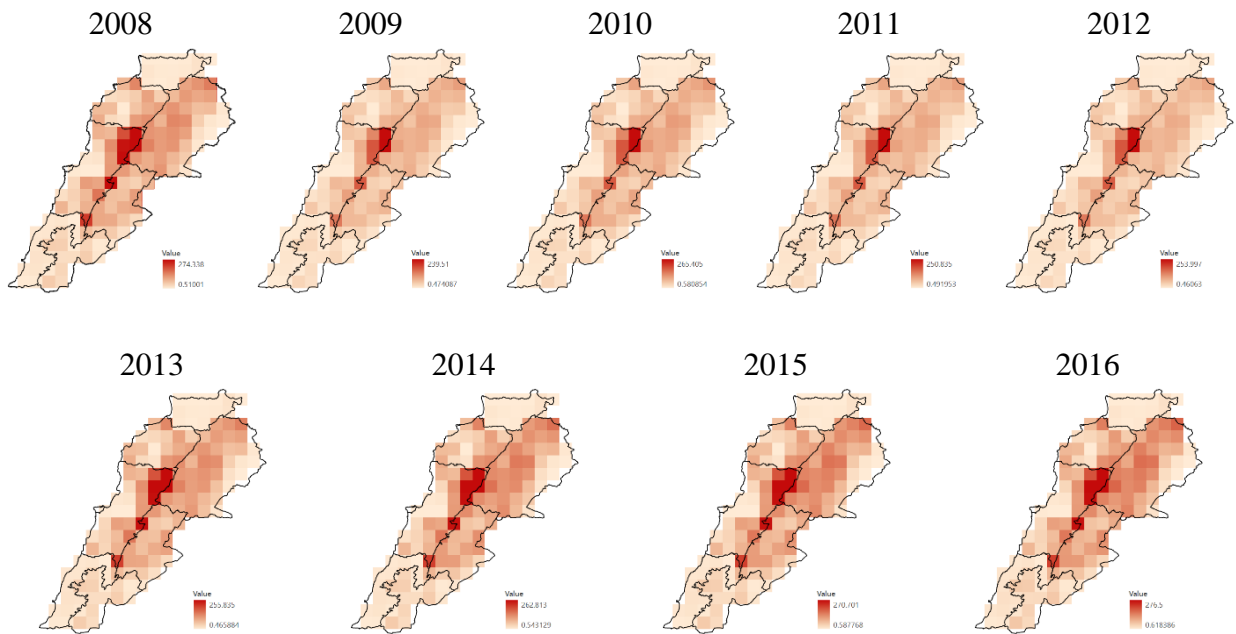


Figure 39 – Peaches' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

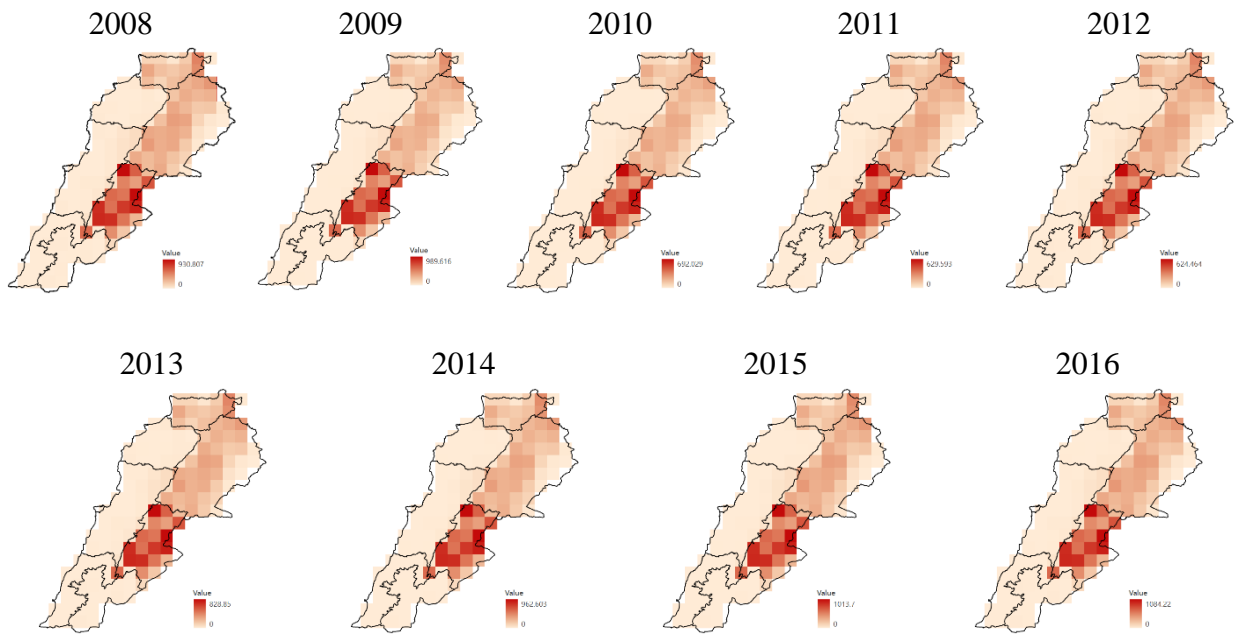


Figure 40 – Potatoes' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

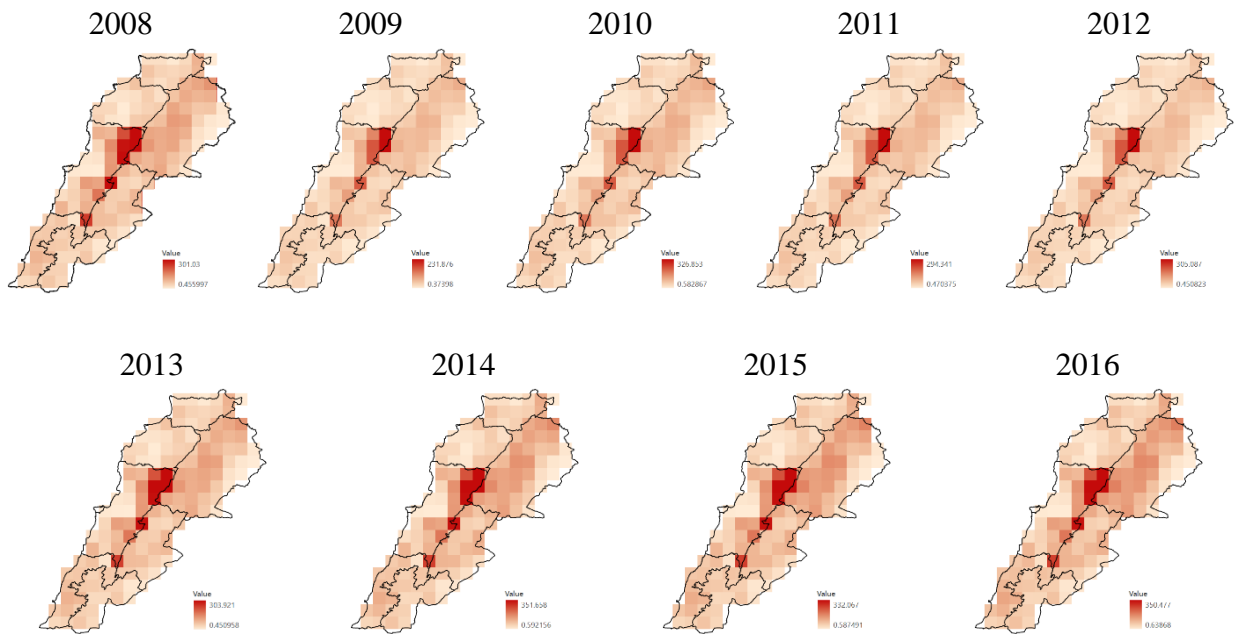


Figure 41 – Tomatoes' Area Harvested in Hectares per Pixel Maps, 2008 – 2016

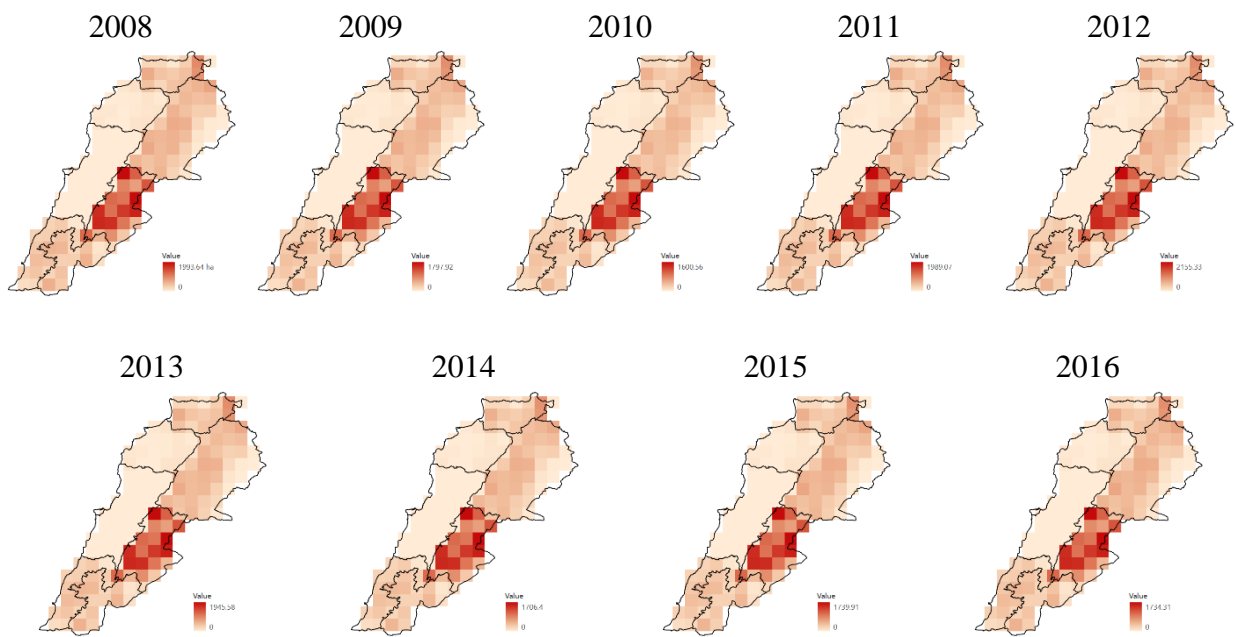


Figure 42 – Wheat's Area Harvested in Hectares per Pixel Maps, 2008 – 2016

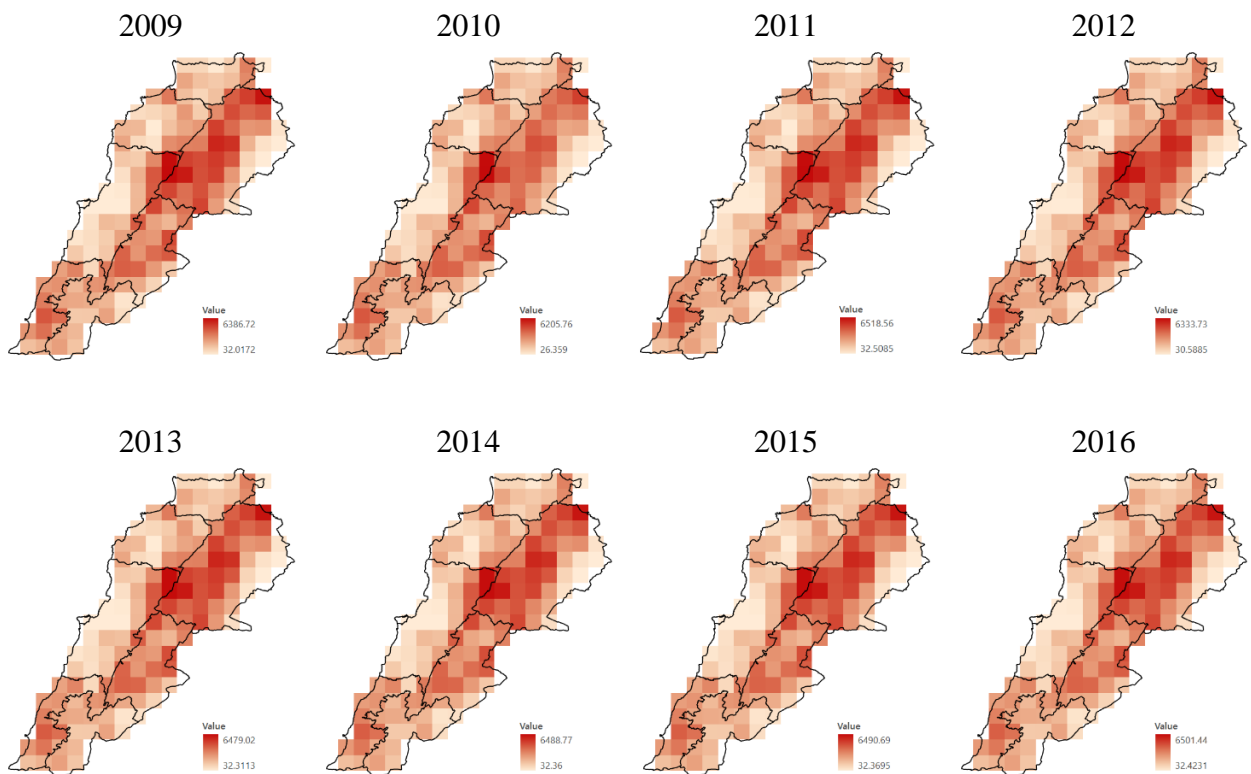


Figure 43 - Total Area Harvested in Hectares per Pixel Maps, 2009 – 2016

```

Lebanon=Tiff('Almonds_Pixel.tif','r');
Lebanon_data=read(Lebanon);
imshow(Lebanon_data);
[aa,ab]=find(Lebanon_data>0.01);
POS=1;
for i=1 :size(aa,1)
    IMDLEB(POS,1)=POS;
    IMDLEB(POS,2)=1;
    IMDLEB(POS,3)=1;
    IMDLEB(POS,4)=1;
    IMDLEB(POS,5)=0;
    IMDLEB(POS,6)=0;
    IMDLEB(POS,7)=aa(i)+663;
    IMDLEB(POS,8)=ab(i)+2581;
    IMDLEB(POS,9)=1;
    IMDLEB(POS,10)=POS;
    IMDLEB(POS,11)=Lebanon_data(aa(i),ab(i));
    POS=POS+1;
end
Lebanon2=Tiff('Apple_Pixel.tif','r');
Lebanon_data2=read(Lebanon2);
imshow(Lebanon_data2);
[bb,cd]=find(Lebanon_data2>0.01);
POS=2;
for i=2:size(bb,1)
    IMDLEB(POS,1)=POS;
    IMDLEB(POS,2)=2;
    IMDLEB(POS,3)=1;
    IMDLEB(POS,4)=1;
    IMDLEB(POS,5)=0;
    IMDLEB(POS,6)=0;
    IMDLEB(POS,7)=bb(i)+663;
    IMDLEB(POS,8)=cd(i)+2581;
    IMDLEB(POS,9)=1;
    IMDLEB(POS,10)=POS;
    IMDLEB(POS,11)=Lebanon_data2(bb(i),cd(i));
    POS=POS+2;
end
Lebanon18=Tiff('Wheat_Pixel.tif','r');
Lebanon_data18=read(Lebanon18);
imshow(Lebanon_data18);
[rr,rs]=find(Lebanon_data18>0.01);
POS=18;
for i=18:size(rr,1)
    IMDLEB(POS,1)=POS;
    IMDLEB(POS,2)=18;
    IMDLEB(POS,3)=1;
    IMDLEB(POS,4)=1;
    IMDLEB(POS,5)=0;
    IMDLEB(POS,6)=0;
    IMDLEB(POS,7)=rr(i)+663;
    IMDLEB(POS,8)=rs(i)+2581;
    IMDLEB(POS,9)=1;
    IMDLEB(POS,10)=POS;
    IMDLEB(POS,11)=Lebanon_data18(rr(i),rs(i));
    POS=POS+18;
end

```

Figure 44 - Snippet of the MATLAB Code

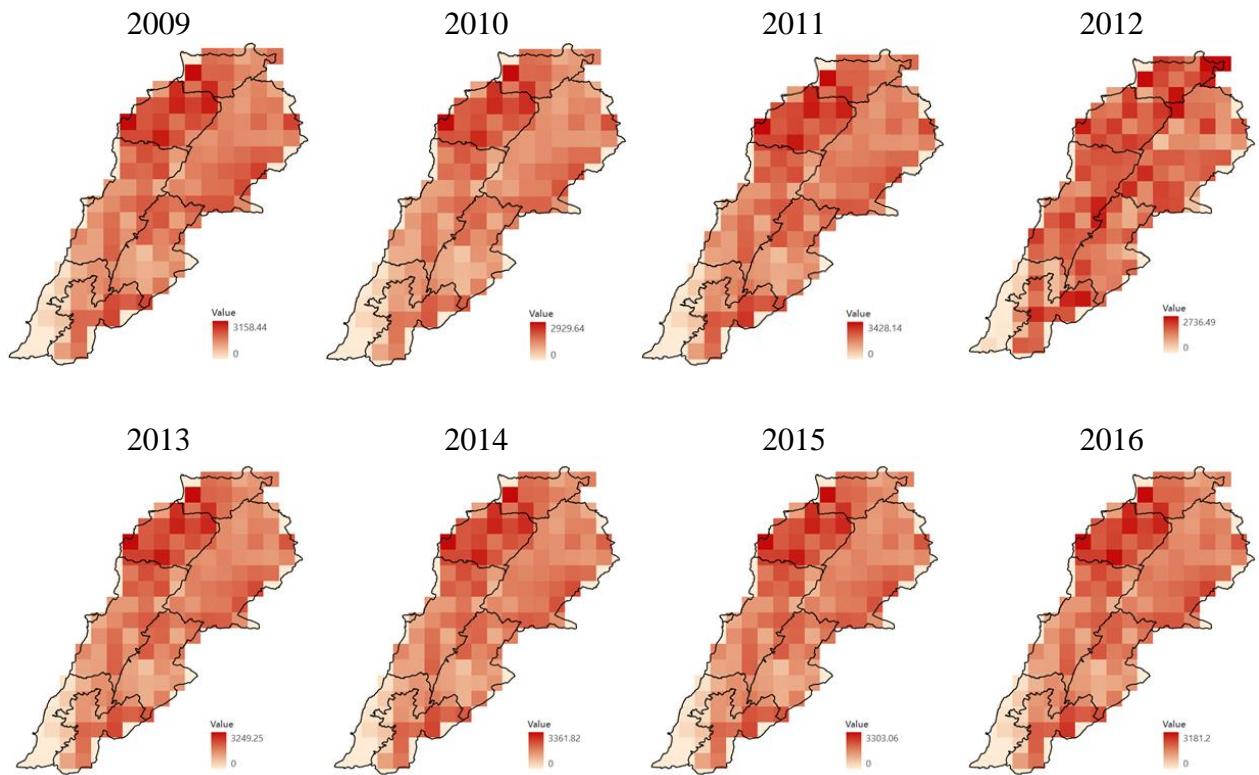


Figure 45 - Total Water Required in Km<sup>3</sup> per Pixel Maps, 2009 – 2016

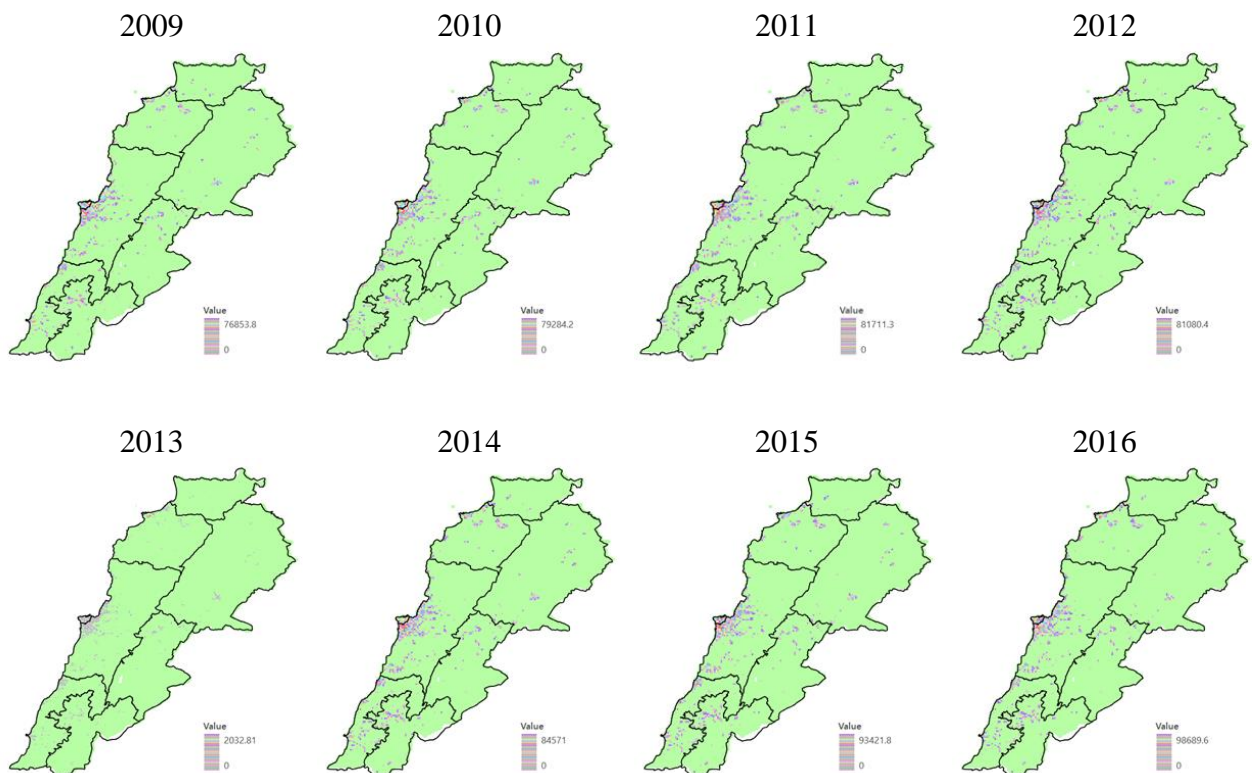


Figure 46 - Lebanon's Population Count Maps, 2009 – 2016



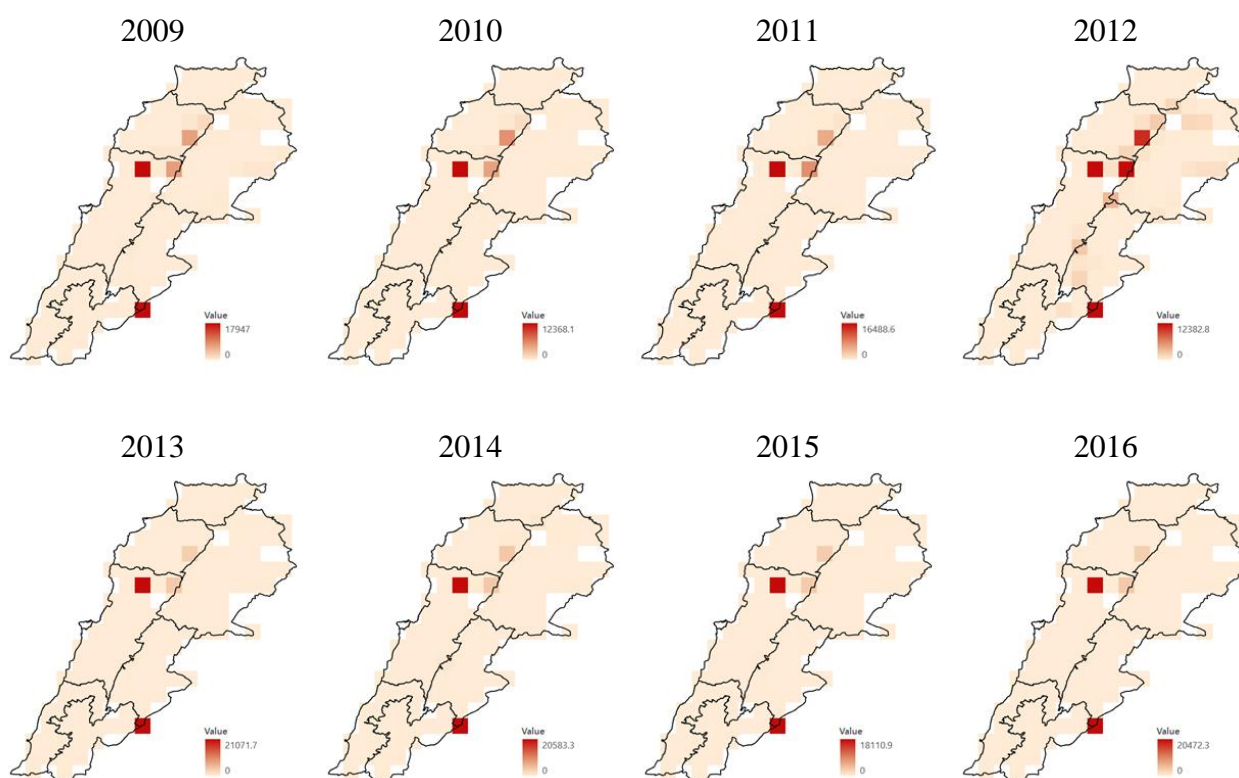


Figure 47 - Water Availability Maps, 2009 – 2016

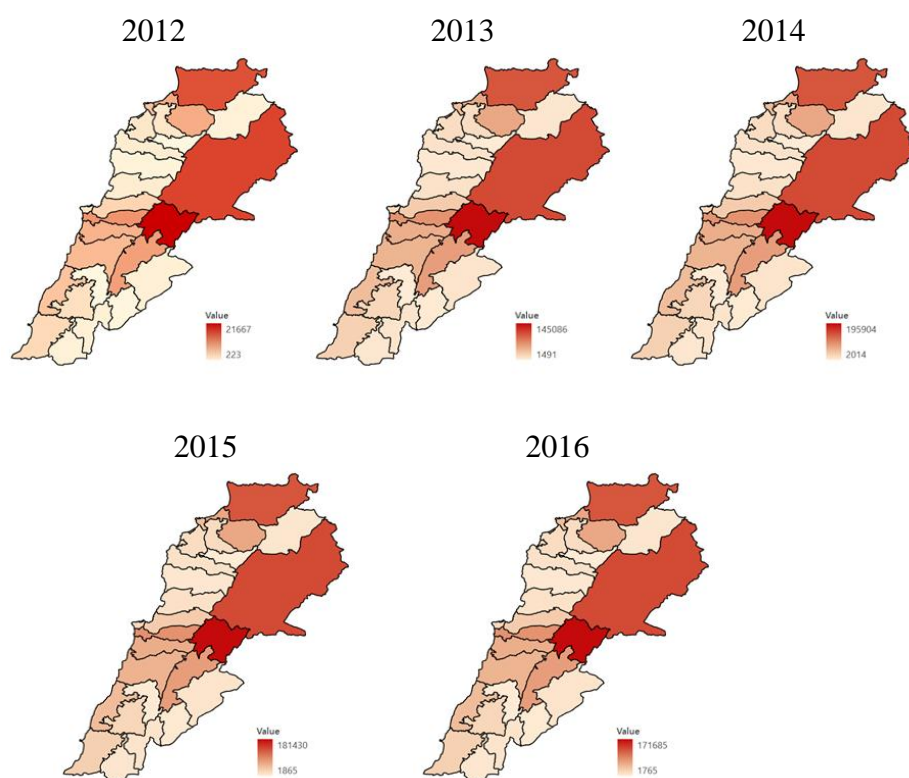


Figure 48 - Spatial Distribution of the Syrian Refugees by District Maps, 2012 – 2016



	(kcal/g)	Supply (kcal/capita/day)									Demand (kcal/capita/day)
		2008	2009	2010	2011	2012	2013	2014	2015	2016	
Almonds	6.070	107.53	121.52	91.62	84.72	92.71	99.29	96.60	92.36	74.08	183
Apples	0.570	21.70	24.58	23.88	22.68	11.14	17.45	39.36	44.33	78.59	53
Apricots	2.500	44.29	39.82	27.74	16.63	26.72	29.97	37.57	39.88	45.83	100
Bananas	1.809	32.30	43.62	46.94	35.52	22.23	10.96	49.00	60.36	67.23	36
Barley	3.540	178.97	201.37	183.84	210.93	178.51	202.85	203.01	213.34	349.16	159
Beans	0.850	11.98	11.46	16.57	14.74	14.71	14.85	13.07	10.45	8.28	111
Cherries	0.640	10.07	10.48	7.36	6.29	6.96	7.01	7.87	7.96	8.75	90
Cucumbers	0.130	10.30	6.86	14.59	12.70	9.84	10.46	9.71	8.60	6.29	21
Grapes	2.002	110.14	94.67	82.18	66.38	65.31	63.32	73.98	89.44	95.95	243
Lemons and limes	0.300	13.04	15.28	9.19	10.59	13.84	14.51	14.20	14.77	16.44	64
Olives	1.670	81.62	75.10	73.90	77.48	62.15	99.35	103.60	111.62	126.41	25
Onions	0.323	8.37	14.33	15.99	14.43	14.58	12.83	13.30	17.09	19.78	28
Oranges	2.498	202.50	104.97	51.84	6.42	120.98	166.14	164.10	193.37	193.44	50
Peaches and nectarines	0.556	9.04	6.73	5.70	4.90	5.75	5.04	10.88	12.59	15.31	83
Potatoes	1.285	336.33	303.85	191.29	173.48	163.33	203.29	210.21	290.55	358.81	143
Tomatoes	0.210	38.33	25.23	33.87	33.19	32.69	34.66	38.32	31.51	25.68	34
Wheat	5.219	1,599.31	1,888.25	1,603.49	1,551.46	1,792.39	2,092.66	2,060.00	1,879.80	1,632.25	934

Table 32 - Supply and Demand in Optimum Conditions in kcal/capita/day

	Surplus or Shortage (kcal/capita/day)								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Almonds	-75.66	-61.66	-91.57	-98.46	-90.48	-83.89	-86.58	-90.83	-109.11
Apples	-31.50	-28.62	-29.32	-30.52	-42.06	-35.75	-13.84	-8.87	25.39
Apricots	-55.71	-60.18	-72.26	-83.37	-73.28	-70.03	-62.43	-60.12	-54.17
Bananas	-3.87	7.44	10.77	-0.65	-13.95	-25.21	12.83	24.19	31.06
Barley	19.67	42.07	24.54	51.63	19.21	43.55	43.71	54.04	189.86
Beans	-98.52	-99.04	-93.93	-95.76	-95.79	-95.65	-97.43	-100.05	-102.22
Cherries	-79.53	-79.12	-82.24	-83.31	-82.64	-82.59	-81.73	-81.64	-80.85
Cucumbers	-10.24	-13.68	-5.95	-7.84	-10.70	-10.08	-10.83	-11.94	-14.25
Grapes	-133.10	-148.58	-161.06	-176.86	-177.94	-179.92	-169.26	-153.80	-147.30
Lemons and limes	-50.56	-48.32	-54.41	-53.01	-49.76	-49.09	-49.40	-48.83	-47.16
Olives	56.57	50.05	48.85	52.43	37.10	74.30	78.55	86.57	101.36
Onions	-19.21	-13.25	-11.59	-13.15	-13.00	-14.75	-14.27	-10.49	-7.79
Oranges	152.55	55.02	1.89	-43.53	71.03	116.19	114.15	143.42	143.49
Peaches and nectarines	-74.29	-76.60	-77.63	-78.44	-77.58	-78.29	-72.45	-70.75	-68.03
Potatoes	193.09	160.60	48.04	30.24	20.08	60.05	66.96	147.31	215.56
Tomatoes	3.89	-9.21	-0.57	-1.25	-1.75	0.22	3.88	-2.93	-8.76
Wheat	665.13	954.07	669.31	617.28	858.21	1158.48	1125.82	945.62	698.07

Table 33 - Net Production vs Demand in Optimum Conditions in kcal/capita/day

## Emails with MoA

### Inquiry about Lebanon's Agriculture

Inbox x



**Noura Sakr** <noura.sakr@gmail.com>  
to info

Tue, Feb 22, 1:01 PM



Dear Sirs,

I am a Lebanese student in Politecnico di Milano, currently writing my thesis on the Syrian refugees' impact on Lebanon's food security.

I would like to ask you if you have the yield (in tons per hectare) of the crops, mentioned below, harvested in Lebanon from 2008 until 2016. If possible, also per governorate, and in geotiff format.

I already found the Comprehensive Agricultural Statistics report done in 2010 and I have been using it along with data from FAOSTAT, but I wanted to ask if the ministry of agriculture might have more local data.

The crops needed: Almonds, Apples, Apricots, Bananas, Barley, Beans, Cherries, Cucumbers, Grapes, Lemons and limes, Olives, Onions, Oranges, Peaches and nectarines, Potatoes, Tomatoes, Wheat.

I would appreciate your reply whether you have the data or not.

Thank you in advance.

Noura Sakr

### Inquiry about Lebanon's Agriculture

Inbox x



**Noura Sakr**

Thu, Feb 24, 5:24 PM



Dear Sirs, I am a Lebanese student in Politecnico di Milano, currently writing my thesis on the Syrian refugees' impact on Lebanon's food secur...



**Mail Delivery Subsystem**

Fri, Feb 25, 7:08 PM



Delivery incomplete There was a temporary problem delivering your message to [info@agriculture.gov.lb](mailto:info@agriculture.gov.lb). Gmail will retry for 46 more hours. Yo...



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## Inquiry about Lebanon's Agriculture

Inbox x



**Noura Sakr** <noura.sakr@gmail.com>  
to selabiad2021@gmail.com

Thu, Feb 24, 5:24 PM



Dear Mrs. El Abiad,

I am a Lebanese student in Politecnico di Milano, currently writing my thesis on the Syrian refugees' impact on Lebanon's food security.

I would like to ask you if you have the yield (in tons per hectare) of the crops, mentioned below, harvested in Lebanon from 2008 until 2016. If possible, also per governorate, and in geotiff format.

I already found the Comprehensive Agricultural Statistics report done in 2010 and I have been using it along with data from FAOSTAT, but I wanted to ask if the ministry of agriculture might have more local data.

The crops needed: Almonds, Apples, Apricots, Bananas, Barley, Beans, Cherries, Cucumbers, Grapes, Lemons and limes, Olives, Onions, Oranges, Peaches and nectarines, Potatoes, Tomatoes, Wheat.

I would appreciate your reply whether you have the data or not.

Thank you in advance.  
Noura Sakr



**Sonia El Abiad**  
to me

Sun, Mar 13, 8:47 PM (2 days ago)



Dear Noura

for the statics and number we are using these days , it is the Comprehensive statistical census that you are using dated 2010 , it is the latest one done in lebanon and find the link <http://www.agriculture.gov.lb/Statistics-and-Studies/Comprehensive-Agricultural-Statistics/statistics-2010>

best regards  
Sonia

## Inquiry

Inbox x



**Noura Sakr**

Mon, Mar 7, 12:38 PM (8 days ago)



Dear Sirs, I am a Lebanese student in Politecnico di Milano, currently writing my thesis on the Syrian refugees' impact on Lebanon's food secur...



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Tue, Mar 8, 2:01 PM (7 days ago)



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Wed, Mar 9, 2:08 PM (6 days ago)



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Thu, Mar 10, 2:49 PM (5 days ago)



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