

Climate Change and Environment in the Arab World Program

Impact of Population Growth and Climate Change on Water Scarcity, Agricultural Output and Food Security

Issam Fares Institute for Public Policy and International Affairs
American University of Beirut

Climate Change and Environment in the Arab World Program

Research Study Report | April 2014

Impact of Population Growth and Climate Change on Water Scarcity, Agricultural Output and Food Security

The Climate Change and Environment in the Arab world Program aims to understand the climate change and environment policy process in the region and define the most appropriate policy recommendations by linking development in applied sciences on issues related to climate change and environment to social sciences.

Rami G. Khouri *IFI Director*
Nasser Yassin *IFI Research Director*
Nadim Farajallah *Program Research Director*
Rana El Hajj *Program Coordinator*
Rabih Mahmassani *Communications Manager*
Donna Rajeh *Designer*

THE EARTH INSTITUTE
COLUMBIA UNIVERSITY

COLUMBIA UNIVERSITY
MIDDLE EAST RESEARCH CENTER

USAID | MIDDLE EAST
FROM THE AMERICAN PEOPLE

fhi360
THE SCIENCE OF IMPROVING LIVES



Published by the Issam Fares Institute for Public Policy and International Affairs, American University of Beirut.

This report can be obtained from the Issam Fares Institute for Public Policy and International Affairs office at the American University of Beirut or can be downloaded from the following website: www.aub.edu.lb/ifi

The views expressed in this document are solely those of the author, and do not reflect the views of the Issam Fares Institute for Public Policy and International Affairs or the American University of Beirut.

Beirut, April 2014

© all rights reserved

Acknowledgements

We would like to express our special appreciation and thanks to the research project team. This report was prepared by Columbia University Middle East Research Center, Earth Institute at Columbia University, the American University of Beirut, and the American University in Cairo. The following are the research team members:

FHI 360 – Regional Partnership on Culture and Development

Matthew Pietz
Mariam Hanna
Dalia Abulfotuh

Columbia University Middle East Research Center - Institute for Sustainable Development Practices

Mohammad Alamoush
Nasma Barghouthi

Columbia University's Earth Institute - Center on Globalization and Sustainable Development

Kye Baroang

American University of Beirut – Issam Fares Institute for Public Policy and International Affairs

Dr. Nadim Farajalla
Charbel Abou Haidar
Elias Chnais
Nadine Modad
Patricia Haydamous

American University in Cairo – Research Institute for Sustainable Environment

Dr. Richard Tutwiler
Dr. Tina Jaskolski
Hagar El Didi
Cindy Youssef
Yara Moustafa
Shaymaa Hassan
Colleen Devlin
Yumna Kassim.
Eng. Hassan Hussein

Executive Summary

The Middle East and North Africa (MENA) region is no exception to the increasing distress facing water resources around the world, especially as a consequence of climate change and population growth. With less available water, the agriculture sector faces challenges in providing a greater output to meet the increase in population.

The MENA region consists of different climatic zones, irrespective of the closeness of the countries in terms of distance, which emphasizes the importance of varying the input conditions given under the same initial changes in climate and population, when addressing the region.

Accordingly, “The Impacts of Population Growth and Climate Change on Water Scarcity, Agricultural Output and Food Security” research project explored the changes in water availability and agriculture production as a result of the changes in climate change and population growth in chosen areas in Egypt and Lebanon.

The research is based on a comparative study across different areas in one country, and across the two countries. In order to account for the different initial conditions, the methodology of the study had to take a wider angle to set a baseline dataset for further analysis. The research methodology involved a literature and background review, focus groups/expert consultations, and case studies.

The research report, which provides key findings, analysis and recommendations, was produced with equal efforts by the following regional academic institutions: the AUC Desert Development Center from Egypt, the Columbia University Middle East Research Center (CUMERC) through the Institute for Sustainable Development Practice (ISDP) in Amman, and the Faculty of Agriculture and Food Science with the Climate Change and Environment Program in the Arab World from IFI at AUB. A summary of the case studies and a cross-case study analysis is provided to illustrate the similarities and differences between the chosen sites.

The background study showed that Egypt and Lebanon are both facing challenges in supplying enough food and water for their citizens, especially under the changes in climate and population size. In spite of the differences in population growth and climatic properties of the two countries, each country has tangible food and water insecurities, tied with impacts of climate change in terms of dryness, higher temperatures, and sea level rise.

Different areas in both countries were chosen in such a way as to diversify the input factors of the study such as location, irrigation practices, population size, and climatic zones.

In Egypt the chosen areas, Shubra Qubala, Imam Malek and Abu Minqar, vary in location and natural conditions, in terms of distance to water bodies, average temperatures, and population size. Irrigation methods in these three areas are limited to either flood irrigation, or drip/sprinkle irrigation; moreover, they all depend on either the Nile River or water aquifers for water supply, with a high reliance on water pumps. The water distribution schedule was the highest reported reason for water shortage; so most farmers dug private shallow wells to satisfy their water need, and sometimes over-irrigated their lands in times of water abundance causing a great water loss.

Interviews showed that most farmers were not familiar with the concept of climate change however most of them have been shifting their plantation and cropping seasons. Most families working in agriculture in those areas try to satisfy their personal food needs but are left with too little income to buy other personal necessities. One of the main problems in selling the agricultural production was the low prices set by the “middle-men”; the distance to the markets was another big problem especially for the areas that were reclaimed desert lands, as they are not well connected. Other recorded problems were increases in prices of fertilizers and pesticides and the changes in market prices.

The Lebanese areas chosen have different properties, but represent most of Lebanon’s agricultural land. The Beqaa, the plateau land between the Lebanon’s two mountain chains, is known for field crops and protected agriculture, for the use of drip and sprinkler irrigation, and for a mostly dry climate weather. Kfardebian, the mountainous area, is known for the agriculture of fruit orchards that only grow in open fields and need furrow irrigation, as well as the high renewable water availability as it receives a lot of snow annually. Irrespective of the differences between the two areas, they both seemed to have similar problems and similar solutions, which also parallel the solutions sought after in Egypt.

The interviews in the Lebanese areas have shown the great impact of a shock to population growth, as the huge influx of refugees has imposed great stress on water availability and on water quality. The extreme weather

conditions, floods in winter and droughts in summer, on the other hand, have also been playing a negative role on water and agriculture. In that regard some farmers were familiar with climate change, whereas others were aware of climatic changes without identifying them as climate change and have as such tried to adapt their crop seasons and plantation times to the weather changes. Water scarcity was a major issue in all regions and to all farmers, and just as in Egypt the Lebanese farmers also tried solving the problem by drilling their own private wells. General factors affecting farmer outputs in Lebanon included the volatile market prices, and the high cost of production.

Farmers in the two countries seemed to face very similar conditions, and in return have comparable resulting solutions.

Based on the case studies, the focus groups and the background study, the concluding recommendations were directed towards the farmers, and towards governmental and nongovernmental organizations. Some of the farmers' recommendations are changes in irrigation patterns and methods, accommodation to the crop patterns, cooperation between the farmers on land use and water management, as well as exploring options on water reuse. As for recommendations addressed to governments and non-governmental organizations, the most needed steps include investing in research and data collection, developing stronger connections with farmers, improving water and agriculture management, and encouraging successful and innovative practices and technologies.

This research project brought together several teams from across multiple countries to conduct a review and analysis on a wide range of complex, interconnected topics. Any one of these issues (e.g. climate change, population dynamics, food security and water security) can allow for vast and deep exploration. Seeking to integrate the concepts into unified analysis that is comprehensive and coherent is both exceptionally challenging and incredibly necessary. By viewing these issues in isolation, one risks missing significant drivers of change in the other areas. Thus, such projects are critical for fully understanding how communities and countries are affected by growing environmental and human-caused threats, how they are responding, and ideas for how they can improve their adaptation strategies. With the invaluable benefit of being able to draw from an in-depth literature review, expert consultation and findings from case studies in disparate conditions in multiple sites across two countries, the team was able to identify, detail and explore these critical issues in great breadth and depth.

Contents

List of Figures.....	7
List of Tables.....	8
1. Introduction	9
2. Methodology	10
3. Background.....	11
3.1 Egypt.....	11
3.2 Lebanon.....	15
3.3 Summary of key findings	21
4. Case Studies	24
4.1 Egypt.....	24
4.1.1 Case study 1: Shubra Qubala	24
4.1.2 Case Study 2: Abu Minqar.....	28
4.1.3 Case Study 3: Imam Malek.....	30
4.2 Lebanon.....	33
4.2.1 Case Study 1: Kfardebian	33
4.2.2 Case Study 2: Beqa'a.....	36
4.3 Cross-Case Analysis	40
5. Recommendations.....	44
5.1 Egypt case study recommendations.....	44
5.2 Lebanon case study recommendations	45
6. Conclusions	49
Bibliography	50

List of Figures

Figure 1 Potential Impact of Sea Level Rise: Egypt's Nile Delta. (Source: Sermonett et al., 2005).....	14
Figure 2 Value added of agriculture as % of GDP (Source: World Bank 2013).....	17
Figure 3 Percentage of total land agricultural production (Source: World Bank 2013).....	18
Figure 4 Reasons for water scarcity as perceived by farmers (Shubra Qubala).....	25
Figure 5 Different water sources usages in Shubra Qubala.....	26
Figure 6 Crops cultivated by small farmers in Shubra Qubala.....	26
Figure 7 Responses to Water Scarcity in Abu Minqar.....	29
Figure 8 Abu Minqar Families Experiencing Food Insecurity & Perceived Reasons.....	30
Figure 9 Responses to water scarcity in Imam Malek (Total number of farmers who responded).....	31
Figure 10 Main Crops grown by small farmers in Imam Malek.....	32
Figure 11 Irrigation methods in Kfardebian.....	34
Figure 12 Adaptation to climate change in production techniques.....	35
Figure 13 Type of Irrigation systems.....	37
Figure 14 Land Tenure.....	38
Figure 15 Adaptation Techniques to Climate Change.....	40

List of Tables

Table 1	Population growth (annual %)	15
Table 2	Comparison Matrix of Egypt and Lebanon	21
Table 3	Population and Cultivated Land in Shubra Qubala (population in numbers)	24
Table 4	Land distribution (in feddan)	24
Table 5	Population Dynamics in Abu Minqar	28
Table 6	Sources of Water Used in Kfardebian	34
Table 7	Climate Change Knowledge	36
Table 8	Water Source in Beqa'a	37
Table 9	Type of Agriculture	38
Table 10	Summary of Agriculture, Water and Climate Conditions and Farmer Responses	43
Table 11	Recommendations for Egypt Case Study	44
Table 12	Recommendations for Kfardebian Area	46
Table 13	Recommendations for Beqa'a	47

1. Introduction

Population growth on a global scale is increasingly putting stress on environmental resources, such as water resources. This is especially true and critical in the Middle East, an area considered as one of the most water scarce regions of the world. An added complication to this issue is the changing climate, which is impacting regions worldwide. This combination of stresses has dire implications on agricultural production as well as food and water security. The communities that are expected to suffer most from stresses on water resources are the poor, particularly the women and children of these societies.

The aim of the Impact of Population Growth and Climate Change on Water Scarcity, Agricultural Output and Food Security research study is to analyze the impact of population growth and climate change in Lebanon and Egypt on water Scarcity, agricultural output and food security by exploring the changes in water availability and agriculture production as a result of the changes in climate change and population growth.

Although both countries Egypt and Lebanon are from the same region, they are each influenced by unique characteristics. Egypt has very limited rainfall, but abundant surface flows; Lebanon has relatively abundant rainfall but more limited surface water flows. Egypt is very large in terms of area, while Lebanon is relatively small. Both have limited appropriate area to sustain population growth, and both are vulnerable to changes in climate and their impact on water resources.

The project was produced under equal efforts of regional academic institutions: the American University of Cairo (AUC) Desert Development Center from Egypt, the Columbia University Middle East Research Center (CUMERC) through the Institute for Sustainable Development Practice (ISDP) in Amman, and the Faculty of Agricultural and Food Sciences (FAFS) with the Climate Change and Environment Program in the Arab World from the Issam Fares Institute for Public Policy and International Affairs (IFI) at the American University of Beirut (AUB).

The research is based on case studies from different areas in Egypt and Lebanon in order to study the variability by region and to omit any conditional factors that might affect the changes in the output.

2. Methodology

The research is based on a comparison study across different areas in one country and across the two countries, Lebanon and Egypt. In order to account for the different initial conditions, the methodology of the study had to take a wider angle to set a baseline dataset for further analysis. The research methodology involved a literature and background review, focus groups/expert consultations, and case studies.

The literature review covered scientific articles, reports, policies and strategies from the two countries. This background study helped set a baseline dataset for each country on water resources, agriculture, food security, climate change vulnerability, and population growth. Moreover, it highlighted the effect of climate change and population growth on: primarily water availability and agriculture production, and secondarily on food security. A big importance was given to the direct stakeholders, the farmers, as they are at the forefront of the changes in agricultural output and water availability.

The expert consultations and focus groups assisted researchers in producing a more holistic and well-rounded study. Key experts from different specializations were invited to focus group meetings to provide a more practical view on the baseline data collected.

The case studies were the main point of focus in the research project. They involved visiting with farmers and local stakeholders in representative regions of Lebanon and Egypt to develop an understanding of how they perceive the issues addressed in this study. The research conducted at the three case study sites in Egypt and two locations in Lebanon draw partly from secondary data from established sources for population, water, land and agriculture data.

A key element in the case studies was the development of the questionnaires to serve as the foundation for the interviews and focus groups. The questions covered current information on and temporal changes in the following, among others: water resources and shortages, climate extremes, crop and farm conditions, food security, population dynamics at the village level and proposed solutions to farmer challenges.

The interviews allowed for more in-depth, targeted exploration of issues and experiences at the individual level. The individual interview format also encouraged input participation by participants who might not participate in the focus group setting (e.g., marginalized individuals or high-level community leaders or officials). Ultimately, the research team collected the findings from across these activities and produced a report including research findings from the five case study sites as well as a cross-case study summary and analysis.

3. Background

3.1 Egypt

Population and Its distribution

Egypt's resident population surpassed 83 million in 2003, according to the Central Agency for Public Mobilization and Statistics (CAPMAS, 2013), making it the most populous country in the Arab World and the third largest in Africa. A recent report published by the Information and Decision Support Center (IDSC) (2011) places population growth rates at close to 2% per year. Egypt's population growth rate remains high compared to growth rates of less than 1% in Europe (World Bank, 2013).

Egypt's surface area is almost entirely desert. Since the climate is hyper-arid, the presence of Nile water concentrates the population within the confines of the valley and delta. A commonly quoted number is 96% of the population living on 4 % of the land (El-Sadek, 2010). Rural population densities as high as 1,600 people per km² (El-Ramady et al., 2013) exert profound pressure on natural resources of land and water. The rapid urbanization and urban encroachment around the metropolitan areas of Cairo and Alexandria, as well as around the cities in the delta, is reducing available agricultural land.

According to the United Nation's Food and Agriculture Organization (FAO), since 1997, Egypt's rural population as a percentage of the country's total population has been relatively stable, declining by only 1.7%, and now makes up almost 56% of the population (FAOSTAT, 2013a). It is worth noting that, despite the relatively stable percentage of rural population, the percentage of the labor force in agriculture has declined to only 24% of the total national labor force (FAOSTAT, 2013a).

Water Resources and Water Security

Without significant rainfall, Egypt is classified as a hyper-arid country, and its agricultural production is almost wholly dependent on irrigation (El-Sadek, 2010). Freshwater resources are limited to the Nile River and groundwater stored in shallow and deep aquifers. National dependence on freshwater withdrawal from the Nile is estimated at between 95% and 98% (Gersfelt, 2007; Abdel-Shafy and Aly, 2002). Desert groundwater withdrawals, accounting to a few billion m³ yearly, are mainly drawn from the deep Nubian Sandstone aquifer supplying the Western Desert, which is depleting at an increasing rate. Egypt's set share of the annual Nile flow is 55.5 billion m³ (Allam et al., 2005; Nour El-Din, 2013). The primary function of the Aswan High Dam is to provide Egypt with water security, protecting it from the unpredictability of the annual flow. About 85% of Nile water is devoted to the agricultural sector, and releases and quantities are timed according to the national agricultural cycle.

The country fell below the World Bank's water scarcity threshold of 1,000 m³ of renewable water available per capita per year in 1997 (El-Sadek, 2010). By 2007, this figure sunk below the 700 m³ international water poverty limit (FAO, 2007, cited in El-Agha, 2011). Economic growth in Egypt also threatens the quantity and quality of water resources, inflating the existing issue of contaminated shallow groundwater from industrial chemicals, and excessive fertilizer and pesticides use (Hamouda et al., 2009). Abdin and Gaafar (2009) cite additional factors contributing to water insecurity, such as unequal distribution of water, and heavy subsidies leading to inefficiencies.

Many commentators see the problem as one of poor distribution more than a lack of supply, per se (El-Agha et al., 2011; Molle, 2013, pers.comm.; Radwan, 1998; Skold et al., 1984). Egyptian farmers still overwhelmingly practice flood irrigation, which results in evaporative loss and over-irrigation, causing soil damage and rises in groundwater tables (Wichelns, 2000). In 2005, only 6% of Egypt's cultivated area was equipped with modern pressurized irrigation

systems (Allam et al., 2005)¹. Inadequate agricultural drainage coupled with the Nile Delta's particularly flat slope contributes to salinization of soil and water resources. Skold et al. (1984) observed that a field's position along the canal has a significant effect on water availability, as those at the end of the canal usually have much less access to water than those at the head. This difference at the local level results in major production problems, inefficiencies and dislocations at the national level.

Local demand for water is also increasing, both through horizontal growth from desert land reclamation projects and vertical growth in terms of production intensification. Policy changes that give more freedom to farmers in cropping pattern choices, while stimulating yield increases have led to an overall increase in water demand (Wichelns, 2000). El-Agha et al. (2011) and Radwan (1998) report a mismatch between irrigation demand and supply at the level of main canals in the Nile Delta, and Radwan (1997) blames bureaucratic, overly centralized government administration and management for inefficiencies in irrigation water supply and distribution. Hamouda et al. (2009) assert that governance issues significantly compromise sound water management in Egypt. Water losses in unlined or badly kept canals are also considerable, with water delivery losses from main canals to fields ranging between 15%-20% (Saeed, 2013, pers. comm.). The DDC recorded water loss reaching up to 50% between wells and fields, in a Western Desert oasis. While water along the Nile is 'recycled' several times between Aswan and the Mediterranean Coast, making the 'effective efficiency' of the Nile as high as 91%, on farm water use efficiency is as low as 40-50% (El-Agha et al., 2011)². On-farm losses are due to the current flood irrigation system, lack of leveled lands, and discrepancies between government water delivery schedules and farmer's actual crop requirements (Saeed, 2013, pers. comm.).

In the current supply-based water management system, the government releases set amounts of irrigation water during the month, regardless of crop water requirements. Water is delivered through an intricate hierarchical system of mostly open canals utilizing gravity flows. Water is diverted from the river into arterial or main canals using barrages, flowing into branch canals through regulated sluice gates. Theoretically, branch canals are supplied with water on a rotational basis. Distributary canals are below field level, and farmers lift water into field ditches using a variety of means, the most common current method being a small portable diesel pump. Since farmers do not trust future water availability in the canal, they tend to over-irrigate during periods of water availability, "using at least 20% more water than the crop and the land require" (Karajeh, 2013, pers. comm.). Many observers recommend a demand-based system, in which local users can plan to receive the amount of water according to their cropping system requirements. This strategy would require a fundamental shift in the way the water distribution system is managed in Egypt.

Agriculture and Food Security

Egypt has 3.15 million ha of irrigated agricultural land, of which 75 % is the "old lands" in the Nile Valley and Delta and 25% is newly reclaimed desert land. In addition, about 229,000 ha are rain fed cultivation along the Mediterranean coast (Eid et al., 2007). According to the World Bank, Egypt leads the world in yields per hectare in a number of major food and industrial crops. Major agricultural crops, such as wheat, maize and rice, have experienced increases in production as a result of land reclamation efforts; between 1986 and 1993, yields surged by 52%, 37% and 34% respectively (Wichelns, 2000). In addition, over the past 30 years, there has been a striking growth in export of horticultural crops based in the New Lands. In terms of national food security, however, these spectacular gains in production at the farm level were largely negated by population growth. It is estimated that "agriculture production has to increase by 70% by 2050 in order to keep pace with population growth and changing diets" (El-Ramady et al., 2013).

The loss of agricultural land due to urban expansion is a serious issue. A recent study concludes that in the Nile Delta alone, over 2,500 km² of prime agricultural land was lost to urban and village expansion between 1984 and 2006 and that the rate of agricultural land loss now stands at over 11,000 ha per year; perhaps more than double this

1 Citing unpublished data from the Ministry of Water Resources and Irrigation from 2002

2 Citing a concept introduced by Keller and Keller, 1995.

figure for the country as a whole (Shalaby 2012). From the 1950s, the government has devoted considerable money and energy in desert land development for agricultural expansion, but agricultural land per person continues to fall - from 542.5m² in 1981 to 472.5m² in 1994 (Khalifa et al., 2000). Even if reclamation efforts were expanded, area gains might not compensate for loss of land in the delta and valley. The main import items are cereals, with about 58% of the total, followed by animal feed, edible oils, and dairy products. Self-sufficiency in food production is clearly not a reasonable target for Egypt in either the short or medium term since the country needs to resort to external sources to balance food requirements.

In 2008, the price of foodstuff in general rose 24% and rice prices rose by 83%, while the cost of cereals and bread went up by 48% (Weber and Harris, 2008). Surging market prices threaten the food security of the most vulnerable parts of Egypt's population. According to the Government's HIES³ conducted in 2008/09, 40% of households live off less than 25% of the country's total income (WFP, 2011). There are around 15 million people in Egypt who do not have sufficient income to buy enough food (Vella, 2012). Undeveloped local markets and poor transportation and logistics further complicate food accessibility and availability (Vella, 2012).

Egyptian Government subsidies programs have been reduced in the past decade, but there are still significant subsidies on bread, edible oil, and sugar. Food subsidies make up 18% of the total commodity subsidies program. Problematically, subsidies disguise the real value of commodities; however, limiting food subsidies would increase the cost of local food production, which would likely be passed on to the consumer (Bush, forthcoming). Reasons for the high cost of food subsidies include increasing volumes subsidized each year and the increase of the number of people eligible for food subsidies (World Bank, 2010). Between 2004 and 2009, 68% of Egyptian households held ration cards making them eligible for subsidized food, compared to 58.5% in 2004 (Bush, forthcoming). The World Bank estimates that improved targeting that excluded the country's richest 40% could save 9.5 billion EGP or 48.6% of the cost (World Bank, 2010).

Climate; Past, Present and Future

According to Egypt's National Environmental, Economic and Development Study (NEEDS) for Climate Change under the United Nations Framework Convention on Climate Change (April, 2010), climate change will impact the country in three principal ways: temperature rise, sea level rise and water availability. This will adversely affect the already tense relations among population, agriculture and food security (Egyptian Environmental Affairs Agency, 2002, cited in Attaher et al., 2006, 1053).

Egypt's increasing temperature levels in the upcoming decades, are a significant subject of the climate change discourse. A 2010 report by the Egyptian Cabinet's Information and Decision Support Center (IDSC, 2010) presents alarming numbers of 1.0°C-1.3°C by 2025, 1.9°C-2.6°C by 2050 and 2.2°C-4.9°C by 2100. As a result of the increased temperature levels, the demand for water is expected to increase, especially for crops (Strzepek et al's, 2000), while agricultural productivity may decrease. Temperature rise may also cause a decrease in organic matter in soils, reducing soil quality (El-Nahry and Doluschitz, 2010). Also, sudden, unusual temperature drops in the year 2012 damaged fruit trees in Nubaria and increased yields for wheat for the country, meaning that shifting weather patterns caused by climate change may have negative as well as positive effects on crop production in Egypt in the future (Gouda, 2013, pers. comm.).

Although a much academically debated and politically avoided topic, most scientists agree that climate change will probably lead to some degree of sea level rise in the Mediterranean Sea, affecting Egypt's Northern shore and Nile Delta. If the Mediterranean Sea were to rise by a meter by 2050, as much as 30% of Egypt's most precious farmland in the Delta as well as several coastal cities would be flooded (Bohannon, 2010; Simonett et al., 2005) (Figure 1). The Delta would naturally sink in a process accelerated by the fact that the Nile River no longer annually deposits the silt washed down from Ethiopia because it is retained in upstream reservoirs, while at the same time the delta shoreline

3 Household Income Expenditure and Consumption Survey

is being eroded by the sea (Bohannon, 2010). Parts of the Nile Delta, depending on the nature of the underlying sediments, may be sinking at a rate of half a meter per century or more (Stanley and Warne, 1998; Becker and Sultan, 2009). Natural subsidence is accelerated by excessive extraction of groundwater, heavy industrial constructions, and compacting of soils due to heavy machinery use (El-Nahry and Doluschitz, 2010; Medany, Mahmoud, 2013, pers. comm.). In 2007, the Intergovernmental Panel on Climate Change (IPCC) thus listed the Nile Delta among the areas globally most vulnerable to climate change (Bohannon, 2010).

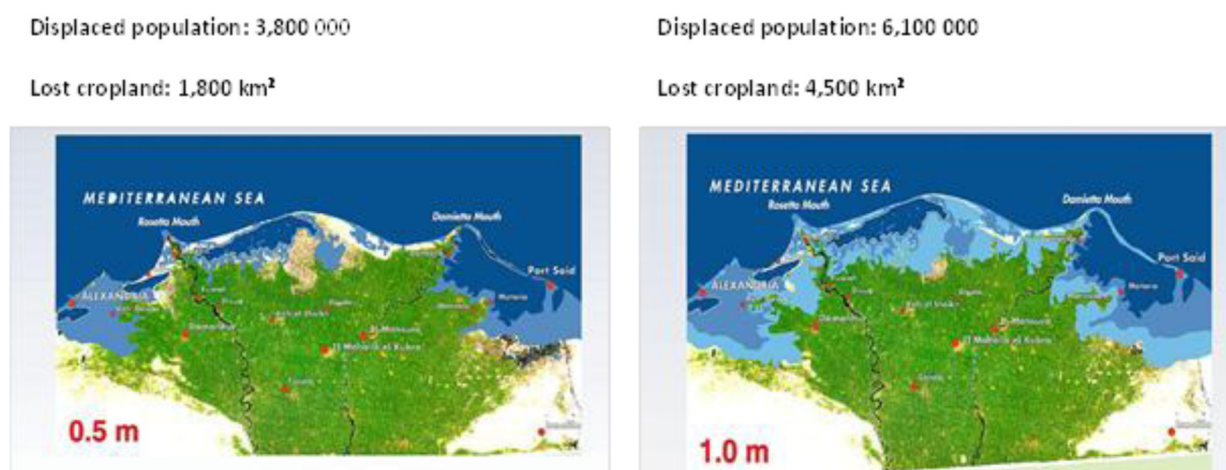


Figure 1: Potential Impact of Sea Level Rise: Egypt's Nile Delta. (Source: Sermonett et al., 2005).

There is also significant saltwater intrusion into the Delta's groundwater, increasing salinity levels in Delta soils (Malm and Esmailian, 2013). Kashef (1983) recorded saltwater intrusion in Delta aquifers as early as the 1980s. Three major environmental processes threaten the Delta, especially the coastal governorates of Port Said, Damietta, Dakahila and El- Behaira; inundation from sea level rise and subsidence, coastal erosion, and soil and water salination. A salt wedge has formed in the underground aquifer that turns well water as far as 30km inland too salty for drinking (Bohannon, 2010). According to Karajeh at ICARDA4, currently, "30% of the Nile Delta has been impacted by some salinity level", and this figure is bound to increase if no action is taken (2013, pers. comm.).

The Upper Nile basin rainfall pattern annual variability has increased, meaning that the already highly variable amount of water flowing in the Nile each year will likely become even more unpredictable. "One climate change scenario predicts that the Nile discharge may decrease to 3/4 of its present volume if CO₂ emissions double" in addition to high probability of increased droughts, directly affecting water availability in the Nile (El-Ramady et al., 2013, 76). Adapting to the challenge of increased uncertainty regarding water availability is a necessary, if daunting, task for both governments and residents in the Nile Valley and Delta.

The Nexus: Water, Food, Climate and population

Improving water use and reducing losses is essential for Egypt's future. This is recognized by the Egyptian National Water Resources Plan (2005), which stresses on better irrigation management through devolving decision making, adoption of modern pressurized field-level irrigation systems, and introducing more water efficient cropping systems. Egypt's Sustainable Agricultural Development Strategy to 2030 (Abul-Naga 2009) focuses on taking advantage of Egypt's comparative advantages within the global food system to achieve agricultural self-reliance. Comparative advantage in the export crops would ensure sufficient returns to cover the costs of food imports. Many technologies, which facilitate these strategies, are available and readily adapted to Egyptian conditions. Modern pressurized drip and sprinkler systems have been successfully employed in Egypt's new lands for a generation. Protected agricultural

4 The International Center for Agricultural Research in the Dry Areas.

systems showed success in Egypt's fresh produce export sector, although there is room for improving environmental and economic efficiencies. Egyptian scientists recorded successes in breeding improved varieties of major crops that have short duration, or are more drought and heat tolerant. New wheat varieties require 1,100 m³ of water per season instead of the traditional 1,560 m³ on average (Karajeh, 2013, pers. comm.).

Both the national water resources and agricultural development plans stress the importance of local farmer contributions to alleviating water scarcity and food insecurity. To organize water management efforts at the level of the command area, the Egyptian Government, supported by USAID, has been helping to formalize water user associations, of which there were about 4,000 operational in 2005 (Allam et al., 2005), under the national Egypt Water Use and Management Project (1977-84) and Irrigation Improvement projects starting in 1989. Abdin (2009) suggests that institutional reform is needed towards more integrated water management systems, away from currently separated domains of irrigation, drainage and electricity generation.

Another dimension in the development of coping strategies for water scarcity, population growth and climate change is to look at ways in which farmers currently respond to such stresses. Molle et al. (2010) suggest that farmers respond to drought and lack of irrigation water by reducing the cultivated area, using alternative water sources such as groundwater and wastewater, changing production patterns, engaging in on-farm water saving techniques, physically reallocating their land, changing land tenure, stealing water or abandoning agriculture. Experts have long called for policy reforms in managing irrigation and drainage water in Egypt (Wichelns, 2000). Gersfelt (2007) suggests policy options for regulating farmers' water management that include direct and indirect pricing mechanisms, quotas and market or user-based allocation mechanisms. Wichelns (2000) adds crop-specific land assessments to render cropping patterns more water efficient, and using financial income from water pricing for upgrading and rehabilitating Egypt's irrigation and drainage system. This study suggests that policies might equally be served by responding to and encouraging local initiatives that help alleviate the impact of population growth, water scarcity, and climate change on food and water security.

3.2 Lebanon

Population and Its distribution

In 2012 the World Bank estimated the Lebanese population at 4.4 million, an increase of 25% from 3.5 million in 1992 (UNDP, 2012). Recent estimates indicate that the annual population growth is on the decline since 2003, when a 4.84% growth was registered falling to 0.96% in 2012 (Table 1). The annual urban growth rate also decreased over the same period reaching 1.1% in 2012 (World Bank 2013).

Table 1 Population growth (annual %)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Population growth (annual %)	4.84	4.33	3.40	2.30	1.46	1.11	1.44	2.19	0.96	0.96

Source: World Bank 2013

Lebanese population is fairly young with the age group under 18 representing 31.1% of the Lebanese; this number drops to 21.1% in Beirut but soars to 41.2% in the northern rural cazas of Akkar and Meniye-Doniyyeh (CAS, 2009). The youth group between the ages of 15 and 29 years old represents 27% of the total population. The majority of this group has a good level of education and is either bilingual or trilingual (UNDP, 2012). Despite having a good education level, unemployment among university graduates is high and reached around 22.1% in 2007 (Index Mundi, 2012). Gender wise, over half of the Lebanese population are females, with only 21% working outside the household mostly in services, finance and insurance (CAS, 2009). However, female employment among the younger generation and university graduates is high and diverse.

Lebanon has a high number of Palestinian refugees, 62% of them live in camps and the rest live in areas proximal to the camps. Over half a million Palestinian refugees have been registered with United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) since 1948 but only 260,000-280,000 currently reside in Lebanon (AUB/UNRWA, 2010). More recently and according to the United Nations High Commissioner for Refugees (UNHCR), there are 541,079 Syrian refugees that have been registered in Lebanon and 104,701 await registration (up till July 2013). Their distribution varies between regions with the highest concentration in the Beqa'a, followed by North Lebanon, Mount Lebanon, Beirut, and finally South Lebanon.

Water Resources and Water Security

Lebanon faces serious water availability challenges due to population growth, water resources pollution, and climate change, which is expected to cause a reduction in precipitation (World Bank 2010 and MoEW 2010).

Annual precipitation over Lebanon is about 8600 million m³ (Mm³). It varies between regions ranging between 600 and 800 mm per year on the coastal areas, while the mountains receive between 1000 and 1400 mm per year. The drier Beqa'a region receives between 200 and 600 mm per year while the South of Lebanon receives between 600 and 1000 mm per year (MOE/ECODIT 2002). Lebanon has approximately 80 to 90 days of precipitation throughout the year (Comair 2010).

Water demand in Lebanon ranges between 1,473 and 1,530 million m³ per year (WB, 2009 & MOEW, 2010), with 61% going for agriculture, 18% for domestic use and 11% for industrial use. Theoretically, the available water exceeds the needs of Lebanon till the year 2035 but water pollution and misuse of water in agriculture and other sectors such as industry has placed a great strain on available water resources (MOEW, 2010). Most water withdrawal is from groundwater (53.4%) with very little water recycling practiced as only 0.2% of wastewater is treated and reused (MoE, 2012).

Historically, Lebanon has had very few dams and lakes to store water during the drier months of the year. The Qaraoun reservoir on the Litani River has a capacity of 220 Mm³ with an effective storage of 160 Mm³; 140 Mm³/year where the water is used for irrigation and domestic usage. This reservoir also operates three hydroelectric power plants (MoE, 2011). To increase water availability, the Ministry of Energy and Water (MOEW) decided to build 17 dams and lakes in different areas as part of its "10-Year Plan" in 1999, which would capture approximately 650 Mm³ of water per year (Comair, 2010). Most of these dams should be finished by 2018 (MoE, 2005).

In 2012 the Lebanese Council of Ministers adopted the National Water Sector Strategy (NWSS) with the aim of ensuring "water supply, irrigation and sanitation services throughout Lebanon on a continuous basis and at optimal service levels, with a commitment to environmental, economic and social sustainability" (World Bank 2012). MoEW estimates the total renewable sources per capita per year at 926m³, which is lower than the international benchmark of 1000m³ (MoEW, 2010). However, other sources put the share per year per capita at around 1100 m³, slightly above the international benchmark (RIO +20 2012). MoEW estimates that by 2015, the individual share will drop to 839 m³ (MoEW, 2010).

Population growth is a determining factor in water availability. The country's water infrastructure needs upgrading and its coverage increased. It is estimated that almost half of the water distribution networks suffers from leakage (MoEW 2010), leading to losses and contamination of water. The connection of Lebanese households to water networks is uneven between regions; the highest share of connection is in the Beqa'a (77%) whereas the lowest is in Nabatieh (27%). The influx of Syrian refugees is also pushing the limits of the already strained water infrastructure. With a constant flow of people escaping war in their motherland, Lebanon's water crisis is expected to hit sooner than expected as the population swells well beyond the capacity of the country's limited natural resources (WFP 2013).

Water quality is a major component of water security, since pollution greatly reduces the availability of potable water. Sewage connection is still an issue with the highest rate of connection to sewage networks being recorded in Beirut (96%) and the lowest in Batroun district (1%). Due to limited knowledge and awareness as well as the lack of means, many communities in Lebanon discharge their untreated sewage water directly into rivers that carry their toxic contents all the way to the sea (Houry and Jeblawi 2007, Massoud 2012). Agriculture pollution of rivers adds to the water quality issues. Industries add to the chemical pollution of rivers as industrial refuse is discharged directly into rivers, streams or municipal networks with little or no treatment at all (RIO +20 2012).

Agriculture and Food Security

The geographical location and topography of Lebanon enables it to have a diverse agriculture production that ranges from semi tropical produce from coastal areas to orchards in high mountains with a wide range of different crops in between (CDR 2005). Around 270,000 hectares are cultivated in Lebanon, half of which are irrigated (ICU 2013). Banana plantations are the biggest irrigated water consumers and are commonly found along the coast with less than 150m of elevation, as they require hot and humid conditions (MoE 2011). South Lebanon is famous for banana plantations, as is Mount Lebanon, though to a lesser extent (MoA 2007).

The highest percentage of agriculture lands can be found in the Bekaa valley, which accounts for 42% of total cultivated lands in the country and constitutes the bulk of dietary staples such as cereals and vegetables (MoA 2007). Agriculture's contribution to Lebanon's GDP is small and has been dropping over the years from about 7% in 1994 to about 5.5% in 2013 (see 2). Between 20% and 25% of Lebanon's active population are involved in agriculture either as full time, part-time, seasonal or family laborers.

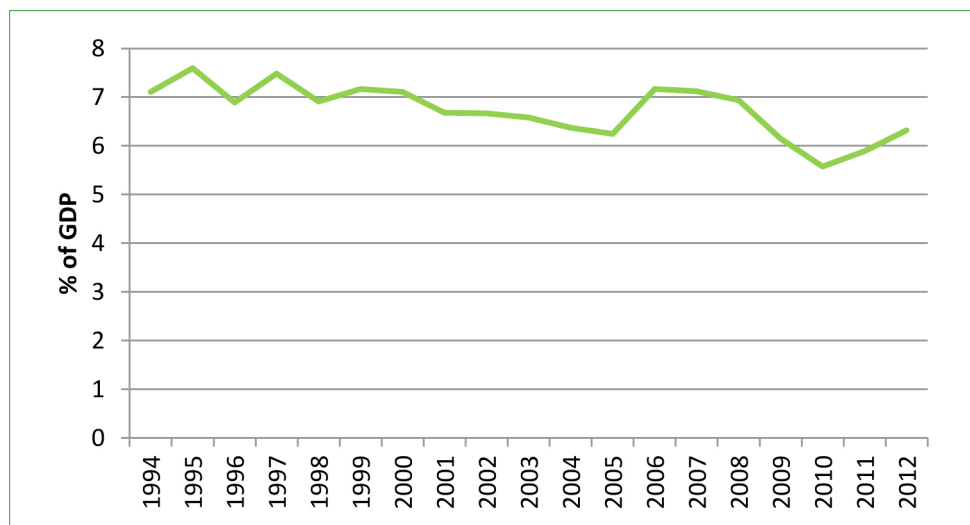


Figure 2: Value added of agriculture as % of GDP (Source: World Bank 2013)

Land dedicated to agriculture has also been declining over the past twenty years, starting out at nearly 18% of Lebanon's total land it dropped precipitously to about 13% in 1999 and has continued to drop ever since reaching a little below 11% in 2011 (see Figure 3).

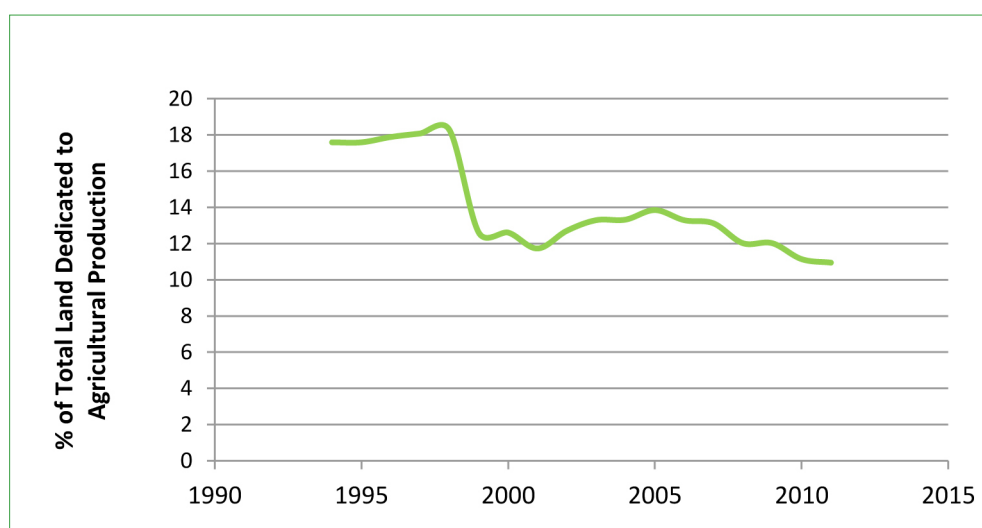


Figure 3: Percentage of total land agricultural production (Source: World Bank 2013)

One of the important factors that inhibit agriculture development is gender, as the role of men and women in agriculture differs from one region to another in developing countries, depending on the socio-economic development of that country. In Lebanon only 16% of the females work in agriculture (UN, 2001). Of the population involved in agriculture, women are believed to be one of the most vulnerable groups as evidenced in increased poverty incidence. Women's contribution to the agricultural sector has been underestimated and undervalued. Furthermore, women have been shunned from effective participation in the decision-making process (FAO 2012). Constraints and challenges facing women in the agricultural sector are legal, cultural, and socio-economic. These may be summarized as follows (FAO 2012):

- Women in rural areas have little access to land, which is caused by legal (in heritage laws, property rights), economic and cultural constraints;
- Technology transfer in rural areas is generally not geared towards women's needs and concerns; and
- The lack of access to credit is one of the most important challenges facing rural women.

Lebanon adopts a free market policy, which allows free and easy access of food to and from the country. The agricultural sector at the moment cannot meet with the internal demand for basic food commodities. Thus, Lebanon imports 80% of its cereal needs, 82% of red meat and 75% of fish needs and 37% of its dairy needs from abroad (Chaaban 2012).

The openness of the Lebanese economy makes it easy to supplement the market with any lacking fresh or processed food but also makes it dependent on foreign imports even for some food staples such as meat and grains. The situation becomes riskier when food prices fluctuate internationally, incurring a significant increase on the already strained budget of the Lebanese consumer (WFP 2013).

Nutrient deficiency is common in the poorer areas of Lebanon since adequate diets cost more than what the impoverished families can sustain. This results in iron and iodine deficiencies and disorders such as anemia and goiter (Baba 1998, Baba 2000). Nearly 25% of children under 5 and 33% of women have been shown to suffer from iron deficiency (Hwalla, Adra and Jackson 2004). Around 16.6% of Lebanese women of low socio-economic status were found to suffer from anemia although for the greater part their cases were not severe (Khatib 2004). The share of carbohydrates from bread and cereal in the Lebanese diet decreased, while fat, milk and animal protein intake increased (Baba 2000).

Poorer families, especially in the deprived parts of the country (suburbs, rural areas) spend over a third of their monthly income on food, making their situation particularly precarious in case of fluctuation in food prices or food shortages. The exact number of people living in a food insecure or precarious situation is not available but it is estimated to hover around 15 to 20% (Chaaban 2012), even though some 9% of Lebanese are classified as deprived and 41% are considered poor (ESFD 2004, MoSA 2011).

The limited budget accorded to the Ministry of Agriculture along with high production costs, lower returns, lack of government planning, monopolized agricultural supply chain, fragmented lands, among others have impeded the development of the sector into one capable of coping and meeting the growing demands of the Lebanese (Hunter 2008, Chaaban 2012).

In addition, the recent Syrian war is greatly impacting food security in Lebanon. Within the host communities, in the mostly poor Beqa'a and Northern Lebanon region, the situation is becoming ever more critical, especially since international aid has not matched the scale of the crisis. There is an increased demand for primary agricultural products and decreased access to food for Lebanese people. It is estimated that there is a shortage of 55,000 million tonnes of cereal resulting from heightened demand (FAO, 2013). Before the crisis, total living expenses in Northern Lebanon were estimated at US\$ 793 jumping to US\$ 842 one year after the crisis, with up to 12% inflation rates in food prices (DMI 2012).

Climate: Past, Present and Future

The climate profile of Lebanon varies with its topography, which allows for a wide distribution of temperature and precipitation. During the previous century, the observed temperatures fluctuated between 23°C and 25°C without any discernible trend. The PRECIS (Providing Regional Climates for Impacts Studies) model temperature (adjusted for an approximate -1.5°C climatological bias from the observed) also looks stable in the recent past (MoE 2011).

Climate models are projecting hotter, drier and less predictable climate, resulting in a possible drop in water run-off by 20% to 30% in most of the MENA region by 2050, mainly due to an increase of 3°C to 5°C in mean temperatures and a decrease of 20% in precipitation (Milly et al., 2005). The reduced stream flow and groundwater recharge might lead to a reduction in water supply of 10% or greater by 2050. Climate change effects can be summarized by the following: greater seasonal temperature variability, more extreme weather events including droughts and floods, significant sea level rise where by the end of the century the Mediterranean is predicted to rise between 30 cm and 1 meter, expected shifts of Mediterranean biomes by 300-500 km northward if a 1.5°C warming occurs, and an increase in vector-borne diseases and pests, as well as mortality (Elasha 2010).

The Regional Climate Model (RCM) simulations predict that temperature will start to change after 2025 and by the end of the 21st century may reach unprecedented levels. By 2040, maximum temperatures are predicted to increase between 1°C around the coast and up to 2°C in the mountainous region in the summer. By 2090 the increases are from 3 to 5°C respectively. Minimum temperatures will also increase in a similar manner, but are not expected to exceed 4°C by the end of century (MoE 2011). Regarding rainfall, significant reductions are projected, ranging from -10% to -20% for 2040 and -25% to -45% for 2090. These conditions will result in an extended hot and dry climate. The drought periods over the whole country will likely become nine days longer by 2040 and 18 days longer by 2090 (MoE 2011).

It is worth noting that in the event of extreme weather conditions, people living in remote locations in Lebanon (particularly underserved populations mostly concentrated in the rural north and east) will be more vulnerable to environmental issues and less able to cope with the consequences of such events (MoE 2011). Climate change presents a great challenge for Lebanon and the region, and it necessitates more regional cooperation to mitigate its impacts and protect people's livelihoods.

The Nexus: Water, Food, Climate and Population

Though population growth in Lebanon is slower than other countries in the MENA region (Gregoire 2012), it has one of the highest population densities in the Arab World. The impact of the population growth caused by the influx of Syrian refugees remains to be quantified but will surely have negative implications on the long term resilience of Lebanon to water shortages. MoE (2011) highlights that water security in the country will be threatened in the future due to the expected decline in water availability, in addition to the increase in water demand and groundwater salinity.

Climate change is expected to cause a reduction in agricultural productivity as a consequence of a decrease in water availability, especially for the crops that depend on irrigation like wheat, tomatoes, cherries, apples and olives. Climate change will have an effect on temperature that may directly affect the chilling requirement of some fruit trees like apples and cherries, which will also negatively affect their productivity. An increase in temperatures would have a detrimental effect on other crops like grapes leading to low quality production. Rainfed crops will show either a slight decrease in their productivity or no changes as they are adapted to low water requirements. Vegetables and fruit growers may start to face new pathogens and insects that can have a significant effect on their plantations in areas where they had lower incidence due to the change in climate making a suitable environment for different pests and diseases that were not a problem in the past (MoE 2011).

Recent estimates indicate a 20 days decrease in the time dense snow cover persisted on high mountains before its subsequent melting in the warmer months of the year (Shaaban 2009). Water quality is expected to decrease as percolation of water will decrease leading to higher salinity in the underground water resources (MoE 2011). Adapting to this water stressed situation implies a need to optimize water use in the domestic, agricultural and industrial sectors as well as protecting ground and surface water resources from pollution (MoE 2011).

To face these upcoming challenges, farmers should also start taking some precautionary measures like planting new varieties of crops that tolerate low water and high temperatures, adjusting the planting dates to the change in environmental conditions, applying integrated pest management (IPM) techniques that will address production challenges, and even shifting planting locations to areas that are more suitable for crop production (MoE 2011).

In addition to the predicted climate changes, the current trends in population growth will also exert pressure on agricultural production. The higher demand for food will lead to the usage of more intensive agricultural practices characterized by the increase in the use of water for irrigation and by the excessive use of agrochemicals (MoE 2011). Projections, up until 2030, show an increase of 41% in total domestic demand for water (from 296 Mm³ in 2000 to 418 Mm³ in 2030). The estimated need for irrigation water lies at 1,600 Mm³ (CDR, 2005). According to the Ministry of Environment (2001) by the year 2015, only 60% of water resources will be left to agricultural use (as compared to 74% in 1994) and 32% directed to domestic use. Water withdrawal figures for 2005 show that the share of agriculture had already dropped below 60% (FAO, 2010). The National Integrated Water Resources Management Plan for Lebanon mentions other projections and forecasts; a 47% increase in the irrigated surface area by 2030 (2005 as a base year), and a 10% increase in the demand for irrigation water (Hreiche 2009). The total need is estimated at 1,410 Mm³ in 2030, versus 1,600 Mm³ estimated by CDR (2005).

As for food security, MoE (2011) states that Lebanon produces half of the population's consumption in terms of value. The food security balance tends to highlight more disequilibrium with increasing imports and demographic growth that cannot be covered by a notable increase in exports (MoE and AUB, 2009). Demographic pressure and climate change are expected to cause a decrease in the production of exportable crops such as citrus crops, banana, apple, potato amongst other fruits and vegetables. In terms of poultry meat, olive oil and potato, Lebanon is close to self-sufficiency. However, the country imports half of its needs of milk, and most of its consumption of red meat and vegetable oils.

3.3 Summary of key findings

Though the two countries involved in the study are different in size, population, climate and water resources, yet there are many similarities in the poverty levels, food insecurity, and others. These and other key findings are summarized in Table 2.

Table 2: Comparison Matrix of Egypt and Lebanon

	Egypt	Lebanon
Population		
Total	83 million (2013)	4.4 million (2012) <ul style="list-style-type: none"> • Plus almost 0.5 million Palestinian refugees (many on camps) and, recently, several hundred thousand refugees from Syria
Annual growth rate	Around 2% <ul style="list-style-type: none"> • Adding over 1 million per year • Decreasing in recent years 	Around 1% <ul style="list-style-type: none"> • Significant decrease in recent years
Distribution	Very concentrated along the Nile River and Delta (96% of population on 4% of land)	Densely populated and largely concentrated in urban areas of Beirut and Mount Lebanon
Water resources and water security		
Annual precipitation	Typically less than 200mm (hyper-arid)	Varies from 200mm to 1400mm <ul style="list-style-type: none"> • 600-800mm along coast, 1000-1400mm in mountains, 200-600 mm in drier Bekaa
Annual water per capita	Less than 700m ³ (near international water poverty threshold) in 2007 and decreasing	Near 1000m ³ in 2010 and expected to reach 839m ³ by 2015 (below international water scarcity threshold of 1000m ³)
Water Consumption	Up to 85% for agriculture	Around 60% for agriculture
Primary sources	Over 90% from Nile River; limited amounts from groundwater	Primarily from groundwater (53.4%); limited but expanding reservoirs
Quality and availability concerns	<p>Water quality</p> <ul style="list-style-type: none"> • Excess use of fertilizers and pesticides is already contaminating groundwater, and industrial chemicals are also polluting waterways <p>Future water availability</p> <ul style="list-style-type: none"> • Significant concerns due to potential of other counters (principally Ethiopia and Sudan) to divert water from Nile River • High population growth is expected to put great pressure on water security moving forward 	<p>Water quality</p> <ul style="list-style-type: none"> • Untreated sewage is being dumped into rivers, and agriculture-related pollution was found in high levels in rivers during dry months <p>Future water availability</p> <ul style="list-style-type: none"> • Population growth, particularly from refugee populations, are expected to put great strain on water availability in coming years

	Egypt	Lebanon
Policies and strategies	Promote local water user associations, adopt modern pressurized field irrigation systems, introduce more water efficient cropping systems and promote integrated water management	Build dams and lakes, extend the drinking water projects, increase the quantity of irrigation water, build wastewater treatment plants, and clean river courses
Agriculture and food security		
Total cultivated land	3.38 million hectares <ul style="list-style-type: none"> • 3.15 irrigated (93%) • 0.23 rainfed, along the coast (7%) 	0.27 million hectares <ul style="list-style-type: none"> • Around half (0.135 million) irrigated • Around half (0.135 million) rain fed
Distribution	75% in the “old lands” of the Nile Valley and Delta and 25% in the newly reclaimed desert land	Largely in Bekaa Valley, (42%) with many vegetables and cereals, and North Lebanon (25%)
Contribution to GDP and labor force	GDP contribution <ul style="list-style-type: none"> • 13.2% in 2008, with a 3% growth rate Labor force <ul style="list-style-type: none"> • Declining to around 24% of total labor force in agriculture • Rural population declining by 1.7% annually, to 56% in 2013 	GDP contribution <ul style="list-style-type: none"> • Dropping from 7% in 1994 to 5.5% in 2013 Labor force <ul style="list-style-type: none"> • Between 20-25% involved in agriculture labor in some capacity
Exports and imports	Overall net food deficit of US\$6 billion <ul style="list-style-type: none"> • Imports mostly cereals (a global leader in wheat imports), followed by animal feed, edible oils and dairy • Main exports are citrus, cotton and rice 	Overall produces half of consumption needs by value <ul style="list-style-type: none"> • Imports over 75% of needs for cereals, red meat and fish • Main exports are fruits and vegetables (e.g., citrus, apples, bananas and grapes/wine)
Poverty and food security	<ul style="list-style-type: none"> • 22% of population defined as poor (2009), with 50% living off less than \$2 per day and 80% of rural population poor • Estimated 15 million (18%) have insufficient income to buy food 	<ul style="list-style-type: none"> • 41% defined as poor and 9% defined as deprived • Estimated 15-20% thought to be food insecure
Policies and strategies	<ul style="list-style-type: none"> • Investments in reclaiming desert land for agriculture uses • Liberalization of imports/exports, partly resulting in increased food prices • Significant subsidies for basic food commodities (over 60% of population eligible) • Focus on improving agricultural productivity, particularly with respect to water use 	Openness to food imports Strategic plan and framework for agriculture, including infrastructure, extension, credit to SMEs and value chain and agricultural productivity improvements Integrated, cross sector strategy focusing on social development services

	Egypt	Lebanon
Climate change		
Historical conditions	Suggestions of increased temperature and decreased rainfall over recent decades	Temperature and rainfall conditions seem to have been largely stable in recent years in the country, but with temperature increases and rainfall decreases in the region as a whole
Projections	<ul style="list-style-type: none"> • Egyptian report indicates increasing temperatures by 1.0-1.3°C by 2025, 1.9-2.6°C by 2050, and 2.2 -4.9°C by 2100 • Sea level rise may rise by 2.5-3.5cm per year, and some estimates of 1.75m rise along lower Delta zones by 2100 	Differing results from various models <ul style="list-style-type: none"> • Results from regional modeling suggest max temperature increase of 1-2°C by 2040 and 3-5°C by 2090, and annual rainfall reductions of 10-20% by 2040 and 25-45% by 2090, with drought periods increasing by 9 days by 2040 and 18 days by 2090
Potential impacts	<ul style="list-style-type: none"> • Significant possible reductions in crop productivity for many crops by 2050 and even more so by 2100 (e.g., wheat: -36% and maize: -20%), but increase of 31% for cotton • Potential large scale displacement (6.1 million people), cropland loss from sea level rise (4,500 km²) • Possible additional salt water intrusion into groundwater as sea levels rise • Possible impacts on Nile flow, particularly if neighbors change dam management due to climate change 	<ul style="list-style-type: none"> • Decrease in runoff and stream flow (from reduced rainfall, snow and higher heat), leading to decreased water supply of possibly around 10% by 2050 • Possible impacts include increased conflict with neighbors over scarce resources as well as increased rural-urban migration and tension as agriculture conditions deteriorate • Possible reduction in agriculture productivity with decrease water availability, higher temperatures and changing conditions for pest infestations

4. Case Studies

4.1 Egypt

The data collection for this research study was carried out in three case study areas that represent Egypt's different agricultural production systems. Shubra Qubala is an urbanized village in the Nile Delta where farmers practice exclusively flood irrigation. Imam Malek is a settler village on reclaimed desert land near the Cairo-Alexandria desert road, obtaining its water mainly from the River Nile. Here, the irrigation system relies entirely on drip and sprinkler systems. Abu Minqar is a remote new oasis of settlers in the center of Egypt's Western desert that is entirely dependent on the finite waters of the Nubian Sandstone Aquifer. The farmers of Abu Minqar practice largely flood irrigation, except for a small number of private investors. In all communities, the project team carried out initial assessments, collected data from local authorities, and carried out a total of 57 in-depth face-to-face interviews with farmers as well as focus groups (except for the village of Imam Malek, where only interviews were conducted).

4.1.1 Case study 1: Shubra Qubala

Population Dynamics

Tables 3 and 4 summarize the population dynamics and land distribution in the recent few years in Shubra Qubala

Table 3: Population and Cultivated Land in Shubra Qubala (population in numbers)

Year (01 January of each year)	Males	Females	Total
2010	4,896	4,518	9,414
2011	4,994	4,608	9,602
2012	5,099	4,706	9,805
2013	5,194	4,789	9,983

Table 4: Land distribution (in feddan)

Area Cultivated	1,182
Unproductive Fallow Land	169

Water Sources and Uses

The village of Shubra Qubala derives the bulk of its irrigation from the Nile. Banha water station provides the primary canal Um Shalaby with Nile water, which branches out to Shubra Qubala. Three main branch canals called mesqas service Shubra Qubala cultivation areas. El Ghofara Canal, irrigates 100 *feddan* which is relatively a small portion of the land; El Ghannama Canal, which irrigates around 400 *feddan* of agricultural lands located on the western side of Shubra Qubala; El Sheyakha Canal irrigates the east side of the village and irrigate around 700 *feddan*.

Shubra Qubala's irrigation system depends on the use of pumps as Agricultural fields in are higher in elevation than the canal itself. Farmers usually use small, moveable diesel pumps that can be transported from one field to the other. Even though farmers are not charged for water used, there is an indirect irrigation cost for the operation of pumps. All farmers in Shubra Qubala practice flood irrigation, including the village's largest investor who cultivates on a total of 20 *feddan* of land. During the interviews many farmers described flood irrigation as the most successful way of allocating water properly because controlled pipes avoid over-irrigation. Farmers stated that other irrigation methods like sprinkler and drip were never considered because of their high cost of installation.

Farmers in Shubra Qubala complain about water shortages. According to the Government's Irrigation Office water distribution schedule, a canal receives water for five days followed by a 5-day water cut (in winter this rotation is changed to ten days on, followed by ten days off). Water distribution is part of village politics. As one farmer described, "the person in charge of opening the gate for the irrigation cycle often delays the cycle or doesn't open it at all., Personal connections are involved in the cycle of opening the gates or closing it, which is illegal" (Male Respondent 19, pers. comm., 2013). Moreover, the misuse of branch canals leads to blockages in water flow. As another respondent remarked, "We are supposed to get water every other week, but a lot of the time we don't get water for 10-15 days and sometimes the canal gate is closed from 20-30 days" (Male Respondent 15, pers. comm., 2013).

Sporadic and unreliable water supply from the Nile causes farmers to tend to over-irrigate their land on the days when water is available. This reduces the availability of water for farmers whose lands are located further downstream, even during periods when water should be available. In addition, due to water scarcity farmers have started to rent out half of their land and cultivate only half of their property.

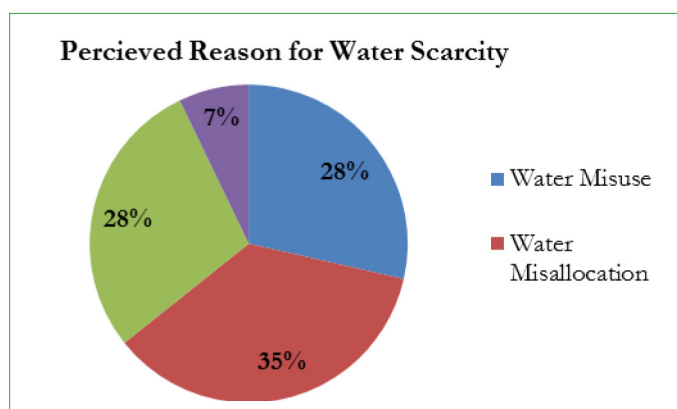


Figure 4: Reasons for water scarcity as perceived by farmers (Shubra Qubala)

One common reaction among Shubra Qubala farmers when facing the shortage of water is to dig shallow wells in order to access groundwater for irrigation. Such wells are typically 60m to 80m deep and cost around 8,000 EGP to drill, providing 100-150 cubic meters of water per hour, according to one farmer. An estimate of 50-60 wells of around 75 meter depth was drilled during the past 5 years (Male Respondent 1). Only 7% of farmers are totally dependent on canal water, and that is due to their inability to afford digging a well. 93% use both the canal and wells waters most of the time.

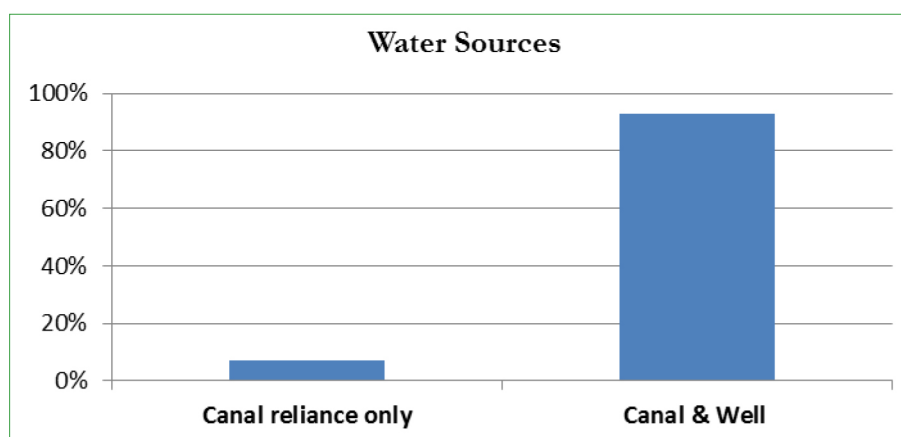


Figure 5: Different water sources usages in Shubra Qubala

In practice, well drilling (which requires permission from the Egyptian Ministry of irrigation) often occurs semi-informally. Groups of farmers of up to 15 individuals pool money to drill a new well as it is expensive to be charged to one farmer. Farmers in Shubra Qubala share this water free of charge with family members, friends and neighbors at times of water shortages. Almost 64% of the people in the village rely on shared wells for irrigation.

Livelihoods and Farming

Shubra Qubala is an agricultural community with few other options for livelihood generation. Most families engage in a combination of agricultural cultivation and paid jobs. Farmers in Shubra Qubala follow two main planting seasons: summer and winter. The main winter crops grown are wheat, clover, and vegetables (onion, fava bean, pea, lettuce, cabbage, cauliflower, potato). The main summer crops produced are corn, maize (fodder), and vegetables (squash, cucumber, peppers, eggplant, potato, sweet potato, tomato). There are also 160 *feddan* of citrus production in the village's agricultural area and a few *feddan* each summer are planted with rice. In the winter of 2013, 450 *feddan* of the area were planted with clover, representing 40.6% of the total agricultural area, and 153 *feddan* with citrus, representing 12.9% of the area, while 8.4% of the area or 100 *feddan* were planted with potatoes and onions. Some farmers still grow cotton in summer, which used to be the main crop produced in Shubra Qubala. According to interviewees, Shubra Qubala's cropping calendar has changed over the years because of population growth, consumption increase, and the need to plant more clover for livestock (Figure 6). There used to be two cropping seasons and in between the land stayed idle for two months, now they are three cropping seasons a year. This resulted in an increased water demand, despite the unchanged land area.

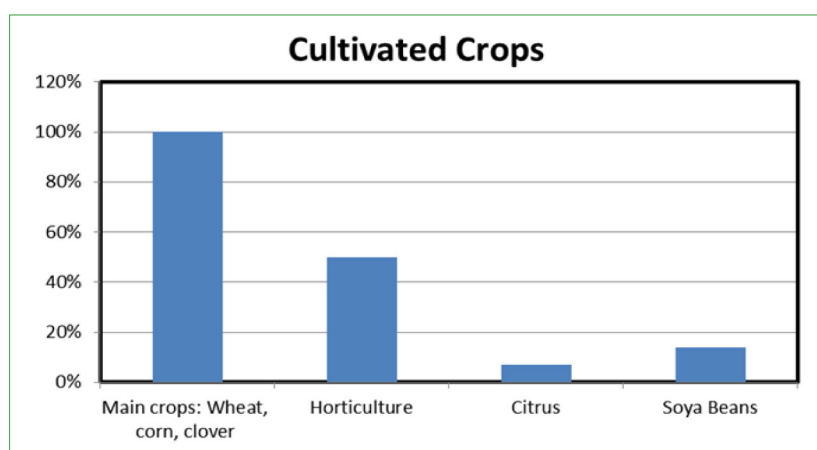


Figure 6: Crops cultivated by small farmers in Shubra Qubala

Raising livestock is an important source of income for the residents of Shubra Qubala. Livestock is raised mainly for milk and meat production for the family and as an asset to be sold whenever larger amounts of money are needed.

Food Security

Residents of Shubra Qubala who engage in agricultural production produce much of their family food requirements on their own land. The surplus is then usually sold on the market. When productivity goes down, families have nothing to sell, and family expenditures are then covered by the sale of livestock.

Employees who do not cultivate land, according to a resident, used to spend around 60% of their income on food 10 years ago (e.g. 300 EGP per month). Now, even as minimum salaries went up to 1,000-1,200 EGP per month, a family of 5 persons would spend as much as 80% of their income purchasing food. In 2012 as many as 5,499 food ration cards for access to total food subsidies were handed out in Shubra, benefiting a total of 7,460 residents (compared to a total population of 9,805 that year).

According to the local council, the total amount of government-subsidized flour of the types 76 and 82 going out to Shubra is 1.60 tons per day. Ironically, according to a resident, some of this bread, especially the low quality bread, is used for feeding ducks and chickens, because it is subsidized and thus cheaper than purchasing fodder. Shubra Qubala residents have suffered from a sharp increase in price levels over the past few years, threatening food security in the village.

Farmers complained about the rising costs of food and the prices of agricultural inputs as well, such as fertilizers. As agricultural production necessities increase in price, so does the final price of agricultural products, unless the government sets a particular price (Male respondent 13, pers. comm., 2013). The increased prices affect the household's ability to spend on necessities and spending on crop production, in turn leading to lower crop quality and making marketing more difficult. In addition labor has become more expensive because the education level has gone up therefore unskilled labor has decreased.

According to the Shubra Qubala's veterinarian, over the past 10 years, animal production in Shubra Qubala in terms of numbers of livestock has increased, while the quality of meat has decreased, mainly as a result of water pollution. According to the vet, polluted water stifles animal growth, which leads farmers to either sell the animal or treat it with hormones, which pollute the meat itself and can harm consumers. The vet claimed that animal production can have a 99% dependence on the use of clean water, and that he had seen at least a 20% increase in animal production at farms that use filtered water for animals. Water shortages, according to the vet, also have detrimental effects on animal production and food security.

Climate Impacts

Generally, farmers interviewed in Shubra Qubala were much less aware of climate change impacts than of water shortages. Most farmers were not familiar with the scientific background of climate change and its impact on Egypt. Some farmers expressed a feeling that the weather in Shubra Qubala was getting hotter in general, even if they did not necessarily link this to climate change. Some farmers mentioned changes in planting dates over the past decade years, which can be seen as a reaction to the microclimatic conditions in Shubra Qubala, even if this reaction was not consciously linked to the concept of climate change. One respondent saw a link between the effect of climate change and the increase in pests, therefore requiring farmers to increasingly use pest control measures.

4.1.2 Case Study 2: Abu Minqar

Population Dynamics

The oasis of Abu Minqar did not become a permanently settled community until the 1980s, when government resettlement programs offering land at low prices, opened the area for agricultural development and desert settlers. Under the settlement program, beneficiaries received 6 *feddan* of land, divided into three separate plots of 2 *feddan* each. By design, the 6 *feddan* a new settler receives were typically divided into 3 plots of 2 *feddan* each, one located at the beginning of a main canal, close to a well, one located in the middle of a canal and one located at the end. This is to avoid misallocation and unequal water distribution.

Residents of the oasis's six villages have diverse social and cultural backgrounds and originate from other oasis. According to Official figures from the Information Office of the Local Council in Farafra the population is also slowly increasing (Table 5).

Table 5: Population Dynamics in Abu Minqar

Year	No. of Males	No. of Females	Total Population
2008	1316	1096	2412
2013	1871	1560	3431

Water Sources and Uses

The oasis depends exclusively on the water supply from 15 deep-water wells, which tap the finite Nubian Sandstone Aquifer System, irrigating 1,680 ha. Some of these wells are artesian or free flowing wells, as the pressure causes water to gush out continuously, while some others need pumps for water extraction. As the discharge of some free flowing wells has gone down over the past 7 years, several farmers have taken to organizing the private drilling of wells. Most farmers in the oasis use traditional flood irrigation methods.

Abu Minqar is made up of several villages, with each served by its own well. The schedule for the irrigation of the 346 *feddan* serviced by the artesian wells of the Bir Wahid (or "Well Number One") area foresees that farmers receive one hour of water per *feddan* of land every 15 days. In order to make the water distribution more efficient and minimize loss, farmers informally negotiate the water distribution schedule and swap irrigation hours. Distribution schedules for pump-operated wells are more rigid, as these wells only discharge during the day while the pump is running.

All farmers interviewed are experiencing significant water shortages. The decrease in discharge in some of the artesian wells of Abu Minqar, have caused significant disruptions in the irrigation and cultivation schedules. An older farmer stated that the Bir Wahid wells, when they had first been drilled, were used to irrigate as much as 570 *feddan*. This number had gone down to 360 *feddan* in 2006. In 2013, according to the farmer, these wells irrigate only about 150 *feddan*.

Some farmers expressed the concern that part of the problem was the recent presence of big agricultural production companies nearby, consuming large amounts of water extracted from the same layer of the aquifer and thus increasing the pressure on the shared water resource. An immediate response to water scarcity is to cultivate smaller agricultural areas.

There was a total of 18 privately drilled wells in Abu Minqar in 2013, compared to none in 2006 since the government only recently (in 2012) started issuing permits for shallow private wells. Most farmers agreed that digging shallow wells (200-250 meters deep) is only a temporary solution. Most farmers would like the government to dig a deep artesian well to cover the village's water demands and to ensure sufficient water supply for irrigation in the long term. Some farmers felt that the process of obtaining government permits for drilling such additional private wells was

unfair, with priority given to large investors and companies. As one farmer stated, “The government does not issue licenses for us to dig wells; the reason being that they want to conserve the aquifer’s water. At the same time they allow companies and investors to dig wells at depths of 650-800 meters and sometimes even 1,000 meters. When we objected, the government allowed us to dig only surface water wells” (Male respondent 3, pers. comm., 2013).

Abu Minqar farmers are not very aware of the finite nature of their groundwater. For many farmers, improved well drilling techniques and strategies can actually solve shortages rather than running aquifers dry.

Another solution to irrigation water shortages mentioned by farmers was the lining of irrigation canals. Some farmers mentioned having a water reservoir to store water for times of need might be a solution, utilizing the free flowing artesian wells during times of no irrigation. Farmers also mentioned switching to pressure irrigation systems such as drip and sprinkler irrigation in order to irrigate more efficiently. Yet, government support in installing such costly systems is needed. Some farmers have adjusted their choice of crops to meet the limited availability of water. Many farmers stopped growing profitable rice, due to its high water demand. Many farmers have shifted to less water demanding crops, such as alfalfa as even maize requires significant water inputs.

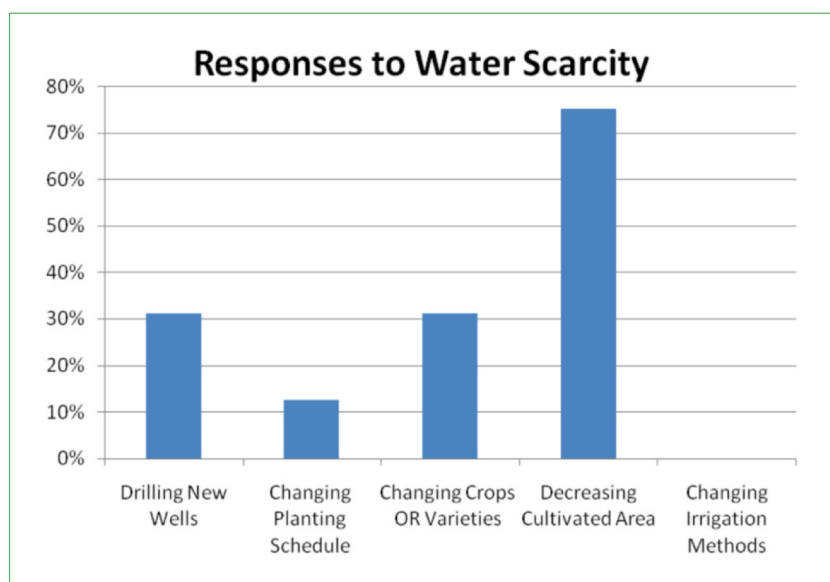


Figure 7: Responses to Water Scarcity in Abu Minqar

Livelihoods and Farming

The main crops grown in Abu Minqar are alfalfa, clover, maize and grasses as livestock fodder crops in addition to wheat, fava beans, rice (although the growth of this water intensive summer crop is prohibited by law in the Western Desert), as well as some dates, olive and vegetables. Wheat is a popular crop as it can be sold directly to the government owned agricultural development bank in the village at a fixed price announced by the government before the start of the season. Farmers can thus securely calculate incomes for wheat production. Marketing is a problem in Abu Minqar given to the community’s distance to large markets. The transportation of some agricultural products is even rendered impossible due to the long. Abu Minqar farmers are largely reliant on traders and middlemen coming into the oasis to buy livestock and agricultural produce. In Abu Minqar irrigation and farming are mainly men’s tasks, although some women do help out with lighter agricultural tasks such as harvesting clover and raising livestock.

Food Security

The most important economic activities in Abu Minqar are growing and marketing crops and livestock. Animal production is a central economic activity in Abu Minqar – both in terms of income generation and input consumption. Livestock and its products serve both as traded and domestic goods. As one farmer mentioned during the interview, “[t]here are three things that are essential to life in Abu Minqar: 1. Flood irrigation, 2. Clover, 3. Our cattle” (Male respondent 13, pers. comm., 2013).

Water shortages have tangible effects on the village’s food security. Most of the interviewees experiencing food insecurity said that it’s due to water scarcity, which restricts their farming area (Figure 8).

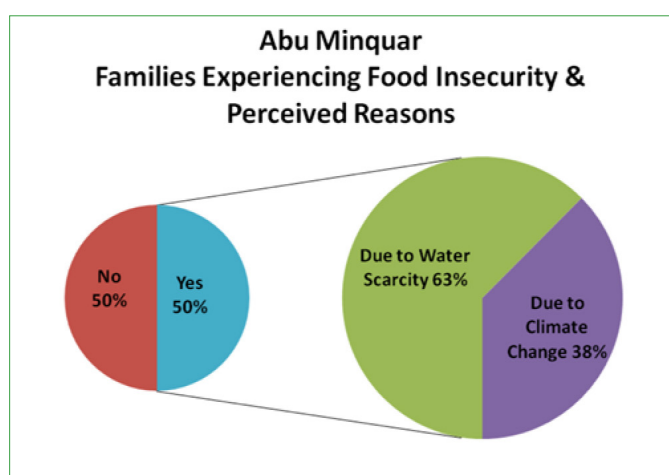


Figure 8: Abu Minqar Families Experiencing Food Insecurity & Perceived Reasons

Climate Impacts

Many farmers interviewed in Abu Minqar stated that they were not aware of a significant change in climate. Some farmers mentioned an increase in temperature over the past few years and stated that they had changed the planting dates for some crops.

4.1.3 Case Study 3: Imam Malek

Population Dynamics

The settlers village of Imam Malek is only around 15 years old, is located in the third region of El Bustan in Nubaria. It has an estimated population of around 5,000 settlers (approximately 1,000 families). Of the first wave of settlers who arrived in Imam Malek, most had previously lived in the El Beheira governorate and were displaced under the land owner-tenant relationship law coming into effect in the Nile Delta. Displaced farmer tenants are called beneficiaries, and they each receive 2.5 *feddan* of land for a low price on installment. University graduates, who also benefit from this settlement scheme each receive 5 *feddan*. Investors owning large horticultural farms cultivate 38,000 *feddan* in Bustan III. Imam Malek is primarily an agricultural village, with most livelihoods revolving around agricultural activities.

Water Sources and Uses

The Nubaria canal supplies all three of El Bustan regions with water from the Nile. A pumping station supplies water to the village of Imam Malek, among others. Water is taken out of the main feeder canal or mesqa to electric pumping stations that push water into the drip and sprinkler irrigation pipes, each serving 20 *feddan* of land. Farmers open their field valves when water is available. Flood irrigation is prohibited in Nubaria, as lands are equipped with pressurized irrigation systems

According to the local governmental agriculture office, the official water distribution schedule consists of three days of water availability in the canal per week, followed by four where the canal is dry. However, four farmers related that water cuts have been increasing, causing water to be unavailable for 5-7 days in a row. One farmer believes that the usual 5-6 day water cuts are one of the main reasons behind what he estimates to be a 40%-60% loss in agricultural yield. A government employee mentioned that the pumping station's supposed efficiency of 10 cubic meters per second has been declining over the years, as the station requires maintenance.

Many farmers in Nubaria specialize in the production of horticultural crops, which are particularly vulnerable to water scarcity. As farmers mentioned, a decrease in irrigation water availability, coupled with the strong winds of the desert, causes young fruits to rip off of trees before maturity, resulting in production loss. A 6-7 day water cut is a significant issue for fields irrigated with sprinkler or drip systems as crops dependent on these systems require more frequent irrigation compared to flood irrigation. In comparison, the two neighboring sectors of El Bustan I and II, receive irrigation water on a daily basis, and experience production losses as insignificant as 1%, according to Male Respondent 4.

The electrical pumping system in Imam Malek is beneficial during times of diesel shortages in Egypt, but also bears risks in the form of electricity cuts. Moreover, fields closer to the canal receive two days of irrigation out of the three available days, while the fields further away irrigate on the third day and at night, the farmer explained. In this system of unequal distribution, the agricultural lands downstream are disadvantaged, often receiving the least water, as 66% of the farmers confirmed⁵. Electricity payments to the government however, are divided up equally among the farmers who share a pipe.

The most common method farmers use to adapt to water shortages is accessing groundwater through wells. Five out of six farmers who mentioned responses to water scarcity said they would drill a well. Wells (which are usually dug by groups of 8 farmers) are usually between 100-120 meters deep, with construction costs rising as wells drill deeper. While wells are a temporary solution during weeks of water scarcity, there are some drawbacks. Other than the significant costs involved in drilling and maintenance, all farmers agreed that well water quality is inferior to Nile water, due to lack of sediments. A less popular response is the construction of a water reservoir to store irrigation water in order to bridge times when the canal is dry. Two other farmers also reported the increased salinity levels of well water negatively affecting land productivity and crops (see Figure 9)

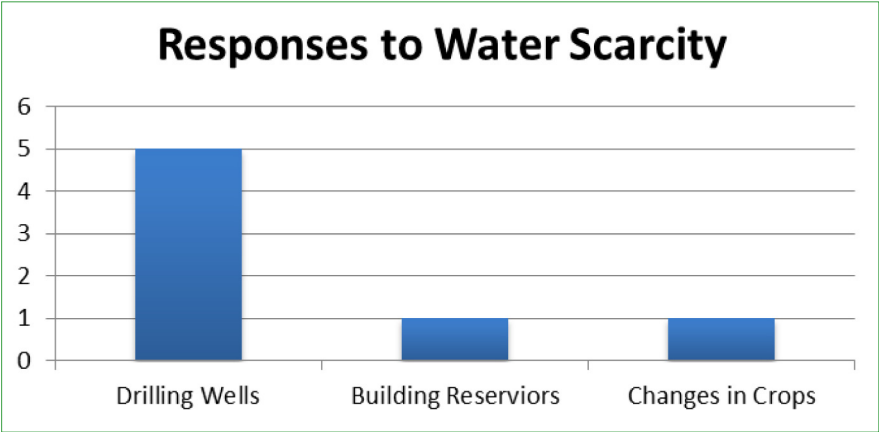


Figure 9: Responses to water scarcity in Imam Malek (Total number of farmers who responded)

⁵ The majority of those commentators have land located at the beginning of the canal.

Livelihoods and Farming

Around 85% of the farmers interviewed cultivate field crops for subsistence purposes, mainly wheat, peanuts, beans, clover, and corn. Some also devote a portion of their land to citrus (Figure 10). All beneficiaries interviewed commented on the fact that the 2.5 *feddan* allocated to each farmer were far from enough to sustain a living. Farmers often try to find more land to rent from graduates in order to get enough produce.

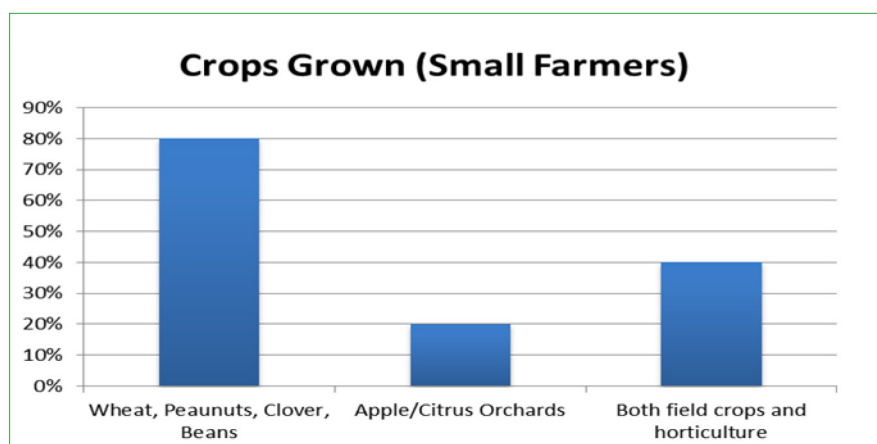


Figure 10: Main Crops grown by small farmers in Imam Malek

Farmers complained about the rising costs of land maintenance and agricultural inputs such as fertilizers and pesticides. The region faces a recent spread of whitefly infections, particularly affecting grape fields. Four respondents cited grievances with regards to the ineffectiveness of often tampered-with fertilizers. Agricultural Association offices in local villages provide fertilizer at subsidized rates for farmers. The amount provided, however, is often not enough, forcing farmers to turn to the free market. Several farmers commented that this years' (2013) peanut harvest experienced extraordinary losses due to under-irrigation.

Food Security

In Imam Malek, much of the population's food requirements derive from what is grown on the village's agricultural lands. Despite this, 33% of the farmers interviewed stated they spent around half their income on food. A third of the farmers reinvest their remaining income into the land (including maintenance and buying fertilizer and pesticides) for the next cropping season. Many farmers are experiencing income loss from their crop yields due to declining market prices. Marketing is an issue that significantly impact farmers' incomes, where merchants often offer very low prices for small farmers' harvests. A large investor acknowledged, "small landowners and farmers are getting destroyed by merchants" (Male respondent 1, pers. comm., 2013).

Climate Impacts

Most farmers were not familiar with the scientific background of climate change and its impact on Egypt. Most of the farmers did not try changing their cropping patterns to cope with climate change. Male Respondent 5 stated that he would be changing his apples trees, as the heat rendered them unproductive. During hot weather, farmers merely increase irrigation hours or intensity as an instinctual response to higher temperatures.

4.2 Lebanon

In Lebanon, the research focused on two sites: the Beqa'a region and Kfardebian. These two target areas were chosen to give a comprehensive approach to the case studies based on the diversity of landscape in Lebanon. The two regions represent a variety in landscapes, agricultural production outputs and socio-economic conditions. The Beqa'a plain is Lebanon's leading agricultural production region and is famous for its open field crops such as wheat, barley, onions, grapes and high quality fruits and vegetables. On the other hand, Kfardebian (in Mount Lebanon) has more water resources but lacks large lands suitable for agriculture. Kfardebian, like most of Mount Lebanon, grows fruit crops, with apples being in the lead. Additionally, vegetables are grown in greenhouses or unprotected.

4.2.1 Case Study 1: Kfardebian

Population Dynamics

Kfardebian is one of the larger villages of Keserwan district and, as such, supports a large population for a high altitude mountain village. The range of economic activities that are practiced in Kfardebian and the surrounding villages allow for a large permanent population to reside within it. Agriculture has long been the backbone of rural economies, and Kfardebian was no exception. However, in modern times, Kfardebian has become a major touristic attraction in both winter and summer. As a result, many locals from Kfardebian invest in service and tourism activities as a reliable and more lucrative source of income.

Population estimates remain tricky in Lebanon, with a lack of an official census. It is estimated that Kfardebian has around 10,000 registered individuals. However, in addition to its resident population, individuals from other villages, permanent and seasonal workers, seasonal residents and occasional visitors swell its population to 30,000 in peak touristic times.

The impact of the Syrian crisis on Kfardebian's population has been felt by an influx of refugees that came to this locality to seek work or shelter. The exact number of refugees within Kfardebian is not yet determined, but current estimates indicate that some 2,000 refugees are living within the Kfardebian. The locals are noticing some negative impacts on water resources and solid waste management due to the refugees.

In Kfardebian, the agriculture workforce among the surveyed farmers was dominated by male workers (69%). However, agriculture fuels certain economic activities that are usually practiced by local women, especially the transformation of raw agricultural products into high quality food items such as jams, molasses, pastes, dried fruits and vegetables, pickled goods among many other staples of the Lebanese diet.

Water Sources and Uses

Kfardebian receives some of the highest amount of rain and snow in Lebanon. Several major springs exist in the village, such as El Assal and El Laban. With the seemingly abundance of water, many farmers in Kfardebian, especially orchard owners, maintain an irrigation system that can be classified as wasteful. In fact, 60% of the surveyed farmers still practice furrow irrigation, whereas only 40% have upgraded their systems to modern ones such as drip or mini-sprinklers (for orchards) (See Figure 11).

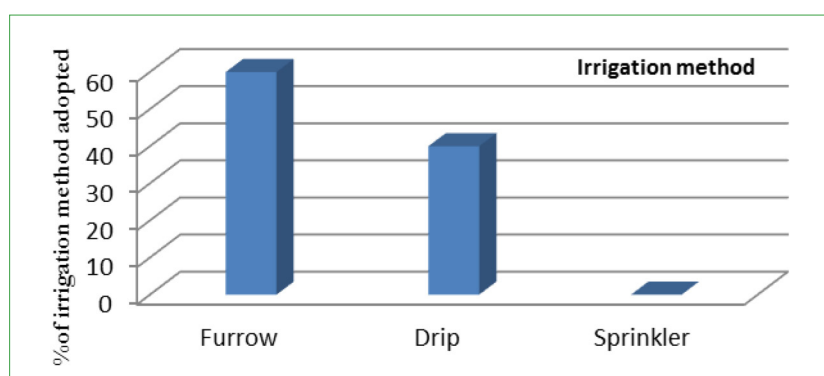


Figure 11: Irrigation methods in Kfardebian

Table 6 shows the main water sources adopted among farmers in Kfardebian

Table 6: Sources of Water Used in Kfardebian

Source of Water	Spring	Artesian Well	Buy and Transport Tank Trucks	Shared water network	Other Means
Percentage of adoption among farmers	70.00%	10.00%	0.00%	30.00%	10.00%

Out of the surveyed farmers, a total of 55.6% expressed that they have not encountered issues with water availability, whereas 44.4% reported the opposite. This divergence in perception between respondents can be attributed to the geographical situation of their orchards. Farmers whose lands are upstream and near major water springs hardly notice a lack of water by the end of summer. However, those situated downstream notice a lack of water, especially towards the end of summer and in early fall.

A lack of proper water treatment poses a threat to the finite water sources of the village. Some locals expressed their concern that the chaos accompanying the Syrian refugee crisis is posing a risk to water resources, as the agglomeration of the refugees within certain parts of the village and the complete lack of sanitation causes effluents to be discharged haphazardly, even in irrigation or water transfer canals. Due to its high elevation, Kfardebian is upstream of many water resources that feed the villages of Keserwan and Maten districts. As a result, the contamination of water resources upstream due to lack of proper sewage networks is also a hazard to downstream communities.

Livelihood and Farming

Farming is still practiced in the village, although its importance has dwindled. Most land holdings are small, as is the case in most mountain villages with a difficult landscape. Around 60% of respondents reported having lands ranging in size between 1 to 10 dunums, and the rest have lands between 10 to 30 dunums. The high real estate value of the lands in the village, the fractioning of lands due to inheritance rights and the lack of large plains (as the nature of the landscape is quite steep and mountainous) provide barriers to large land holdings.

When asked about the ownership of the lands they work, all of the farmers reported that the lands are their own property. However, some lease additional lands in order to expand their production, this is especially true of more experienced and more financially capable farmers.

Fruit orchards form the backbone of agricultural production in Kfardebian, as the weather and the nature of the land provide the ideal conditions for their growth. Apples, pears, peaches, and plums are the most widespread, with apple serving as the most economically significant crop. This corroborates the results of the survey, where all

farmers reported owning orchards (open field) and only one farmer had small greenhouses in addition to his orchard plantations. This is mainly for household vegetables production, as the large-scale production in greenhouses at this altitude is difficult due to the heavy snow pack in winter and the difficult land topography.

Food Security

The importance of agriculture is decreasing for many of the Kfardebian locals, as is the case in most Mount Lebanon villages. The survey conducted among the apple farmers showed that around 70% of them rely on agriculture as their main source of income, whereas this is not the case for the remaining 30%. Fruit orchards remain more lucrative than other agricultural products and, therefore, manage to provide a living for those who depend on them, especially if their lands are not too small.

Additionally, the survey determined that, on average, for farmers that rely on agriculture mainly, there are 3.43 dependent persons per farmer. This reflects the moderate-to-small size of families in this village, which is the norm in the more affluent district of Keserwan.

Food insecurity is not evident in Kfardebian, as farmers and other locals have a variety of economic activities, including the reliance of money sent from diaspora to their families. Nevertheless, it should be noted that farmers use their lands to produce products that can be sold at a high value and do not try to use their holdings to produce the staples of their dietary needs. This is not always the case, especially in poorer areas where subsistence agriculture is more widespread. The increase in the prices of fertilizers and pesticides and the absence of an established crop calendar increase the initial cost of production for farmers and limit productivity with the drop of market prices.

Climate Impacts

During the field visits to Kfardebian and interviews with the farmers, 80% of them reported a noticeable change in climate. The change in weather is affecting their production quantity and quality. The last growing season, for example, was catastrophic, as late hailstorms damaged the flower stage of the orchards, which also affected pollination and reduced production significantly to very low rates. Another climatic condition the farmers reported was the longer period of sustained high humidity, which is increasing the likelihood of fungal disease attacks and infection, thereby affecting quality and yield. Apple scab is one of the main diseases affecting the apple production in this area, and it is usually favored by high humidity with the availability of a film of water on the previously infected leaves.

The earlier onset of colder temperatures and the prolonged periods of drought, which are causing irrigation problems in late summer, have forced many farmers to favor the use of early maturing varieties or mixing such varieties with traditional ones to ensure the productivity of their orchards.

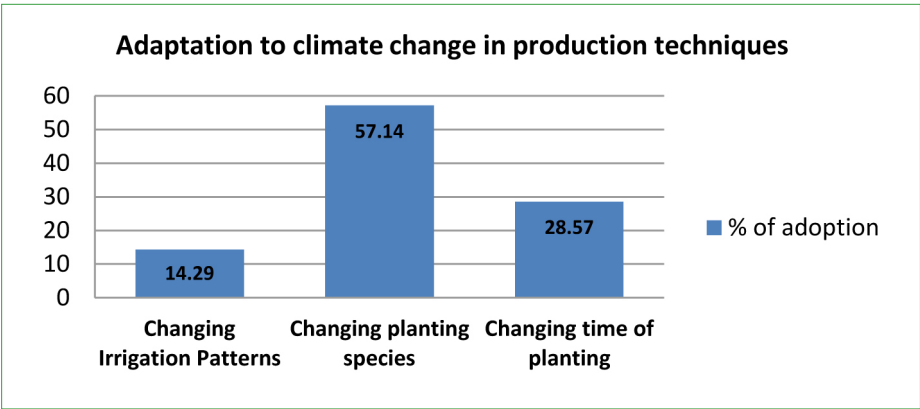


Figure 12: Adaptation to climate change in production techniques

Having those noticeable climatic changes, 60% of the farmers interviewed had a clear idea on climate change and its effects (Table 7), and they have started to engage in some adaptation measures.

Table 7: Climate Change Knowledge

Knowledge of climate change	Yes	No
Percentage of farmers (%)	60	40

As such, 57% of the farmers shifted to new varieties more adapted to the change in climate. Additionally, 14% of the farmers interviewed in Kfardebian made changes to their irrigation practices in response to this change in climate (see Figure 12). Most of the farmers who changed to better irrigation methods (drip) are the ones planting vegetables and maintaining orchards, and now they are using bubbler irrigation or short sprinklers instead of surface irrigation, which is more water demanding. While orchard producers can change varieties to adapt to climatic changes, they cannot change planting time, since trees are only planted once and then last for several seasons. This makes the choice of appropriate varieties more delicate. The farmers in this region had a fair knowledge of climate change, as most of them reported knowing and understanding the meaning of climate change and its impacts. This is attributed to their higher education level and to the dependency of their growing system on parameters such as humidity, temperature and water availability.

Pest and diseases increased noticeably by an average of 40%, as stated by 80% of the interviewed farmers, due to weather conditions compounded by poor management as well as the suspected decrease in the quality of available pesticides, which led to an increase of chemical inputs usage. Farmers receive very little extension support from the MoA, and they are left to take whatever decision they deem suitable.

4.2.2 Case Study 2: Beqa'a

Population Dynamics

The central Beqa'a between the districts of Zahleh and Baalback is more densely populated than all other regions in the Beqa'a and has been inhabited since ancient times due to the productive nature of its lands. Agriculture remains a central economic activity in the Beqa'a, employing a large percentage of the active population and allowing the most important agro-industries of the country to be based there. Besides agriculture and agriculture-derived industries, the Beqa'a has a number of other economic activities to support its growing population, including trade and small-scale industries.

The Beqa'a families are larger, on average, than their counterparts in Mount Lebanon. This is especially true among farming families, as evidenced by the number of dependents per person among the surveyed farmers, which averaged at 6.42 individuals. This indicates that the Beqa'a population grows at a faster rate than in other parts of the country.

The Beqa'a's geographical proximity to Syria has led to the displacement of a large number of Syrian refugees to it. As of December 6, 2013 the UNHCR figures indicate that the number of Syrian refugees in the Beqa'a is 274,235 individuals - nearly equal to the combined population of the two largest districts in the Beqa'a. This sudden dramatic rise in population has a deep impact on the limited water resources of the region and increases the strain on the economies of the mostly underdeveloped villages of the Beqa'a. Additionally, though a large number of the refugees are residing in homes within the villages and cities of the Beqa'a, the extremely poor ones are living in tents built, in most cases, on agricultural lands. Though the areas these camps occupy are not large, the production potential is lost. Further compounding the environmental, economic and social stress is the lack of adequate solid waste management and a water infrastructure to cater to these refugees. Within the surveyed municipalities, some took drastic measures against refugees and banned their entry to their territories. This was the case in Rayak, whereas Talia and Hawch el Refka host around 300 refugees – 15% of their combined population.

In the Beqa'a, the agriculture workforce among the surveyed farmers was dominated by female workers (71% of

workforce). These females are employed seasonally and come from nomadic or gypsy communities that have lived in the Beqa'a for many generations now. The larger workforce needed in the Beqa'a is due to the nature of crops grown, such as potatoes, tobacco, vegetables and others that require picking, collection, careful cleaning and packaging. Females are preferred in many cases because of the lower remuneration rates they receive. The local females of the Beqa'a also engage in economic activities that are fueled by agriculture, such as the preparation of "mouneh" (food cooked, stocked and used out of season, mainly during winter) or other food commodities. Many local NGOs based in the area see the knowledge of local women in the transformation of raw agricultural products into high quality food as means to enhance their living conditions, provide them with economic independence and improve their social standing.

Water Sources and Uses

The Beqa'a plain's climate is controlled by its geographic inland location locked between two mountain ranges. The northern and eastern parts of the Beqa'a are the driest parts of Lebanon whereas the central and southern parts have a more humid climate. The Beqa'a receives less rain than Mount Lebanon and North Lebanon. However, the plain is rich in its rivers and springs. The Litani River and its twelve tributaries constitute the Upper Litani watershed flowing into the Qaroun Lake - a vital water resource for the Beqa'a and for Lebanon. The groundwater resources of the Beqa'a are an important source of water that the Beqa'a population relies upon for potable water and irrigation.

Depending on their location, the Beqa'a farmers' sources of irrigation water are either from a well, irrigation networks or surface water bodies – namely the Litani and its tributaries. The interviewed farmers showed a clear preference for digging wells as their main source of water. In fact, 95% of them rely on groundwater, whereas only 5% use spring water for irrigation (see Table 8).

Table 8: Water Source in Beqa'a

Water Source	Spring	Artesian Well	Buy and Transport Tank Trucks	Shared water network	Other Means
Percentage %	4.76%	95.24%	0.00%	0.00%	0.00%

Most of the lands of the surveyed farmers in central Beqa'a are irrigated especially for greenhouse production. Irrigation practices in the Beqa'a have been upgraded over the years, and farmers rely on modern irrigation techniques. In fact, most use sprinklers and drip irrigation, whereas furrow irrigation is marginally practiced, with use in around 10% of the surveyed sites (see Figure 13).

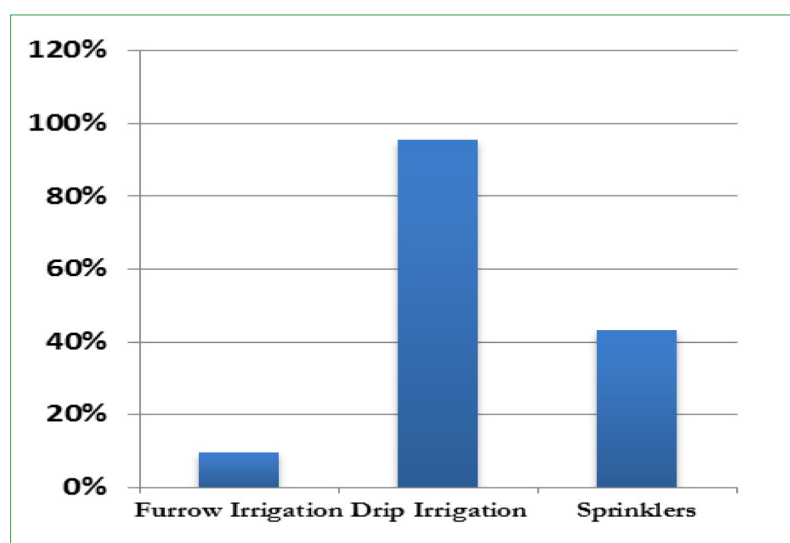


Figure 13: Type of Irrigation systems

Out of the surveyed farmers, a total of 81% expressed that they have encountered issues with water availability, whereas the remainder have not faced such a problem. This clearly indicates that water availability will be more problematic in the near future, which should stimulate more research and practical solutions to reduce water consumption, especially in key crops.

Livelihoods and Farming

Beqa'a represents one of the most fertile areas in Lebanon. Farmers in eastern and central Beqa'a, where semiarid environmental conditions prevail, usually plant open field crops such as wheat, barley, potatoes and grains in addition to vegetable production in greenhouses approximately all year round and in open field during summer time.

During the field visits, it was determined that the majority of the farmers grow open field crops. However, many grow vegetables under greenhouses along with their open fields to ensure year-round production (see Table 9).

Table 9: Type of Agriculture

Agriculture Type	Open Field	Greenhouse
Percentage %	95.24%	80.95%

As shown in Figure 14, land tenure differs between farmers. While most own their lands (around 71.43%), many lease and some even lease lands in addition to their owned land, as this helps them to increase their production. Leasing is especially helpful for farmers who grow crops in greenhouses, as after repeated years of growing a narrow selection of crops, diseases and pests start building up and soil salinity increases leading to a decrease of land productivity. Thus, leasing and then turning the land over to other farmers who typically would not pursue greenhouse production is beneficial to the farmers and the land itself.

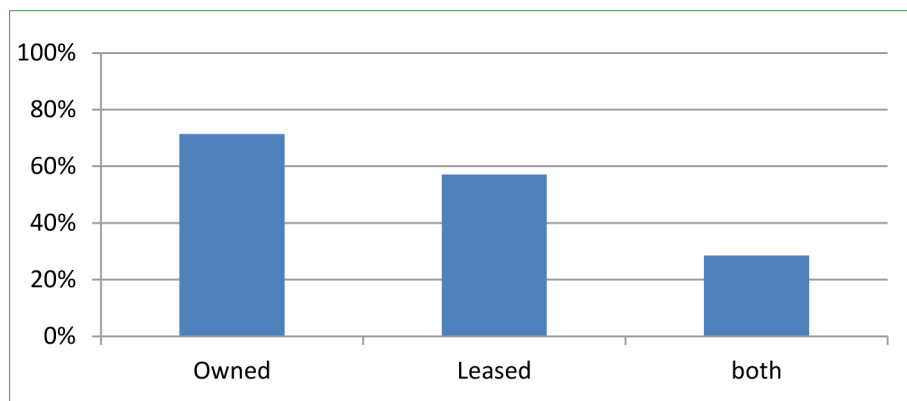


Figure 14: Land Tenure

Food Security

Agriculture remains an important economic activity in the Beqa'a. Agriculture is the exclusive source of income for the vast majority of the surveyed farmers in the Beqa'a as 90.5% reported that agriculture is the only economic activity they pursue, whereas 9.5% engage in additional activities to complement and support the income they generate from their lands. Additionally, the survey determined that, on average, for farmers that rely on agriculture mainly, there are 6.4 dependent persons per farmer, reflecting the fairly large size of families that is more common in the Beqa'a.

Though most of the Beqa'a villages can be considered of middle income, in general, with some poor areas, food availability and food quality can become problematic for the less fortunate families. However, most farmers will use a small portion of their lands to produce some of the products they would likely consume and otherwise buy at higher prices, which increases their resilience to food price fluctuation and shortages. The increase in the prices of fertilizers and pesticides and the absence of an established crop calendar both increase the initial cost of production for farmers and limit productivity with the drop of market prices. Most of the surveyed Beqa'a farmers use their lands to produce products that can be sold at a high value, and most of them try to diversify their crop profile in order to have continuous production, which allows them to be more profitable.

Climate Impacts

Central Beqa'a is considered to have a semi-arid climate characterized by cold winters, with rain and snow from mid-December to late February, and hot summers temperatures starting mid-May till late August. Farmers in the region are used to these climatic features and synchronize their planting depending on weather conditions that get repeated year after year. During the field surveys in the Beqa'a, all of the interviewed farmers noticed a change in weather conditions in the past 10 years that is affecting their regular planting cycle. The interviewed farmers explained that they are witnessing an early onset of colder temperatures in the late summer by as much as one month, which severely affects their summer plantation, especially the annual open field crops. This includes cereals and vegetables, leading to a loss of one month of production and a drop of their revenues.

This change in temperatures each year led 90.5% of the interviewed farmers to change the time of plantation in order for their crops to mature earlier in summer to have better production before the drop of temperatures kills their crops. This decrease in the length of the cropping season affected the production quantity, as reported by 95% of the interviewed farmers. Pests and diseases increased, as confirmed by all of the interviewed farmers. This induced 90% of the interviewed farmers to use more pesticides for control.

As a result of the water shortages, due to the change in climate, 88% of the farmers interviewed dug an additional artesian well to adapt. 23.5% of them made their wells deeper, and only 12% changed their irrigation systems. This latter number is low probably because the majority of the farmers already use efficient irrigation systems like drip or sprinkler irrigation.

Another adaptation measure practiced by 79% of those farmers was the change in the time of planting to adapt to the early drop of temperatures in order to avoid crop loss. 42% of farmers changed the variety to be more suitable to the change in climate and ensure high production.

When asked about their familiarity with climate change, the majority of the Beqa'a respondents reported their lack of knowledge about the topic (76.19%). However, this does not mean they are not taking note of changes in climatic phenomena. Rather, climate change as a global threat is not something they are familiar with, even if they are facing local changes in climate conditions.

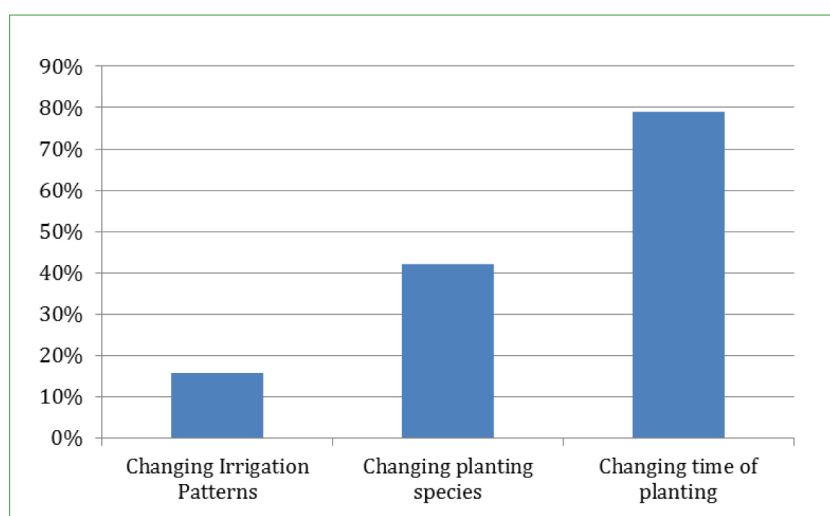


Figure 15: Adaptation Techniques to Climate Change

4.3 Cross-Case Analysis

Population Dynamics

All three villages in Egypt have been experiencing slight population growth, albeit not at alarming rates. Although each village will be indirectly affected by overall population growth in Egypt, the direct impacts of current levels of population growth on water availability, food security or agricultural productivity seem rather limited in these villages. However, the shrinking size of land holdings due to family growth and land inheritance is likely already affecting agricultural productivity and may grow increasingly important in the coming years. Additionally, the growth in population and its attendant increase in agricultural demand can be expected to put additional strain on both water quantity and quality in the near-to-medium term.

The population situation in the Lebanon sites is rather different from Egypt. In addition to the higher natural population growth rate in both areas in Lebanon, they also experience significant pressures due to the influx of Syrian refugees. This has already had measurable impacts on the villages in terms of water availability (both quantity and quality, due to pressures on the waste treatment system), food security and even agriculture land availability as the refugee population seeks accommodation. The tourism boom is also driving an important shift in labor and livelihoods away from agriculture.

Water Sources and Uses

Both Shubra Qubala and Imam Malek draw their water mostly from the Nile. In both villages, farmers complain about official water distribution schedules being unreliable. In Imam Malek, farmers are particularly frustrated with this condition, given that by preparing land for settlement for these farmers in Nubaria, the government had promised to make enough water available for cultivation. Farmers in Abu Minqar also complain about water shortages, which are a result of deep groundwater wells running dry. As Abu Minqar, too, is a settler village, there are similar sentiments of government responsibility for water provision.

Farmers in all three villages have turned to private well drilling in order to obtain sufficient amounts of water needed to irrigate their land. In Abu Minqar, farmers have started irrigating significantly smaller plots due to water shortages, particularly in summer, and have adapted their crop selection to water shortages. In Shubra Qubala and Imam Malek some farmers have also reported changes in crop selection, however at less significant levels. Other responses to water shortages in Abu Minqar have been canal lining and the installation of drip and sprinkler irrigation. In Nubaria,

farmers already operate on drip and sprinkler irrigation with pipes replacing tertiary canals, while in Shubra Qubala no farmers have changed their irrigation practices or lined canals.

There are numerous parallels between the conditions in the Egypt sites and those in Lebanon. As in the Egypt case study locations, both the Kfardebian and the Beqa'a sites have significant sources of water (surface springs for the former, and springs and groundwater for the latter). The downstream locations noted water stress in Kfardebian, indicating challenges in water management, given the relative abundance of water available from the springs. While the Beqa'a sites did not experience this due to their reliance on groundwater wells, an even higher percentage indicated experiences with water scarcity. As in the Egypt sites, the different agriculture water sources and levels of perceived water scarcity have contributed to different irrigation practices and responses. Similar to Shubra Qubala, the relative abundance of availability of water from springs is a contributor to the dominance of less efficient furrow-style irrigation. However, in the Beqa'a, as in Abu Minqar and Imam Malek, the reliance on groundwater and other farming system conditions have helped shaped the significant use of drip and sprinkler irrigation.

Livelihoods and Farming

In all villages, farmers are starting to diversify their income by taking up employment outside farming or starting a small enterprise such as a small shop. Farmers in all three villages complained about the rising costs of agricultural inputs such as fertilizers and pesticides, while farmers particularly in Nubaria complained about the tampering with fertilizers and pesticides, causing them to spend large amounts of money on ineffective products.

While the disparate climate and landscape in Lebanon compared to Egypt results in somewhat different crop portfolios, the irrigation systems in Egypt lead to some similarities. The drier Beqa'a has some overlap with the Egypt sites, with significant cereal production and some vegetables. In Kfardebian, however, orchards dominate, somewhat similar to the situation in Imam Malek, though to an even great degree and using less efficient irrigation systems due to the high availability of water. Overall, those engaged in agriculture in the Lebanon sites appear to have more reliance on other employment outlets than the farmers in the Egypt sites. While the general situation in Kfardebian is leading to a diminishing role of agriculture, several farmers in the study are expanding their orchards and all own their own lands.

Food Security

In all three Egyptian villages, farmers reserve a portion of their agricultural production for subsistence. As agricultural production decreases, some farmers only have this subsistence part left and nothing to sell, leading to significantly reduced family income. Farmers in all communities have livestock such as cows, sheep, goats and poultry for milk, egg and meat production. Farmers in all three villages spend a significant amount of income on purchasing food and suffer greatly from the increased food prices in Egypt.

The situation in the Egypt sites is generally rather different from that in the Lebanon regions, and particularly with the farmer respondents in the Lebanon surveys. None of the surveyed farmers in Kfardebian included agricultural outputs for subsistence, and this seemed to largely reflect conditions in the area. The farmers are able to raise and sell high value crops and then meet all food needs on the market. Among those interviewed, there were essentially no concerns regarding food security. The farmer respondents in Beqa'a also experienced little to no food security concerns, though subsistence farming is more prominent in the region than in Kfardebian, and the region is in general poorer.

While the ability to earn sufficient income to allow for food purchase offers great food security in general, there are also increased risks from market fluctuations. Farmers in both Kfardebian and the Beqa'a complained of increases in input costs. This similarity to the sites in Egypt conveys the significance of this issue across multiple systems and levels of reliance on subsistence farming. However, the greater availability of funds to purchase food appears to provide agriculture families in Lebanon with more diverse food options than those found in Egypt.

Climate impacts

There were no conclusive, tangible results on the local impact of climate change in the Egypt sites. While some farmers in each of the three communities felt that it was getting hotter, others in the same community reported no change in climate. Farmers showed no, or very low, awareness of climate change itself, and it was only through indirect questions about local weather, extreme weather events and planting dates that the researchers were able to gather information about possibly changing climate conditions.

The situation was markedly different in the Lebanon sites. Nearly a quarter of the respondents in Beqa'a were familiar with climate change, and a full 60% of those in Kfardebian were aware of this issue. The difference between the two may largely be attributed to education level (with Kfardebain much more educated on average). While this might also explain some of the differences with Egypt on the issue, the more significant factor is likely the great degree to which agriculture communities in the Lebanon sites report having experienced a changing climate over the past ten years. This is likely driven by both more observable changes in the local climate as well as greater reliance of the irrigation systems in Lebanon on rainfall.

The respondents in Lebanon reported a strong emphasis on changing practices to adapt to the changing climate and its impacts, including lower or more variable water supply. This included changing planting time and the variety planted. Respondents also indicated that they had made changes to the irrigation system/patterns and efforts to improve reliable water availability. Importantly, these activities, which include digging new or deeper wells, are consistent with actions reported in the Egypt case studies. However, in the latter, the activities are framed as responses to water scarcity, while in Lebanon they were often reported as climate change adaptation strategies. Thus, while the experience of climate change may be less pressing in Egypt, communities in both countries are experiencing similar climate and/or water-related pressures and seeking to respond in somewhat similar approaches.

Key challenges solutions and analysis

Across the Egypt sites, the principal concerns regard availability of sufficient and reliable water sources. In Shubra Qubala, the primary issue is shortage of canal water from the Nile River and unreliability of irrigation water provision. The unreliability of water schedules is also a leading challenge in Imam Malek, with a main contributor being technical and mechanical failures in addition to poor and unequal distribution. While a critical significant constraint for Abu Minqar is also water scarcity, it is largely due to decreasing availability of water from existing deep wells in the Nubian Aquifer and lack of resources or ability to drill deeper or new wells.

While water scarcity was cited as a key challenge in the Beqa'a, there were some differences between how it was perceived and experienced in Egypt versus Lebanon. The awareness of climate change was quite low in the Egypt sites, and the water scarcity issues were almost entirely attributed to direct human-related management or technical constraints. However, the key driver for scarcity in the Beqa'a was identified as decreasing rain and snowfall. In general, population growth was not cited as a key challenge in the Egypt sites. While population growth in the other Egypt locations was not significant, there is awareness that the combination of decreased water availability and increasing demand by more people could have a more serious impact in the future. It is clear that the spike in population due to the Syrian refugee situation is an immediate and critical challenge for the Lebanese villages, in terms of pressures on both food and water security.

For communities in both Egypt and Lebanon, the challenges from water scarcity, climate change and population are all compounded by increases financial burdens. Financial constraints also compound challenges in nearly all sites where well drilling is necessary, given that costs of drilling wells and running pumps are increasing. Given that the most common response to water scarcity across the sites in Egypt and in some parts of the Lebanon regions is the drill informal wells, the rising costs are creating more significant financial barriers to successful farming.

Many of the necessary solutions to the key challenges require investment and improvements from the national and sub-national governments. As drawn from both countries' case studies and applicable in each context, the

government (in partnership with the private sector) can help address these barriers through increased agriculture extension, improved skills and technical training, enforcement of fertilizer and pesticide price and quality regulation, agricultural marketing support, and improved water infrastructure and management of existing systems.

The findings in these case studies can be understood to be representative of a wide range of different on-the-ground conditions, both within the two research countries and elsewhere in the region. While it is critical to conduct further research and analysis of other ecosystems, landscapes and socioeconomic conditions (e.g., coastal regions facing sea level rise, urban or peri-urban areas, and communities with significantly different government involvement), the case studies in this project cover rather disparate conditions and reflect a spectrum of possible impacts and responses. Ultimately, findings such as well-drilling as a response to scarcity, an overall limited awareness of climate change science, and the need for more active and informed support from national and sub-national governments can be seen across both countries and many others in the region. Thus, the recommendations and further analysis in the subsequent section may be able to be broadly applied in similar contexts elsewhere in these countries and region. It could also be of great value to fund and conduct projects similar to this one, but focusing on vastly different conditions.

Following is a summary table of the agriculture, water and climate conditions as well as the farmer responses in the five sites of the case studies.

Table 10: Summary of Agriculture, Water and Climate Conditions and Farmer Responses

ABU MINQAR	SHUBRA QUBALA	IMAM MALEK	BEQA'A	KFARDEBIAN
Desert	Delta	Desert	Plateau between mountains	Mountainous
Flood irrigation / some drip and sprinkler	Flood irrigation	Drip and sprinkler irrigation	Drip and sprinkler, little furrow irrigation	Furrow irrigation, some drip
Main complaint water scarcity Wells running dry	Main complaint water scarcity Mismanagement, unequal distribution	Main complaint water scarcity Mismanagement, technical failure	Water scarcity and quality key constraints Wells facing challenges	Water availability and quality key constraints Downstream suffers most
Decreasing agricultural area Drilling private deep wells Changing crops	Over-irrigating when water is available Drilling private shallow wells	Drilling wells as temporary solution Water reservoir	Change planting time and varieties, some changing irrigation patterns	Change crop varieties, planting time and irrigation patterns
Mainly open field crops Some date palm	Open field crops, some horticulture Cotton virtually abandoned	Horticulture and field crops	Open field crops and many greenhouses for vegetable production	Fruit orchards, limited greenhouses for household vegetables
Water scarcity impact on food security Improved access and services	Subsistence but large portion of income spent on food	Subsistence but large portion of income spent on food	Limited subsistence, mostly sell high value crops for food purchase; most rely solely on agriculture for work	Sell high value crops to purchase food; many use agriculture as work supplement
Some change in temperature noted No conclusive evidence	Some change in temperature and occurrence of rain mentioned	Fire caused by extreme heat Crop loss due to extreme cold and hail	Changing crop seasons (onset and length), changing climate averages; reduced rainfall and snowmelt	Increased extreme weather events, changing crop seasons, changing climate averages

5. Recommendations

5.1 Egypt case study recommendations

The recommendations for Egypt case studies are summarized in the following table per site.

Table 11: Recommendations for Egypt Case Study

Abu Minqar	Shubra Qubala	Imam Malek
More efficient irrigation infrastructure and practices: Lining canals, switching to drip and sprinkler irrigation, water reservoirs	More efficient irrigation infrastructure and practices: Pipe conveyance flood irrigation systems as practiced in neighboring village Switching to drip and sprinkler irrigation	Bridging supply gaps: Water storage facilities
Improved cultivation systems: e.g. raised bed	Improved cultivation systems: e.g. raised bed	Farmer cooperatives helping to avoid fraud
More water efficient, heat tolerant crop varieties	More water efficient, heat tolerant crop varieties	More water efficient, heat tolerant crop varieties
Integrated farming systems that implement 'more crop per drop' and reuse drainage water	Integrated farming systems that implement 'more crop per drop' and reuse drainage water	
Large scale planting and marketing through farmer cooperatives	Large scale planting and marketing through farmer cooperatives	Large scale planting and marketing through farmer cooperatives

Recommendations that could be implemented and up-scaled at a national level in Egypt:⁶

1. Research

- *Data base for national findings and recommendations* - collecting and compiling research results and data collected in Egypt about climate change, water scarcity, food security and response strategies in a centralized database would greatly assist the implementation of strategic interventions. Such data could also help prepare a toolkit of farmer responses that could be compared with knowledge about best practices, thereby informing knowledge and capacity building approaches.
- *Agricultural and climate mapping* - in order to strategically plan and coordinate crop production according to area and expected climate and water availability changes, the development of an agricultural map that reflects expected climate projections is essential

2. Education and Extension

Bridging the gap between research institutions, government agencies, farmer associations and farmers - more efficient extension and educational models are needed. Possible approaches would include raising extension agents' capacity and training, bridging the gap between senior and junior agriculture students, raising the enrolment of students in agriculture and making sure government extension agents, engineers and technicians are hired based on a minimum catalogue of skills and experiences.

⁶ As per experts participating in workshop held in Cairo

- *Visible pilot fields in villages* - showcase best practice farming solutions on demonstration plot that can be observed by farmers without them having to bear the financial risk of experimenting with new solutions.
- *Key farmers* - partnering with key farmers and community champions is essential, as these farmers can implement best practice examples and enhance farmer to farmer knowledge transfer.
- *IT-based extension* - most promising in Egypt: SMS extension services: Governmental extension services should collaborate with private Telecom companies to provide farmers with sufficient and useful agriculture related issues and conditions. i.e. crop water requirement, weather forecast, best agricultural practices, provision of new crops and varieties, market prices, notifications of prohibited or tampered-with fertilizers/pesticides, etc.

3. Encouraging Private Investment

- *Private sector investments incentives* - investors are better positioned than small farmers to make investments in water efficient irrigation technology; cost sharing schemes involving government/donors/private sector might provide incentives for farmers to make investments.
- *Private sector services* - efforts to involve the private sector in providing and maintaining water management infrastructure. Private sector can be involved as a contractor to provide machinery, fertilizers, etc.

4. Government Incentives

- *Obligatory crop selection and rotation* - possibility to introduce obligatory set crop rotation per area in response to water scarcity and climate change impacts, including incentives such as set higher prices for participants, subsidies on fertilizers or assistance with crop marketing, providing security for farmers. This solution would limit farmers' freedom on crop choices, however.
- *Land consolidation and joint production/marketing* - encouragement of farmer cooperatives, associations or companies run by farmers that enable mass production and marketing. Farmer cooperatives could be supported through incentives, while the private sector can act as a wholesaling agent. Financial incentives to encourage urban agriculture, green roofs, hydroponics, aquaponics on roofs to help with climate change alleviation.
- *Rationalizing virtual water flows* - importing high water consuming crops and exporting low water consuming crops.

5.2 Lebanon case study recommendations

Governmental policies should focus on improving the extension and outreach programs at the Ministry of Agriculture. Equally important is the launching of awareness campaigns to educate farmers on the climate change phenomenon and helping point out what farmers must know and do in terms of adaptation efforts and behavioral change (leading to applied activity changes). Recommendations for both Kfardebian and Beqa'a are summarized in tables 12 and 13 respectively.

Table 12: Recommendations for Kfardebian Area

Recommendations – Kfardebian	Implementer/ funder	Obstacles	How to overcome obstacles
More efficient irrigation infrastructure and practices Upgrade from surface irrigation to drip and micro-sprinkler irrigations systems, and build water reservoirs and hill lakes.	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Land structures • Cost 	<ul style="list-style-type: none"> • Secure funding from international donors or Ministry of Agriculture • Secure loans from agriculture companies
Improved cultivation systems: e.g. raised beds	<ul style="list-style-type: none"> • Farmers 	<ul style="list-style-type: none"> • Lack of Knowhow 	<ul style="list-style-type: none"> • Provide technical trainings
Use more water efficient, heat tolerant, early-maturing fruit crop varieties	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Lack of know how • Availability 	<ul style="list-style-type: none"> • Work with reputable companies
Adopt integrated pest management techniques	<ul style="list-style-type: none"> • Private sector • NGOs 	<ul style="list-style-type: none"> • Lack of know how • Cost 	<ul style="list-style-type: none"> • Technical trainings • Extension agents follow up
Use improved orchard varieties / grafting	<ul style="list-style-type: none"> • Private institutions • NGOs 	<ul style="list-style-type: none"> • - Lack of know how • - Higher costs 	<ul style="list-style-type: none"> • Provide technical trainings • Work with reputable seed companies
Introduce conservation agriculture (no till), intercropping between fruit orchards	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Lack of knowhow • Availability of equipment 	<ul style="list-style-type: none"> • Provide technical trainings • Link to input suppliers offering no-till equipment
Optimize the role of agriculture cooperatives in reducing input costs, marketing and extension services	<ul style="list-style-type: none"> • NGOs 	<ul style="list-style-type: none"> • Seriousness of cooperative work 	<ul style="list-style-type: none"> • Good selection of serious cooperatives working with farmers
Implement a good crop calendar to improve marketing	<ul style="list-style-type: none"> • Governmental institutions 	<ul style="list-style-type: none"> • Lack of government actions 	<ul style="list-style-type: none"> • Good government strategy
Use carton boxes packaging with good labeling	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Lack of governmental and NGO initiatives 	<ul style="list-style-type: none"> • International or local funding to projects
Record keeping	<ul style="list-style-type: none"> • NGOs 	<ul style="list-style-type: none"> • Lack of governmental and NGO initiatives 	<ul style="list-style-type: none"> • Training on its importance

Table 13: Recommendations for Beqa'a

Recommendations – Beqa'a	Implementer/ funder	Obstacles	How to overcome obstacles
More efficient irrigation infrastructure and practices (such as building water reservoirs)	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Financial • Land structures 	<ul style="list-style-type: none"> • Secure funding from international donors of Ministry of Agriculture
Improved cultivation systems (e.g. raised beds)	<ul style="list-style-type: none"> • Farmers 	<ul style="list-style-type: none"> • Know-how 	<ul style="list-style-type: none"> • Provide technical trainings
Use more water efficient, heat tolerant and high producing crop varieties	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Know-how • Availability 	<ul style="list-style-type: none"> • Work with reputable companies
For protected agriculture, improve greenhouse structures from regular hoop houses to side wall greenhouses with side nets and use Integrated pest management techniques	<ul style="list-style-type: none"> • Private sector • NGOs 	<ul style="list-style-type: none"> • Know-how • Cost 	<ul style="list-style-type: none"> • Select local good companies • Loans availability
Use grafted vegetables seedlings	<ul style="list-style-type: none"> • Private institutions • NGOs 	<ul style="list-style-type: none"> • Knowhow • Higher Cost 	<ul style="list-style-type: none"> • Provide technical trainings • Work with reputable seed companies
Introduce conservation agriculture (no till)	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Knowhow • Availability of equipment 	<ul style="list-style-type: none"> • Provide technical trainings • Linkage to input suppliers offering no-till equipment
Optimize the role of agriculture cooperatives in reducing input costs, marketing and extension services	<ul style="list-style-type: none"> • NGOs 	<ul style="list-style-type: none"> • Seriousness of cooperative work 	<ul style="list-style-type: none"> • Good selection of serious cooperatives working with farmers
Implement a good crop calendar to improve marketing	<ul style="list-style-type: none"> • Governmental institutions 	<ul style="list-style-type: none"> • Lack of government actions 	<ul style="list-style-type: none"> • Good government strategy
Use carton boxes packaging with good labeling	<ul style="list-style-type: none"> • Governmental institutions • NGOs 	<ul style="list-style-type: none"> • Lack of governmental and NGO initiatives 	<ul style="list-style-type: none"> • International or local funding to projects
Record keeping	<ul style="list-style-type: none"> • NGOs 	<ul style="list-style-type: none"> • lack of governmental and NGO initiatives 	<ul style="list-style-type: none"> • Training on its importance

Below are some of the recommendations for future research and activities in the field⁷:

- Encourage academic centers to engage in studies on enhanced agricultural practices and the development of varieties of plant crops that are more resilient to climatic changes.
- Through extension work, spread agricultural practices that ensure higher adaptation to foreseen changes, such as grafting on vegetables on rootstocks that are adapted to drought and higher temperatures.
- Use the Technology Needs Assessment as a launching pad to develop its general concepts into concrete and tangible projects that are cross-cutting and affect a wide range of sectors.
- Educate farmers on water scarcity issues and instruct them on means of determining their water use and means to optimize it.
- Conduct qualitative surveys and interviews for a more in-depth study of targeted localities and a better understanding of the needs of local communities.
- Study the order of priority of water availability and consumption, food security, land use, and agriculture practices for Lebanese farmers, and investigate the connection of these factors together and their combined effect on agriculture and the environment.
- Tackle important topics separately (e.g., water use optimization or resistant crop varieties), and then combine various results into a unified framework to have a comprehensive picture of the problem.

7 As per experts participating in workshop held in Beirut

6. Conclusions

Projects such as this one are critical for fully understanding how communities and countries are affected by growing environmental and human-caused threats, how they are responding, and ideas for how they can improve their adaptation strategies. With the invaluable benefit of being able to draw from in-depth literature review, expert consultations and findings from case studies in disparate conditions in multiple sites across two countries, the team has identified the two sets of broad recommendations below.

On the Farmers Level:

- Consider drip and/or sprinkler irrigation
- Change crop pattern, calendar and/or variety
- Invest in lining canals or small retention reservoirs
- Explore options for water reuse and multiuse systems
- Collaborate with other farmers for water management and land use
- Share knowledge with decision makers on priorities

These proposed changes in equipment and/or practices will ultimately be taken up by individual farmers or sometimes groups of farmers. However, they currently face challenges due to financial constraints, limited knowledge or technical knowhow and limited availability of resources to implement these solutions. The recommendation to collaborate with other farmers can be a robust option for aggregating resources and centralizing forces to seek and secure additional resources. A combination of support from the government, NGOs and private sector can help address these obstacles. There is a key role for international donors and the development community to address these barriers through offering targeted support for the above recommendations and the critical needs identified by stakeholders.

On the donors and high level decision makers:

- Invest in research on best practices, including successes and failures of previous projects
- Strengthen agriculture extension – e.g., through improved training and demonstration farms
- Develop stronger connections with farmers to improve two-way communication channels
- Promote institutional and policy architecture for water user associations
- Improve data collection, quality control, dissemination and use in water and agriculture
- Identify, support and scale-up successful and innovative practices and technologies
- Increase local control for water and agriculture resource management

Bibliography

- Abdel-Shafy, H.I. and Aly, R.O., 2002: Water Issue in Egypt: Resources, Pollution and Protection Endeavors, *CEJOEM*, 8(1), 3-21.
- Abdin A.E. and Gaafar I., 2009: Rational Water Use in Egypt. In El Moujabber, M., Mandi, L., Trisorio-Liuzzi, G., Martín I., Rabi, A. and Rodríguez R. (eds.): *Technological Perspectives for Rational Use of Water Resources in the Mediterranean Region*. Options Méditerranéennes: Série A. Séminaires Méditerranéens, 88, CIHEAM, Bari, 11 -27.
- Abul-Naga, A.M., 2009: *Egypt Sustainable Agricultural Development Strategy: Towards 2030*. CIHEAM Analytical Notes, 53, Bari.
- Allam, M.N., El Gamal, F. and Hesham, M., 2005: Irrigation Systems Performance in Egypt. In Lamaddalena, N., Lebdi, F., Todrovic, M. and Bogliotti, C. (eds.): *Irrigation Systems Performance*. Options Méditerranéennes: Série B, Etudes et Recherches, 52, CIHEAM, Bari.
- Attaher, S., Medany, M.A., Abdel Aziz, A.A., and El-Gindy, A., 2006: Irrigation-Water Demands Under Current and Future Climate Conditions in Egypt, *Irrigation and Drainage*, The 14th Annual Conference of the Misr Society of Agricultural Engineering, 22 Nov, 1051-1063.
- AUB/UNRWA, 2010. Socio-economic survey of Palestinian Refugees in Lebanon, Final Draft.
- Baba, Nahla H., 1998. Food and dietary fiber consumption pattern in Lebanon. *International Journal of Food Sciences and Nutrition* 49: 41-45.
- Baba, Nahla H., 2000. Dietary intake and nutrition related disorders in Lebanon. *Nutrition and Health*, 14: 33-40.
- Becker, R.H. and Sultan, M., 2009: Land Subsidence in the Nile Delta: Inferences from Radar Interferometry, *The Holocene*, 19(6), 949-954.
- Bohannon, J., 2010: The Nile Delta's Sinking Future, *Science*, 327(5972), 1444-1447.
- Brown, O and A. Crawford, 2009. Rising Temperatures, Rising Tensions: Climate Change and the risk of violent conflict in the Middle East. International Institute for Sustainable Development.
- Bush, R., forthcoming November 2013: Food Security in Egypt. In Babar, Z. and Mirgani, S. (eds): *Food Security in the Middle East*. Hurst, London, in press.
- CAS, 2006. Census of Buildings, Dwellings and Establishments. Central Administration of Statistics.
- CAS, 2009. لبنان، المسح العنقودي المتعدد المؤشرات. Central administration of statistics
- CDR, 2005. National Physical Master Plan for the Lebanese Territory. Council for Development and Reconstruction
- CDR., 2009. Solid Waste Progress Report. Lebanon: Council for Development and Reconstruction.
- CDR, 2011. Agriculture and Irrigation. Analytical Report. Council for Development and Reconstruction
- Chaaban, Jad. 2012 Lebanon's Food Security Challenges: Public Policy Requirements to Tackle Food Insecurity in Small Import-Dependent Economies. Abstract Presented in the International Conference on Food Security in Dry Lands, Doha 2012.
- Central Agency for Mobilization and Statistics (CAPMAS, 2013): Population. *Egypt Statistical Yearbook*, 2013, 4. <http://www.capmas.gov.eg> (accessed December 9, 2013)
- Climate Change Central Department and Egyptian Environmental Affairs Agency, Ministry of State for Environmental Affairs, 2010: *Egypt National Environmental, Economic and Development Study (NEEDS) for Climate Change Under the*

United Nations Framework Convention on Climate Change (UNFCCC). April 2010. http://unfccc.int/files/cooperation_and_support/financial_mechanism/application/pdf/egypt_final_report_needs.pdf (accessed August 22, 2013).

Comair, Fadi. 2010. La Géopolitique de l'eau au Liban. Observatoire d'études géopolitiques.

CWO (Construction Weekly Online), 2011. "Lebanon Launches Green Building Rating System." *Construction Weekly Online*, June 6. <http://http://www.constructionweekonline.com/article-12670-lebanon-launches-greenbuilding-rating-system/>.

DML, 2012. Rapid Assessment of the Impact of Syrian Crisis on Socio-Economic Situation in North and Beqa'a. Development Management International.

Eid, H. M., El-Masrafawy, S.M., and Ouda, S. A., 2007: *Assessing the Economic Impacts of Climate Change on Agriculture in Egypt: A Ricardian Approach*. Policy Research Working Paper, 4293, Development Research Group, The World Bank. <http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-4293> (accessed August 24, 2013)

Elasha, Balgis Osman., 2010. "Mapping Climate Change Threats and Human Development Impacts in the Arab Region." Arab Human Development Report Research Paper, United Nations Development Programme, Regional Bureau for Arab States, New York.

El-Agha, D.E., Molden, D.J. and Ghanem, A.M., 2011: Performance Assessment of Irrigation Water Management in Old Lands of the Nile Delta of Egypt, *Irrigation and Drainage Systems*, 25, 215-236.

El-Nahry, A. H., Doluschitz, R., 2010: Climate Change and its Impacts on the Coastal Zone of the Delta, Egypt, 1497-1506.

El-Sadek, A., 2010: Virtual Water Trade as a Solution for Water Scarcity in Egypt, *Water Resource Management*, 24, 2437-2448.

El-Ramady, H.R., El-Masrafawy, S.M., and Lowell N. L., 2013: Sustainable Agriculture and Climate Changes in Egypt, *Sustainable Agriculture Reviews*, 12, 41-95. http://link.springer.com/chapter/10.1007/978-94-007-5961-9_2 (accessed August 10, 2013).

ESFD, 2004. Formulation of a Strategy for Social Development in Lebanon. *Economic and Social Fund for Development*.

FAO, 2006. Food Security Policy Brief. Agricultural and Development Economics Division. Food and Agriculture Organization.

FAO, 2008. Information system on water and agriculture - Lebanon. Food and Agriculture Organization.

Accessed online in July 2013: <http://www.fao.org/nr/water/aquastat/dbase/index.stm>

FAO, 2009. FAOSTAT online database. Available at: <http://faostat.fao.org/>

FAO., 2010. *Information system on agriculture - Lebanon*. Food and Agriculture Organization. Retrieved from <http://faostat.fao.org/>

FAO, 2012. LEBANON: Country Programming Framework, 2012–2015

FAO, 2013. Agricultural Livelihoods and Food Security Impact Assessment and Response Plan for the Syria Crisis in the Neighboring Countries. Food and Agriculture Organization.

FAOSTAT, 2013a: *Country Profile Egypt*.

http://faostat.fao.org/CountryProfiles/Country_Profile/Direct.aspx?lang=en&area=59 (accessed August 20, 2013).

Farajalla, N., 2009. Knowledge Mapping of Climate Change Issues and Stakeholders in Lebanon, American University of Beirut/ Issam Fares Institute.

Gersfelt, B., 2007: *Allocating Irrigation Water in Egypt*. Case Study 8-4 of the Program: Food Policy for Developing Countries: The Role of Government in the Global Food System. Cornell University, Ithaca, New York.

GlZ, 2013: *Participatory Development Programme in Urban Areas*.

<http://egypt-urban.net/context/urbanisation-in-egypt> (accessed August 28, 2013).

Gregoire, Gael ., 2012. Climate change adaptation in the water sector in the Middle East and North Africa: A review of main issues. Technical Note prepared by METAP under the EC-funded SMAP III project "Promoting awareness and enabling a policy framework for environment and development integration in the Mediterranean with a focus on Integrated coastal Zone Management.

Grey, David; Sadoff, Claudia. 2007. Sink or Swim? Water security for growth and development, Water Policy, 9 number 6, IWA Publishing.

Hajjar, Z., 1997. للملايين العلم دار: الأوسط الشرق في والسلام اللبنانية المياه. Beirut

Hamouda, M.A., Nour El-Din, M.M. and Moursy, F.I., 2009: Vulnerability Assessment of Water Resources Systems in the Eastern Nile Basin, *Water Resource Management*, 23, 2697-2725.

Houri, Ahmad and Jeblawi W. El, Saadieh, 2007. Water quality assessment of Lebanese coastal rivers during dry season and pollution load into the Mediterranean Sea. *Journal of Water and Health*, 5, 04, 615-623.

Hreiche, A., 2009. Irrigation needs and management. In MED EUWI *National policy dialogue on integrated water resources management planning in the republic of Lebanon*. Greece: EU Water Initiative.

Hunter, Elizabeth. 2008. Food security in rural Lebanon links with diet and agriculture. MSc Thesis, Faculty of Agricultural and Food Sciences in the University of Laval, Quebec.

Hwalla, Nahla; Adra., Nada; Jackson, R.T., 2004. Iron deficiency is an important contributor to anemia among reproductive age women in Lebanon. *Ecology of Food and Nutrition*, 43: 1-2, 77-92.

Kashef, A.-A. I., 1983: Salt-Water Intrusion in the Nile Delta, *Ground Water*, 21(2), 160-167.

ICU. 2013. Paper on agricultural sector in southern Lebanon. Middle East Office. Istituto per la Cooperazione Universitaria ONLUS

Index Mundi Lebanon, 2012 <http://www.indexmundi.com/lebanon/>

Information and Decision Support Center (IDSC, 2010): Future Impacts of Climate Change on the Egyptian Economy: Application on the Agriculture Sector. The Egyptian Cabinet.

Information and Decision Support Center (IDSC, 2011): *Future Changes and Future Demands: Food Security*. The Egyptian Cabinet.

IPCC (Intergovernmental Panel on Climate Change), 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Fourth Assessment Report of the IPCC. Cambridge University Press, UK. Karam, F. 2002. *Climate Change and Variability in Lebanon: Impact on Land Use and Sustainable Agriculture Development*, Lebanon: National Agriculture Research Institute.

JICA, CDR and MoEW, 2003. The study on water resources management master plan in the Republic of Lebanon. Interim report. Japan International Cooperation Agency, Council for Development and Reconstruction and Ministry of Energy and Water.

Karajeh, F., 2013: Principal Scientist and Water management and Irrigation specialist, International Center for Agricultural Research in the Dry Areas (ICARDA), Personal communication, 27 August 2013, Giza (approximately 60 minutes).

- Karam, F., 2002. Climate Change and Variability in Lebanon: Impact on Land Use and Sustainable Agriculture Development, The First Technical Workshop of the Mediterranean, Component of CLIMAGRI Project on Climate Change and Agriculture, Rome, September 25-27, 2002.
- Keller, A.A. and Keller, J., 1995: *Effective Efficiency: A Water Use Efficiency Concept for Allocating Freshwater Resources*. Discussion Paper No. 22, Center for Economic Policy Studies, Winrock International, USA.
- Khalifa, M., DaVanzo, J. and Adamson, D.M., 2000: *Population Growth in Egypt - A Continuing Policy Challenge*. RAND. http://www.rand.org/pubs/issue_papers/IP183/index2.html (accessed August 18, 2013).
- Khatib, Lynn Bassam, 2004. Assessment of anemia, iron, folate, and vitamin B12 in Lebanese women of childbearing age, MSc Thesis, Faculty of Agriculture and Food Science, American University of Beirut.
- Malm, A., and Esmailian, S., 2012: *Ways In and Out of Vulnerability to Climate Change: Abandoning the Mubarak Project in the Northern Nile Delta, Egypt*, Antipode 45(2), 474 - 492.
- Massoud, May Afif, 2012. Assessment of water quality along a recreational section of the Damour River in Lebanon using the water quality index. J. Environmental Monitoring Assessment, 184 (7).
- MED EUWI, 2009. Summary report. In MED EUWI *National policy dialogue on integrated water resources management planning in the Republic of Lebanon*. Greece: EU Water Initiative.
- Milly PCD, Dunne KA, Vecchia AV, 2005. Global pattern of trends in streamflow and water availability in a changing climate. Nature 438: 347-350
- Ministry of Water Resources and Irrigation, 2005: *Water for the Future: National Water Resources Plan 2017*. Arab Republic of Egypt, Cairo.
- MoA, 2007. Project of Agriculture Census 2005. Ministry of Agriculture.
- MoA, & LARI, 2008. A technical package of booklets for the following selected crops: apple, cherry, grapevine, tomato, potato. EU Agriculture Development project MED/2003/5715/ADP. Beirut.
- MoEW, 2010. National Water Sector Strategy: Ministry of Energy and Water.
- MoE, 2001. Lebanon State of the Environment Report. Ministry of Environment.
- MoE, ECODIT, 2002. 2001 State of the Environment Report, Lebanon. Prepared by ECODIT for the Ministry of Environment.
- MoE, 2005. National Environmental Action Plan (NEAP). Ministry of Environment.
- MoE, 2011. Lebanon's Second National Communication to the United Nations Framework Convention on Climate Change. Ministry of Environment
- MoE, 2012. Lebanon Technology Needs Assessment Report for Climate Change. Ministry of Environment.
- MoE, MoFA, MoSA, MoET, UNDP and CSOs, 2012. National Report to the United Nations Conference on Sustainable Development RIO +20.
- MoSA, 2011. The National Social Development Strategy of Lebanon. Ministry of Social Affairs.
- Molle, F., Venot, J.P., Lannerstad, M. and Hoogesteger, J., 2010: Villains or Heroes? Farmers' Adjustments to Water Scarcity, *Irrigation and Drainage*, 59, 419-431.
- Najem, W., 2007. Le Liban Face au Changement Climatique- Réponse du Centre de Recherche de l'Eau de l'ESIB. (L'Orient le Jour newspaper February 7, 2007).

- Nour El-Din, M. M., 2013: *Proposed Climate Change Adaptation Strategy for the Ministry of Water Resources & Irrigation in Egypt*. Ministry of Water Resources and Irrigation, Egypt. <http://www.eeaa.gov.eg/English/reports/CCRMP/7.%20CC%20Water%20Strategy/CC%20Final%20Submitted%208-March%202013%20AdptStrtgy.pdf> (accessed August 1, 2013).
- Radwan, L.S., 1997: Farmer Responses to Inefficiencies in the Supply and Distribution of Irrigation Requirements in Delta Egypt, *The Geographical Journal*, 163(1), 78-92.
- Radwan, L., 1998: Water Management in the Egyptian Delta: Problems of Wastage and Inefficiency, *The Geographical Journal*, 164(2), 129-138.
- Republic of Lebanon., 2011. *Lebanon's Second National Communication to the United Nations Framework, Convention on Climate Change*. Beirut: Ministry of the Environment, Republic of Lebanon.
- Saade, C., 1994. Agricultural performance and policy in Lebanon. *Cahiers Options Méditerranéennes*, 70-95.
- Saadeh, M., 2008. *Influence of overexploitation and seawater intrusion on the quality of groundwater in Greater Beirut*. Aachen: Fakultät Georessourcen und Materialtechnik der Rheinisch-Westfälischen Technischen Hochschule.
- Schultz, H.R., Hoppmann, D, & Hoffmann, M., 2005. Climate change and possible effects on the phenological development of grapevines (*Vitis vinifera* L.), simulated varietal suitability and sugar and acidity concentration in the fruits [English abstract from the annual report of Forschungsanstalt Geisenheim].
- Shaban, A., 2009. Indicators and aspects of hydrological drought in Lebanon. *Water Resources Management*, 23, 1875–1891
- Shalaby, A., 2012: Assessment of Urban Sprawl Impact on the Agricultural Land in the Nile Delta of Egypt Using Remote Sensing and Digital Soil Map, *International Journal of Environmental Sciences*, 1(4), 253-262.
- Simonett, O., UNEP and GRID-Arendal, 2005: *Nile Delta: Potential Impact of Sea Level Rise*. http://www.grida.no/graphicslib/detail/nile-delta-potential-impact-of-sea-level-rise_ec80 (accessed July 15, 2013).
- Skold, M.D., Shinnawi A.A.E.S. and Nasr, M.L., 1984: Water Distribution Along Branch Canals in Egypt: Economic Effects, *Economic Development and Cultural Change*, 32(3), 547-567.
- Stanley, D.J. and Warne, A.G., 1998: Nile Delta in its Destruction Phase, *Journal of Coastal Research*, 14(3), 794-825.
- Strzepek, K.M. and Yates, D.N., 2000: Responses and Thresholds of the Egyptian Economy to Climate Change Impacts on the Water Resources of the Nile River, *Climate Change*, 46, 339-356.
- UN, 2001. Gender in agriculture and agro-processing in Lebanon. United Nations
- UNDP and Institute of National Planning, Egypt, 2004: *Egypt Human Development Report: Choosing Decentralization for Good Governance*. Project Document EGY/01/2006. http://hdr.undp.org/en/reports/nationalreports/arabstates/egypt/egypt_2004_en.pdf (accessed July 15, 2013).
- UNDP, 2011, Lebanon Recovery Fund, Beirut, Lebanon
- United Nations High Commissioner for Refugees., 2013. Accessed July 2013 data.unhcr.org/syrianrefugees/regional.php
- Vella, J., 2012: *The Future of Food and Water Security in New Egypt*. Future Direction International. <http://www.futuredirections.org.au/publications/food-and-water-crises/813-the-future-of-food-and-water-security-in-new-egypt.html> (accessed August 23, 2013).

Verner, Dorte, ed., 2012. *Adaptation to a Changing Climate in the Arab Countries*. Washington, DC: World Bank. DOI. 10.1596/978-0-8213-9458-8. License: Creative Commons Attribution CC BY 3.0

Vidaud J., Charmont S., and Wagner R., 1993. *Le Raisin de Table*. Paris: CTIFL

Weber, P. and Harris, J., 2008: Egypt and Food Security, *Al-Ahram Weekly Online*, 23 October 2008. <http://weekly.ahram.org.eg/2008/919/sc6.htm> (accessed August 27, 2013).

WFP, 2013. Syrian Refugees and Food Insecurity in Lebanon. Secondary Literature and Data Desk Review. World Food Programme.

Wichelns, D., 2000: Policy Recommendations to Maintain and Enhance Agricultural Productivity in the Nile River Delta, *Water Resources Development*, 16(4), 661-675.

World Bank, 2010: *Egypt's Food Subsidies: Benefit Incidence and Leakages*. Arab Republic of Egypt and The World Bank, Washington.

World Bank, 2009. Lebanon Social Impact Analysis- Electricity and Water Sectors.

World Bank, 2010. Republic of Lebanon Water Sector: Public Expenditure Review.

World Bank, 2012. Lebanon Country Water Sector Assistance Strategy.

World Bank, 2013. Country data. Accessed online in August 2013 at: <http://data.worldbank.org/country/lebanon>

World Food Programme, 2011: *Secondary Data Analysis of the Food Security Situation in Egypt*. Regional Bureau for the Middle East, Central Asia and Eastern Europe – ODC Egypt Country Office, May 2011, 24.

The Issam Fares Institute for Public Policy and International Affairs (IFI)

American University of Beirut | PO Box 11-0236, Riad El Solh 1107 2020, Beirut, Lebanon
Tel: +961-1-374374, Ext: 4150 | Fax: +961-1-737627 | Email: ifi@aub.edu.lb | Website: www.aub.edu.lb/ifi