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Climate change and food security in Egypt

Laila Yassin

The American University of Cairo

School of Global Affairs and Public Policy

CLIMATE CHANGE AND FOOD SECURITY IN EGYPT

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By

Laila Yassin

Supervisor: Dr. Shahjahan Bhuiyan

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ABSTRACT

This study focuses on the climate change impact on food security with a focus on the agricultural sector and the food production system in Egypt. And, it examines how consistently can policies manage to reduce climate change effects on Egypt's food security through qualitative research conducted through in depth interviews with experts in the field. Egypt is one of the most vulnerable regions in the world to climate change risks. The agricultural sector is one of the affected sectors; this sector is very critical for Egypt's national and food security since it shapes 17% of its GDP, 40% of its labor force, and 60% of its food production. Therefore, this study examines the current agricultural system and its vulnerabilities to climate change. Moreover, it discusses how policies can manage to adapt to reduce climate change effects on Egypt's food security and how can environmental and social concerns be integrated into environmental policies, to ensure sustainability. The study found that the current policies are not effective because of the absence of a relevant legal framework, lack of cooperation among stakeholders, and the low awareness levels. Therefore, it is recommended to develop a comprehensive legal framework, which would support the government to increase the cooperation among diverse stakeholders. In addition, it is suggested that the Egyptian government builds its cooperation with non-governmental organizations to raise awareness to the effect of climate change on resources and train stakeholders on how to use new technologies.

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Dedication

"I dedicate this thesis to all vulnerable insecure communities; I wish the world finds practical solutions to the current and prospective hunger risks facing the world."

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List of Abbreviations

AMANA	General Secretariat for Localities
APE	Association for the Protection of the Environment
ARC	Agricultural Research Center
EEAA	The Egyptian Environmental Affairs Agency
EIA	Environmental Impact Assessment
EPR	Extended Producer Responsibility
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GECAFS	Global Environmental Change and Food Systems
ICZM	National Integrated Coastal Zone Management
ILO	International Labor Organization
IPCC	Intergovernmental Panel on Climate Change
MoLD	Ministry of Local Development
MoE	The Ministry of Environment
NCCC	National Council for Climate Change
NCR	National Communication Report
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
WFP	World Food Program
WFS	World Food Summit
WMO	World Meteorological Organization

Chapter 1: Introduction

It is a reality that extreme weather events, resulted from climate change, have increased in numbers and severity in recent years, which largely contributes to forced migration, conflicts, hunger, and destroyed infrastructure across the world. Not all countries face the same risk; countries like Bangladesh, Egypt, and other developing countries are more exposed to the possibility of severe hunger due to climate change. It is noticed that the countries with the lowest carbon dioxide emissions are the most vulnerable to climate change, and vice-versa. However, it is our responsibility to protect vulnerable communities and equip them with the tools that will enable them to face the risks of climate change.

The purpose of this study is to explore the food security challenges that Egypt is facing due to climate change. The study mainly tackles the agricultural sector, which is a key sector as it accounts for nearly 17% of Egypt's GDP, employs 50% of the labor force, and provides almost 50% of the country's food. Therefore, any threat to Egypt's agricultural system is considered a threat to the country's national security and political stability. This policy issue has multiple political and social dimensions. Riots took place in Egypt in the 1970s because of the removal of food subsidies; this turned food security into a sensitive topic. Therefore, it is important for policymakers to secure food production for Egyptian populations to maintain the country's political stability. Consequently, Egypt has developed a national strategy to counter the risks of climate change and food security. However, food production is still expected to decrease because the strategy's solutions are not fully implemented and cannot completely eliminate the expected negative impacts of climate change.

The Intergovernmental Panel on Climate Change (IPCC) in 2007 described the Nile Delta as one of the three most vulnerable sites to sea level rises in the world. The panel expected an increase that ranges from 18 to 59 centimeters (cm) by 2100 (UNDP, 2013). The problem for Egypt is that the Delta has historic significance, since the majority of the country's agriculture takes place in the region and nearly half of Egyptians live there (UNDP, 2009). This puts the whole country's population and economy at risk.

The ministries of environment and agriculture in collaboration with an active participation of the civil society are supposedly responsible for mitigating and adapting climate change risks to safeguard Egypt from the threat of hunger and reduce the effects of climate change on the agricultural sector. So far most of the efforts recorded are minimal and are limited to a small number of beneficiaries. In addition, the effects of climate change are already observed across Egypt and thousands of farmers have been deeply affected by a reduction in their production or even by extreme weather events that have damaged their crops and land.

1.1 Background: Current Climate, Trends, and Socioeconomic Conditions

1.1.1 Geography

Egypt is an African and Arab country; it is located between latitude 22° and 32°. Egypt's total area is 1,001,450 km^2 with a coastline on two seas: the Mediterranean and the Red Sea. The surface level ranges from "133 m below sea level in the Western Desert to 2,629 m above sea level in Sinai Peninsula" (NPR, 2010, p.3). The land is not yet fully utilized, as 97% of the population lives on 4% of the land, concentrated along the Nile and particularly in the Nile Delta. This causes a high average population density per km^2; in 2010, it was 1,435 persons per km^2 (NPR, 2010, p.11).

1.1.2 Climate

The climate is usually dry, warm, and desertic. Rains fall in the winter over the coastal area; the summer season is hot and dry (NPR, 2010). In the 2010 National Communication Report, the Egyptian Meteorological Authority presented data that showed there has been a general movement towards an increase in air temperature, in addition to rises in the number of hot days, and in the frequency of sandstorms.

1.1.3 Observed and Projected Climate Trends

During recent decades, changes in the climate parameters have been observed and recorded. A study by Al-Sharawy (2007) confirmed that there has been an increase in the mean maximum and minimum air temperatures of + 0.34°C per decade. This increase is also observed in the mean air temperature and mean atmospheric pressure of + 0.017 Celsius (°C) per decade and + 0.026 hectopascal (hPa) per year respectively; Hectopascal is a pressure measurement unit (Al-Sharawy, 2007).

The potential increase in atmospheric pressure suggests an increase in the quantity of misty and hazy days, and it will also increase the turbidity of the atmosphere. The country has already started to suffer from an increased severity and frequency of floods, dense haze, and most importantly, sandstorms (National Communication Report, 2010). These observations have several consequences for nearly all sectors in Egypt, among them energy, industry, agriculture, health, electricity, transport, and tourism. Furthermore, the Mediterranean coast has already experienced an increase in the amount of annual rainfall. As reported in the Egyptian media, the governorates of Alexandria and Al-Beheira have recently witnessed an unprecedented amount of rainfall, which has caused massive damage in these regions. At that time, the local media broad-

cast images of flooded buildings and cars. Agricultural Research Center (ARC)'s specialist has confirmed that climate change was one of the main elements that increased the severity of the situation in Alexandria, besides poor infrastructure and weak local governance.

1.1.4 Socioeconomic Conditions

UNDP published a report in 2013 on the potential impact of climate change on Egypt's economic performance (UNDP, 2013). The report used two scenarios to estimate the impact, one pessimistic and one optimistic. Since the impact of climate change depends on many uncertain variables such as population and economic growth, this study will rely on the same approach used by UNDP in 2013 to project potential impacts. In both scenarios, the Egyptian population will be exposed to difficulty in securing the basic food supply. Moreover, the budgetary constrain increases the obligations of the Egyptian government despite its limited resources and it is relatively slow economic growth. These implications are expected to increase the population's needs in housing, education, transportation, roads, electricity and energy.

UNDP's 2013 report selected two years for projections: 2030 and 2060. The optimistic scenarios was based on the assumption of population increase and income increase per capita, while the pessimistic scenario was based on the assumption of population increase and a decrease in the income per capita. The researches of UNDP report avoided assuming that the population decreases because there is no indication that the population will decrease. Based on the assumption that in 2010 there was 82 million Egyptians and has been increasing by 2.3 percent per year (IPCC, 2013). There are two scenarios; the optimistic scenarios are the population will reach 104 million by 2030 and 113 million by 2060. The pessimistic scenario projected to reach 117 million by 2030 and to reach 162 million by 2060 (IPCC, 2013). Cairo city is stressing because of

the high pollution and population residing in it. The below table projects the population increase in Cairo. It is noted in the report that the United Nations projected high rates for Egypt.

Table 1 Optimistic and Pessimistic Population Assumptions

	2009	2020	2030	2040	2050	2060
Optimis-tic	**80**	**92**	**104**	**110**	**112**	**113**
Pessimis-tic	**80**	**98**	**117**	**134**	**149**	**162**

Source: IPCC, 2013

Similar to the population scenarios, the IPCC developed to scenarios for the expected income for the Egyptian population. The IPCC provided a wide range in both scenarios (Kotb et al, 2000). The IPCC projected the per capita income for three years: 1990, 2050, and 2100. These data were based on the exchange rate of 2016, which 8.878 EGP per 1 USD (World Bank, 2016).

Table 2: Projections of GDP and GDP per capita

	2009	2030	2050	2060
GDP in EGP (millions)				
Optimistic	**EGP990,212**	**EGP2,993,208**	**EGP7,200,060**	**EGP9,298,978**
Pessimistic	**EGP990,212**	**EGP2,287,141**	**EGP4,501,023**	**EGP5,907,201**
GDP in USD (millions)				
Optimistic	**$8,791,102.14**	**$26,573,700.62**	**$63,922,132.68**	**$82,556,326.68**
Pessimistic	**$8,791,102.14**	**$20,305,237.80**	**$39,960,082.19**	**$52,444,130.48**
GDP/capita in EGP				
Optimistic	**EGP12,378**	**EGP28,781**	**EGP64,286**	**EGP82,292**
Pessimistic	**EGP12,378**	**EGP19,548**	**EGP30,208**	**EGP36,464**
GDP in USD				
Optimistic	**$109,891.88**	**$255,517.72**	**$570,731.11**	**$730,588.38**
Pessimistic	**$109,891.88**	**$173,547.14**	**$268,186.62**	**$323,727.39**

Source: IPCC, 2013

This study is divided into six chapters. Apart from the introductory chapter, Chapter 2 discusses the literature through the perspective of climate change effect on the agricultural sector with a focus on the developing world. While chapter 3 and 4 presents the conceptual framework and the research methodology adopted in this study.

Chapter 5 examines Egypt's agricultural sector to identify the current gap between current policies and adaptation strategies. Finally, chapter 6 provides overall conclusions and policy recommendations are provided to explore the possible solutions to the current inefficiencies in the agricultural sector with regard to climate change.

1.2 Research Gap and Research Questions

Research up to this point has indicated the risks expected to face the developing countries due to climate change; however, there is no comprehensive study directly correlates the expected food insecurity problem and climate change risks in Egypt. Most of the conducted studies on Egypt focused on the implications of climate change on specific crops without relating it to other food security components. Therefore, this study explored the food insecurity challenges that Egypt could face due to climate change with a focus on agricultural sector in Egypt. The agricultural sector was highlighted because of its importance to the Egyptian society and economy as previously mentioned. In this study, an attempt has been made to answer to the following research question:

- How consistently can policies manage to reduce climate change effects on Egypt's food security?

Chapter 2: Literature Review

2.1 Overview

Füssel (2007) indicated that global warming has various effects that expose the environment to new higher risk levels and defined vulnerability to climate change thus "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extreme vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity." Earth's vulnerability is caused by "the uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic, with increasing body of observations that gave a collective picture of a warming world" (Parry, 2007).

IPCC in 2008 indicated that sectors water-dependent would be highly affected by climate change. Three main sectors are "affected by climate change: agriculture, forestry and fisheries" (UNDP, 2013, p.13). The production process of each of them is affected by climate change; however, the impact will vary from location to location. Global and local food production will be directly affected as production in tropical areas will decrease and developing countries may face adaptation problems due to their limited economic capability (FAO, 2008).

The agricultural sector is almost the most vulnerable sector as it is affected locally and globally in various aspects by climate change (Verburg et al., 2013). Countries with limited capacities to adapt to climate change may suffer from lower yields; and accordingly, they will suffer from lower food supply (Cline 2007; Olesen and Bindi

2002). And due to the global food shortage, poor countries may not be able to import the rest of their needed food supply. Furthermore, the economies of the developing countries depend on the agricultural sector; therefore, many people will lose their income and jobs and many families, especially in rural areas, will get exposed to poverty and food insecurity. In addition, farmers in developing countries may face difficulties in accessing water, social services, and secure places (FAO, 2008). While Bizikova et al (2007) suggested that climate change would lead to high market prices for food; and therefore, food will be unavailable for poorer people and consequently will lead to food utilization problem, which is getting an insufficient nutrients from the food consumed.

Adger (2003, p. 321) pointed out that "climate change-induced sea-level rise, sea-surface warming, and increased frequency and intensity of extreme weather events puts the long-term ability of humans to inhabit atolls at risk. It constitutes a dangerous level of climatic change to atoll countries by potentially undermining their national sovereignty." Climate change, according to the FAO report, will not increase gradually; however, there will be an increase in the frequency and the duration of hot days that will not follow a set pattern across the globe. Climate change effects are expected to have a high impact on global food systems and food security (FAO, 2008).

2.2 Climate Change Impact on Developing Countries

Climate change effects were widely addressed through mitigation strategies to reduce the effect of climate change on the environment. However, since three decades, policymakers found that mitigation strategies are not enough to address climate change; therefore, the world are moving towards addressing climate change risks

through adaption strategies (Pielke, 1998). Burton (2006) also discussed that the current policy dialogue is moving towards integrating mitigation and adaptation strategies together to adopt stronger strategies and policies against climate change.

Developing countries lack efficient and strong adaptive environmental policies to counter major risks (Hardoy & Satterthwaite, 1991). Adaptation policies are developed whenever there are future risks that need to be reduced and addressed by policy-makers (FAO, 2008). Reducing uncertainty can be achieved through a decent information base and innovative techniques to ensure successful implementation (Shardul, 2008). Moreover, adaptations are essential to help the farmers to secure their income, daily activities, overcome extreme weather events, and face market changes because they have low capacities to adapt to climate change (Kandlinkar & Risbey, 2000). Article 4.1b of the United Nations Framework Convention on Climate Change (UNFCCC 1992) states that parties are "committed to formulate and implement national and, where appropriate, regional programs containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change." The Kyoto Protocol (Article 10) also obliges member states to promote adaptation, and implements adaptation technologies to tackle climate change effects (UNFCCC, 1998).

Egypt identifies adaptation as a central component of its climate change strategy and is considering adaptation alternatives in all fields (El-Ramady et al., 2012). Adaptations are essential to help the farmers to secure their income, daily activities, overcome extreme weather events, and face market changes (Kandlinkar & Risbey, 2000). The main problem with African farmers and with Egyptian farmers was that they had low capacities to adapt to climate change. Therefore, it was essential that their

governments and policy-makers work on good policies that help them to lessen the potential risks.

2.3 Adaptation Policies

The research, as indicated above, was focused on the effects of climate change on the agricultural sector, which led to the emergence of research on the potential adaptive policies for the affected countries. Adams et al (1999), Kaiser et al (1993), Easterling et al (1993) indicated the effectiveness the of new adaptation policies and examined the alternative policy options to reduce the effects of climate change on crop production. It is also shown in the literature that adaptation policies are abundant; however, the integration of different sectors together is crucial to making policies effective. Schneider et al (2000), also suggested that awareness among stakeholders and governmental institutions should be included in the policy-making decisions to ensure effective understanding of climate change, new technologies for the current situation and years to come.

In the literature, there is a clear distinction between climate change and climate variability. The adaptation of agriculture against climate variability differs from its adaptation against climate change (Schneider et 2000; Polsky and Easterling 2001; Brumbelow and Georgakakos 2001). Smit and Pilifosova (2001) argued that climate change policies should not be limited only to climate change, but also to include proactive measures to adapt to climate variability. Furthermore, the impact of climate variability was recorded to have high impact on the developing countries (Huq 2002; Hay 2002). Also, many studies highlighted the importance of addressing the climate variability with climate change in developing countries (Murdiyarso 2000).

2.4 African Countries Experiences

The African continent is suffering from an increase in the mean temperature, with some regions warming a lot of than others (IPCC, 2007). The increase in temperature has been recorded to increase by 5°c per century since 1900 (Khan, 2015). Therefore, temperature projections for East Africa indicate that the median near-surface temperature within the 2080–2099 amounts can increase by 3–4 °C compared to the 1980–1999 amounts. It has to be noted that this increase is about one five times the projected world mean response. Despite the detailed vulnerability and adaptation options not being done in Uganda, its drought has increased between 1991 and 2000 seven times (Khan, 2015). Climatic projections for Burundi and Rwanda expect that both countries' climate will become hotter by 1.0–2.5 °C (Baramburiye et al. 2013; Tenge et al. 2013). Similarly, in Kenya, recent studies have discovered that future climate change indicate that the temperature would increase by 1–3.5 °C by the 2050s. While Tanzania will suffer from high increase temperature by 3–5 % as south Tanzania will experience severe decrease in rainfall, which would reach up to 10%. In Tanzania, the rainfall is expected to decrease by 20 % in the inner regions, however, rainfall is expected to increase b 30–50 % in the coastal areas. All the climate models for the East African region show that rainfall regimes will change, but these changes will vary with season and region (Midega et al, 2015). Most models project rainfall will increase on average, although some models project rainfall reductions in some months in some areas. Future predictions on extreme events, such as: floods and droughts vary much more widely (Midega et al, 2015).

Several publications have indicated the high risks of climate change on the African countries (Downing, 1993; Desanker, 1996). These studies examined the impact of climate change on crop production and on individual farmers. Downing (1993) found that there are several non-climatic factors would affect the agricultural sector in Kenya, Zimbabwe, and Senegal, such as, the socioeconomic elements, trade issues, and geography.

One of the main problems with African farmers is that they have low capacities to adapt to climate change. One study surveyed around 8,000 farmers across 11 countries in Africa: Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia and Zimbabwe (Gbetibouo, 2009). The study shows the difference between the perceptions of climate change adaptation strategies versus the actual adaptation strategies. The results show that 50% of the farmers surveyed recognize that continuing temperatures are rising, 30% believe there are changes in the rains' dates, and 16% think droughts are increasing (Gbetibouo, 2009). This shows that the awareness level among farmers is quite high and recognizes the efforts done in this area.

Over the past decade, the local initiatives have worked to increase the awareness on climate change issues of different stakeholders; including both farmers and policy makers. However, there is still a significant lack of knowledge on the nature, magnitude, and direction of impacts at the rural communities; this will likely continue to hinder decision-making processes regarding the development of strong strategies and policies to support adaptation. This may entail changes in the types and forms of information, knowledge, technologies, and institutions leading current production systems. Therefore, it has been concluded that the policy making on climate change in

Africa is not necessarily constrained by the lack of research, but instead by the failure of policy makers to use available empirical evidence and research. The current failures in linking research to policy could be a major barrier to future research and development innovations for climate change adaptation.

Therefore, there is a vital need for decision makers at different levels in Africa to develop corresponding response policies to decrease vulnerability and strengthen resilient systems. The farmers' communities are the most vulnerable to the negative impacts of climate change. Moreover, they usually miss the advantage of any emerging opportunities due to resource constraints and limited budgets. Approximately 65 % of national agricultural income in Africa is derived from the crop production of cereals, especially maize (Tilman et al, 2002). Due to the decrease in cultivated area, production level is very low as it varies from 5–25%, and the region requires increase productivity for food and livelihood. The climate change challenges are intensified by reducing soil productivity and the decrease in natural resources. The communities have obtained their basic knowledge from the local governments and institutions to adopt new methods to sustain their productivity level. However, there is no enough research yet conducted on the effectiveness of these local initiatives, which have risen to face the changes. Therefore, policy frameworks are a prerequisite to enlarge the current climate change adaptation beyond the limitations of the current farming systems (Tilman et al, 2002).

2.5 The Case of Egypt

For more than 5,000 years, Egypt has been known for its agricultural abundance due to its warm weather, fertile soil, and plentiful water supply from the Nile River.

The agricultural sector in Egypt is intensive. Five millions hectares of crops are farmed annually by Egyptian farmers; however, intensive agricultural leads can create problems such as salinization, water logging, and nutrient depletion (El-Shaer et al, 1996; El-Ramady et al, 2012). The agricultural system depends primarily on irrigation from the Nile, in addition to a very small percentage, which comes from groundwater. Water and land determine where to farm in Egypt, there are three factors that have an impact on the climate in Egypt: the Mediterranean, the Nile, and the desert (El-Shaer et al, 1996; El-Ramady et al, 2012). Only three percent of Egypt's territory is being used for agricultural purposes (El-Shaer et al, 1996). To increase agricultural land, the Government of Egypt has been working on expansion plans in the Western Desert (Rosenzweig and Hillel, 1994; El-Ramady et al, 2012).

Sea level rise is also a critical concern in the discussion about climate change (UNDP, 2013). Conway's (1996) study confirms that the rise in sea level will have an adverse impact on water security and will increase water shortage in Egypt. Nash and Gleick (1991)) argue that the Nile Delta is susceptible to significant effects on water supply, as the change is expected to range between 3% decline and a 10% upturn per year. Egypt's population is currently around 90 million, 51% live in countryside and 49% in cities; therefore, both urban and rural people will be exposed to huge risks such as displacement, hunger, and unemployment (Sušnik, 2015).

There are not available studies that comprehensively examined the relationship between climate change and food security. However, there are limited studies examined the impact of climate change on agricultural sector. Yates and Strzepek (1998)

and Sušnik (2015) concluded that climate change will have an adverse impact on agriculture since 96% of Egypt's water originates from the Nile, while the remaining 4% is derived from groundwater and rainfall. Therefore, there are many expected challenges in meeting the future water and food demands of Egypt. Climate change is a threat for Egypt's security; it is one of the vulnerable nations to the anticipated impacts and dangers (Fahim et al, 2013). Since the agriculture sector mainly depends on Nile water, Kurukulasuriya and Rosenthal (2013) indicate high costs will be incurred by the agriculture sector since it provides 17% of the country's GDP and forms 30% of the labor force (UNDP, 2009) and about three-fifths of Egypt's food production comes from the areas around the Nile Delta (Agrawala et al, 2004).

Several studies have examined the implications for Egypt's economy. The World Bank report of 2012 pointed out that climate change will have the largest effect on the coastal region, which includes 40% of Egypt's agricultural production, as well as a number of large urban population centers (Verner, 2012). Wodon et al (2014) in their study indicated that the country is economically vulnerable to climate change since more than 17% of Egypt's GDP comes from low-elevation coastal zones. There are additional factors that increase Egypt's vulnerability to climate change, including its economic reliance on agriculture.

Chapter 3: Conceptual Framework

3.1 Food System and Food Security

There has been growing evidence in the literature illustrating the impact of climate change on food security. This study adopted the World Food Summit (WFS)'s definition, "Food security exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Al, Orking & Clima, 2008, p.3). While according to Dogondaji (2013, p. 167), "Food security is the outcome of food system processes all along the food chain". This definition is very broad and integrates several social and environmental aspects. On the other hand, the FAO report has adopted new concept by explaining that food security relies on socio-economic circumstances and on food access more than on agro climatic factors and food availability. Therefore, in order to assess the impact of climate change on food security, it would be insufficient to examine production level per country (Al, Orking & Clima, 2008, p.3). In addition, it is also crucial to analyze the effect of climate change on the poor households in terms of their incomes (FAO, 2003, pp. 365-366). The food system is presented by the Global Environmental Change and Food Systems (GECAFS) as follows:

> It encompass (i) activities related to the production, processing, distribution, preparation and consumption of food; and (ii) the outcomes of these activities contributing to food security (food availability, with elements related to production, distribution and exchange; food access, with elements related to affordability, allocation and preference; and food use, with elements related to nutritional value, social value and food safety). The outcomes also contribute to environmental and other securities (e.g. income). Interactions between and within biogeophysical and human environments influence both the activities and the outcomes. (GECAFS Online, http://www.gecafs.org/glossary/)

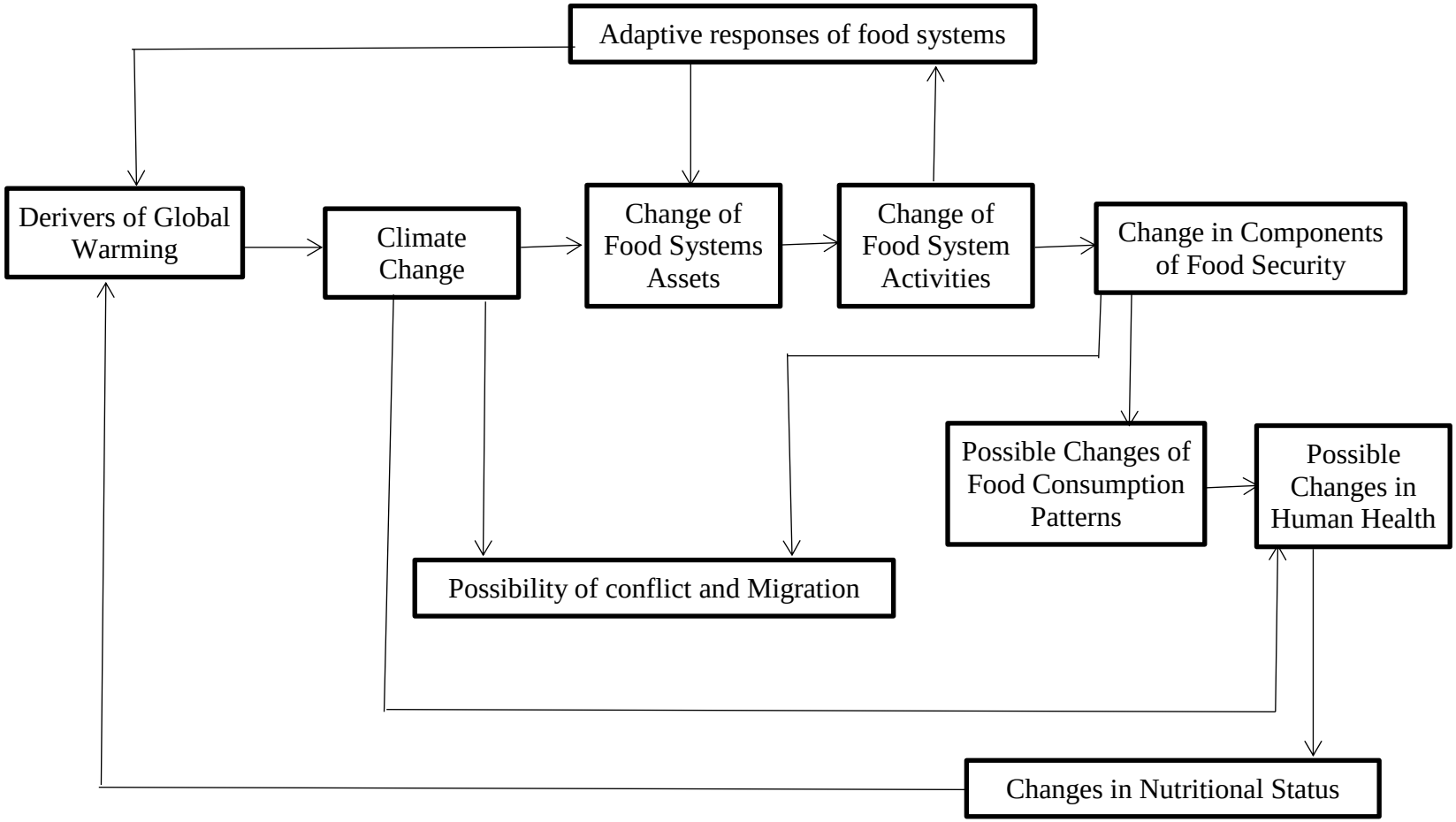
The definition of the food system illustrates its complexity: it is a lively communication of several interactions within the environment (Gregory, Ingram and Brklacich, 2005). Food chain is another key term, which refers to the integration of all the processes of the food system. Climate has a great impact on the food system and the food chain, starting with the effect on farms and production and ending with destroying or damaging transport and infrastructure.

3.2 Climate and Climate Change

While climate refers to "the characteristic conditions of the earth's lower surface atmosphere at a specific location" (Al, Orking & Clima, 2008, p.6) while weather refers to "the day-to-day fluctuations in these conditions at the same location" (Al, Orking & Clima, 2008, p.6; FAO, 2008). This study adopted the World Meteorological Organization (WMO) definition, "long-term changes in average weather conditions" by the (FAO, 2008, p.6). WMO, in that regards, calculates climate change based on measuring averages of 30 years, to avoid year-to-year changes (FAO, 2008).

3.3 Food Security and Climate Change

Figure 1: Climate Change and Food Security: Source: (FAO, 2008, p.13)



Both climate change and food security are a cross cutting issues. Therefore, potential risks on other sectors; such as transportation, infrastructure, tourism, and health, would have a direct and strong effect to increase the severity of the expected food insecurity problem. The vulnerability of the transportation sector to climate change, thus, food might not reach people in some areas (McCarthy, 2001). Accordingly, the cost of transportation is expected to rise to guarantee suitable infrastructure and adequate transportation means. Food storage, distribution, and processing may differ among the regions (IPCC, 2015). WFP 2015 report explained that the food production needs to be redistributed among the regions because many regions, in Africa and Arab World for example, have unstable climate and considered as food-insecure regions. In contrast, the major agricultural production regions have stable climate. Therefore, in order to guarantee global food sufficiency, we require effective food distribution.

Climate change also increases the possibility of political instability, migration and conflict over resources, as shown in Figure 1. The attention of the international community has been drawn recently to an important risk, which is the possibility of migration and conflict (World Bank, 2012). Changes in food security are identified as one of the key triggers of conflict. Moreover, existing conflicts could be fueled and intensified because of a lack of food and water resources. In some cases, the inverse is true, and conflict may have an effect on food security; recent studies have shown that the Middle East has become more vulnerable to climate change and food insecurity risks because of the current armed conflicts in Yemen, Sudan, Syria, and Iraq (WFP, 2015). As a result of these conflicts, millions of refugees have fled to Turkey, Lebanon and Egypt searching for security, shelter, and basic resources. These states were already

struggling to provide basic services to their citizens; therefore, the political instability in the region escalated the food security risks (World Bank, 2012; WFP, 2015).

Lastly, food systems, especially in developing countries, are facing a huge risk from the expected implications of climate change because their infrastructure might be damaged or get exposed to deterioration. In this case, local suppliers might face problems in transporting food and supplies (Ramadan, 2015; Tielens and Candel 2014; Pinstrup-Andersen, 2009; Mirza, 2003). Therefore, all these aspects must be considered in the adaptation strategies of all countries exposed to climate change (Tielens and Candel 2014).

It is very important to determine the relation among various components in the framework to facilitate to policymakers to develop appropriate policies and accommodate the future needs accordingly. This study derived the above conceptual framework from FAO's conceptual framework, (see Figure 1), to explain the interrelation of the various components of climate change and food security. Moreover, it shows the impact of climate change on the four components of food security: production, availability, accessibility, and utilization. All the four components are highly affected by climate change; it has an effect on the agricultural, the forestry, and the fisheries. In Egypt, all the food system components are vulnerable to climate change risks. Egypt's GDP and food production rely on agricultural and the majority of the population live around the Delta and on coastal shores. The geographic distribution increases the impact on the food system because both the delta and the coastal shores are vulnerable areas and are exposed to drown with the coming decades. Consequently, the food system in Egypt as whole is vulnerable and affected by climate change.

Thus, studies on climate change assist policymakers to design suitable policies to reduce the potential risks. A very important finding is that climate change will not increase gradually; however, there will be an increase in the frequency and the duration of hot days that will not follow a set pattern across the globe (Mirza, 2003). This means that, within few days, the crop or infrastructure could be completely destroyed. Hence, it requires necessary and special preparation to protect the people and the environment during these times of extreme weather events. This change has a direct effect and a high impact on global food systems and food security. The FAO identified the potential impacts on the following elements: food system assets, food system activities, food availability and accessibility, livelihoods, and policies and regulations (FAO, 2008).

Chapter 4: Research Methodology

4.1 Data Design and Collection

This study follows qualitative research methods; the researcher aimed to understand the food security risks that result from climate change through conducting in-depth interviews with experts in the field from diverse governmental, local, and international institutions. Arabic sources were reviewed through accessing Cairo University Library. Although, the usage of quantitative research, along with the qualitative methods, could have strengthened the study, it was avoided due to the high financial cost required to gather accurate data and conduct a survey across governorates.

This study also examined different challenges of adaptation policies in countries in the Africa, and the developing world. While each country has its own culture and context, international experiences nonetheless provide insights for policy-makers by highlighting the challenges and the opportunities. As a result, East African region was selected purposively. The countries' examples identify routes to proven successes in agriculture sector with regard to climate changes, recording how they were accomplished, and offering some generalized observations about why countries' interventions were effective. Since East African countries share many characteristics with Egypt; being developing high-populated country, which depends on agriculture, and exposed to extreme weather events and rise in the sea level. Therefore, examining this region would assist to understand deeply the prospective risks of food insecurity and climate change and present practical solutions for Egypt.

4.2 Selection of Respondents and Data Analysis

Qualitative research was conducted to collect primary source data from experts in the field, civilians, and government officials, representatives of NGOs and international organizations, and academic researchers. In-depth interviewing is one of the well-known qualitative research techniques; the researcher interviewed few respondents to discuss thoroughly with them a specific idea or topic (Boyce and Neale, 2006). Impressions and analysis are interpreted from the data obtained from the in depth-interviews. Furthermore, expert opinions provided explanations regarding food security issues and regarding the main governance problems. The data were analyzed based on interpretive techniques.

The respondents were selected based on purposive non-probability sampling to represent diverse stakeholders and policymakers, 12 respondents participated in the research (see Table 3, annex 1). Most of the participants are representatives of institutions relating to climate change and agriculture in Egypt, such as, the Agricultural Research Center, WFP, and UNDP. Moreover, more interviews were conducted with other stakeholders: businessmen, and NGOs to further understand the effectiveness of the current implementation framework and policies. In fact, one of the limitations of this thesis was the difficulty in reaching farmers from different regions across Egypt; however, the researcher tried to overcome this limitation by getting the information through NGOs and researchers working in different regions in Egypt. This could actually lead to inconclusive findings.

The interviewer took notes and recorded most of the interviews, after taking permission from the interviewees. The collected data were complex and covered many aspects on the topic; therefore, the researcher developed inductive codes, after the data

collection, based on themes to represent selective aspects of the data and group similar ideas together (see annex 2). Memos were also written to summarize the initial thoughts on data analysis on interviews' transcripts. Once the codes were established, the coding process allowed for the identification of relationships and sub-themes. The interviews aimed to shed light on the current national strategy related to climate change in Egypt, and on the potential for food insecurity problem, two issues on which there the published knowledge is limited.

Chapter 5: Data Presentation and Analysis

This chapter discusses the impact of climate change on selected issues relevant to Egypt's food security with a focus on the agricultural sector. It also reviews and analyzes the current adopted policies that work to adapt to the risks posed by climate change. This chapter begins with an overview on the status of agricultural sector in Egypt. Then, it discusses in details the current situation of the crop production and water management policies with regard to food security. Each section begins with a brief description of the effects of climate change in the Egyptian context and then reviews the current adaptation policies. The objective of this chapter is to present the current policies and analyze with the current gap or inefficiencies. The data in this chapter is drawn mainly from the in-depth interviews conducted for this research and from official documents including laws and ministerial decrees, and reports by international organizations.

5.1 Overview: the Status of the Agricultural Sector

Policymakers and different stakeholders are aware of the major risks confronting the Egyptian agricultural sector. However, there are concerns and questions around the expected rise in the sea level. A flag was raised because the Government of Egypt is not getting ready for the prospective risks. It was also well noticed in the interviews that people, who do not possess the expertise knowledge, separate the food and agricultural problems from the climate change risks. They understand quite well that the coastal areas and the delta are at risk to drown; however, they are unable to link the decrease of the crop production and food availability to the climate change. Therefore, there is an indication of low awareness level among citizens on climate change and

food security issues. It could be indicated that the low awareness issue requires an effort from the government to make Egyptians more aware of the future risks; this would help the whole society to contribute and assist the government to face prospective risks.

Self-sufficiency is another concern. Egyptians dream that their country would reach the state of self-sufficiency. However, UNDP's expert indicated, during the interview, *"Egypt imports 40% of its food, which means that Egypt is unable to meet the growing demand and highly depends on imports."* The growing population is a major risk factor because it means that the persons' share of water and food will decrease; and consequently, set a higher burden on the government to provide adequate food and water to its citizens. ARC's representative supported the study with information that proves that Egypt is unable to reach food self-sufficiency. Table 4 explains the self-sufficiency in the main commodities under Egypt's current conditions.

Table 4: Self-sufficiency in the main Food Commodities in Egypt under Current Conditions

Main Food Commodities	Production (1,000 tons)	Requirements (1,000 tons)	Self-sufficiency
Wheat	**7,388**	**13,591**	**54.4**
Rice	**4,553**	**3,273**	**139.1**
Maize	**6,300**	**11,900**	**53.2**
Sugar	**1,487**	**1,933**	**76.9**
Tomatoes	**7,888**	**7,623**	**103.5**

Source: Sustainable Agricultural Strategy towards 2030. (Abul Naga, 2009).

As shown in Table 4, wheat is not enough to meet the population's demands. This problem is expected to worsen because the agricultural methods are still the same and the population growth is fast. Therefore, it is recommended that Egypt work on two main elements; modernize the agricultural methods to produce more food with less effort and resources, and to generate more income to be able to import the remaining required food.

Knowing the importance of the food security issue to Egypt, a climate change researcher has confirmed that, *"Egypt has progressed and developed various policies to address climate change and food security issues."* Responding to the risks of climate change, the Government of Egypt has assigned the Egyptian Environmental Affairs Agency (EEAA) to "adopt environmental policy that supports sustainable development programs, taking environmental considerations in perspective, and provides a life fit for its citizens" (Jum'ah, 1997, p.35). In addition, in 2011, Egypt published a National Strategy for Adaptation to Climate Change for the first time. The researcher also added that the Egyptian government was committed to follow the UNFCCC mandate on climate change.

The national strategy aims at increasing Egypt's work scope to include dealing with climate change risks and unexpected disasters. Moreover, it targets different sectors to take an active role to mitigate and to try to adapt to prospective risks. The national strategy also assesses the current situation and risks among different sectors. These sectors include: investment, roads, construction, urban areas, agriculture, water irrigation, electricity, etc. It sets recommendations for each sector and encourages the integration of different sectors to serve specific adaptation plans, which were designed for the coming five years for each sector. Moreover, it works on improving public par-

ticipation and raising awareness of safety programs, and on the promotion of the regional and international cooperation. All these goals must be monitored and evaluated regularly by the government. There are seven elements to measure the achievements of the national strategy to adapt to climate change dangers. These elements are:

> (i) Political will at all levels, (ii) availability of human, financial, and natural resources, (iii) reform and adjustments of institutional frameworks, (iv), (v) strengthening the National Information Exchange System, (vi) identification and monitoring, assessment, and follow-up of performance indicators, and (vii) development of a national model for social and economic analysis and projections (Nachmany, 2014, p.7).

5.2 Legal Framework

Egypt does not have a comprehensive legal framework for climate change adaptation and mitigation. In the new constitution of 2014, mitigation and adaptation of climate change are not addressed in any article explicitly. In contrast, for example, Tunisia recognized climate in change in its new constitution after the so-called "Arab Spring" under Article 45. The Tunisian constitution obliges Tunisia to guarantee "a sound climate and the right to a sound and balanced environment," and to "provide the necessary means to eliminate environmental pollution" (Paramaguru, 2014).

In Egypt, there are also articles in the constitution that are concerned about the environment and food related issues. Articles 29, 32, 44, and 46 advocates towards the protection of agriculture, natural resources, the Nile River and the environment, respectively. The protection of the environment is addressed under the Law 9/2009 on the Protection of the Environment that specifically target the environment; however, until present, there are no binding laws with regard to climate change. There are two relevant laws that tackle the environmental issues: Law 9/2009 on the Protection of the

Environment and Law 48/1982 for the Protection of the Nile River and its Waterways from Pollution.

Law 4/1994 and the amended Law 9/2009 on the Protection of the Environment

Law 4 of 1994 was amended in 2009 include environmental concerns to Egypt's legal framework. The law establishes EEAA as the body that works on decreasing and limiting environmental pollution in air, soil and water (EEAA, 2016). The amended Law 9/2009 also put the EEAA in charge of developing the National Integrated Coastal Zone Management (ICZM) Strategy. In addition, the EEAA provided a long-term binding plan to address several other problems, such as irrational land use, shoreline erosion, and water pollution. Quite significant progress has been recorded by a number of counterparts; however, this long-term plan has not yet been finalized because the political instability and governmental changes occurred after 2011 uprising. The Egyptian government recently resumed its work in the current plan. This law is helpful to tackle climate and agricultural concerns, however, there is no clear statement that tackles the climate change or food security risks.

Law 48/1982 for the Protection of the Nile River and its Waterways from Pollution

Law 48 of 1982 focuses on the purity and the cleanliness of the water resources in Egypt, especially Nile water. The law bans disposing of waste in the Nile, and it imposes regulations on touristic boats please check boats and on industrial factories near any water resource. This law is vital for the environment; however, the status of Nile River is still not improving. Various stakeholders, including citizens and NGOs representatives, have indicated during the interviews that the Nile's water purity and quality is deteriorating. And therefore, this would affect the agricultural sector tremendously because the quality of the crops would decrease and the livestock could get harmed from the polluted water. In addition, water purification techniques add to the total costs. The current Minister of Environment explained to Al-Monitor Newspaper,

"the Nile water pollution problem is still complex and has been going on for over 30 years. The government is trying to find solutions to improve the river water quality" (Aman, 2015). The policymakers focus on the water pollution issue, which is important and complex. However, the law does not include climate change risks or agricultural related statements.

This led to a gap in the current system because all climate change adaptation practices in the agricultural sector are considered optional to farmers. UNDP's Egypt Country Office mentioned in its report that, "the legal framework…needs to be strengthened to meet the international standards and to be in accordance with UNFCCC standards (UNDP, 2009, p. 13). However, with the new Parliament, some participants have expressed their hopes towards the development of a legal framework because, following the 2011 uprising, there has been a substantial progress towards introducing new legislation and amending old laws, as Egypt has become more open to development and change than in previous decades.

However, the question still remains of whether constitution or law is enough to address climate change issues or not. "The constitution is the highest legal document in the land," says Linda Siegele, an environmental lawyer part of the advocacy group Wild Law U.K. Having a specific law or article in the constitution would remain an important notable step towards achieving environmental goal. However, implementation would always remain the key factor to measure the real on ground progress because some countries, after developing environmental law, they remain reluctant to implement and put the law in practice.

Furthermore, the interviews reveal that having halted policies in Egypt was the opinion of the majority of the respondents, who belong to the civil society. PhD student

interviewed indicated that, "*the government possesses a "well-written" strategy; however, it does not have the intention to actively implement the strategies. The government writes professional reports to obtain funds; however, there is not real progress in the field."* Egypt's existing policies are not adequately responsive to the current risk of climate change and there is a policy gap. From the interviews, stakeholders have also indicated lack of governments' cooperation despite the existence of the national strategy that was supposedly integrating diverse stakeholders under the EEAA, and supervised by the Ministry of Environment (MoE).

There is clear contradictory information with regards to the current national efforts. The Government of Egypt seems to be progressing in terms of strategy development; however, some of the local NGOs and representatives from the civil society were uncertain and had concerns on the government's actual implementation plan. This is an indication for the lack of the national policies and the need for developing stronger relationships among stakeholders to enable the civil society to operate efficiently in the field.

5.3 Institutional Framework

The climate change issue, as previously discussed in the literature, is a cross cutting issue that involves several stakeholders. The main sectors affected by climate change, which are identified under the Egyptian Strategy for Climate Change, are:

1. Water resources and irrigation sector;
2. Agricultural sector;
3. Health sector;
4. Urban areas, housing and roads sector; and
5. Tourism sector.

5.3.1 The Parliament

The role of the Egyptian Parliament in Egypt is concerned with legalization and monitoring the government plans and progress. The parliament is then responsible for developing legal framework addressing climate change and food security issues. In addition to, monitoring the government progress towards strategy implementation. However, the climate change was not thoroughly discussed in any of the parliamentary sessions in Egypt. The lack of climate change discussions in the Parliament was observed through the Parliament news reports and press releases issued in the official national newspapers.

5.3.2 The National Council for Climate Change

In order to facilitate cooperation among ministries, a new national council for climate change was established in 2015 under the Prime Minister Decree No.1912 of 2015 chaired by the Minister of Environment. The National Council for Climate Change (NCCC) is composed of diverse representatives from governmental entities, including the Ministries of Defence, Interior, Planning, Finance, Agriculture, Industry, Water Resources, Foreign Affairs, and a representative of the General Union of associations of civil society. The creation of this council aims at bringing together all relevant authorities to update the national strategy for climate change and sustainable development. However, the new council is criticized for being inactive for the year 2015 and 2016 and this was shown from the numbers of meeting held and the activities implemented through the new national council. The NCCC aims to work on:

> Organizing and implementing national research efforts on climate change and projects to reduce emissions and adapt to climate change risks; vet projects submitted to the Green Climate Fund; collect, manage and process climate change data; conduct a report on the results of its work every four months to be submitted to the Prime Minister. It will be also responsible for suggesting, following up on and gradually increasing financial annual allocations in the general budget of

the state inside each ministry concerned with the impact of climate change. (EEAA, 2015)

5.3.3 Ministry of Environment

The role of MoE was restricted to a provisional role. It was responsible for setting the policies and managing international agreements, and provides Environmental Impact Assessment (EIA) for projects. However, the EEAA was the main body that coordinates with governmental agencies to implement the national environmental plan, specifically Law 4/1994, and its amended Law 9/2009 on the Protection of the Environment. The climate change unit at the Ministry of Agriculture is responsible for the initiatives of the local non-governmental agencies as a regulatory body through the EIA process. Any project relevant to the environment must obtain EIA approval prior to implementation.

5.3.4 Ministry of Agriculture

For example, WFP's project, "Building Resilient Food Security Systems to Benefit the Southern Region of Egypt", proved to be a success; this project integrates diverse stakeholder, including NGOs, government, and local communities. In an interview with WFP personnel, the National Project Manager, stated that *"the governmental field offices cooperate effectively with us in Southern Egypt to maximize the reach and raise farmers' awareness."* This program was designed for the southern region of Egypt. The program aims at strengthening the adaptive capacities to face food reduction and to strengthen institutional capacity at all governmental levels to ensure sustainable development. The program works with the government and farmers to improve their adaptation through technology development. In addition to this, it raises their capacities for climate knowledge and adaptation replication. The selection of the region

was made based on intense research by the UN and the Egyptian government to determine the most disadvantaged areas in Egypt. Southern Egypt, also known as Upper Egypt, was the poorest region in Egypt (Egypt Human Development Report, 2010). The impact could be multiplied, if the government, in cooperation with local communities and NGOs, could replicate the program in other regions.

In contrast to the case of WFP, other current efforts are fragmented and work independently without cooperation with other relevant stakeholders. NGOs representatives who work directly with farmers on new irrigation methods and climate change expressed concerns about the government's role, stating that the government "*is not cooperative and did not provide us with any support."* The director of Water Institute NGO said, "*we work alone and the government has to take its responsibilities to mitigate and adapt to climate change risks."* Therefore, this means that the NGOs are willing to cooperate with the government and expand their role in the society through legal channels.

There is clear contradictory information when it comes to the role of the government and field offices are they cooperative or not. The Government of Egypt seems to be more cooperative with international organizations such as, WFP and UNDP; however, the Government is unable to cooperate and reach local NGOs and organizations. Therefore, these data reveal that there is a lack of cooperation among stakeholders, which hinders Egypt's progress, since Egypt does not fully benefit from the NGOs' fragmented efforts.

5.4 Crop Production

Food production has been impacted by climate change intensely in Egypt. As the below table is provided by WFP representative, which shows that crop production is sensitive to climate change conditions in Egypt. The major strategic crops, such as,

wheat and maize, are currently diminishing. The interviewee added, "*climate change is not something that would happen in 100 years, it is happening now; farmers and people in the field are aware*." This means that Egypt is in urgent need to develop immediate action plan to reduce the negative effects of climate change on crop production. There are several techniques and agricultural methods suggested by respondents, who are experts in the field. Most of these methods are discussed in this section.

Table 5: Projected changes in crop production in Egypt under Climate Change Conditions

Crop	Change	Percent
	2ºC temp. Increase	4ºC temp increase
Wheat	- 14	- 36
Maize	- 19	- 20
Cotton	+ 17	+ 31

Source: Egypt Agriculture Climate Adaptation Strategy, 2010.

As shown in Table 5, the most affected crops are strategic crops; wheat, for example, is expected to decrease by 14 percent in case the temperature increased by 2 C or to decrease by 36 percent in case the temperature increased by 4 C. This means that if the production level decrease, Egypt will resort to import the remaining quantity from other countries. Egypt is currently suffering from severe economic condition and this will put the country under more pressure to feed its people. However, UNDP's expert argues against that opinion, he said, during his interview, "*Egypt should not use its water for agriculture because it consumes a lot of water and there is not return or profit. It is recommended to save the water for drinking and other crops and import wheat."* The current news proves that the imported wheat is cheaper than the wheat

cultivated in Egypt. Egypt invests on irrigation; however, other countries, such as, the United States, rely on rain and use advanced technologies in agriculture. It would be more efficient to import wheat and save water rather than face water scarcity issues. However, there was contradictory information with regards to the previous suggestion. This policy has multiple political dimensions because Egypt would be concerned to fully rely on international markets, especially when it comes to the strategic goods and necessities, especially during the threatening economic circumstances. Therefore, this policy suggestion would need further studies to examine its feasibility.

The prevalence of pests and disease are another important potential effect of climate change. Scientific studies confirm that the gravity of some diseases harming crops has increased in the past few decades due to climate change. WFP in 2011 conducted a study on crops in southern Egypt, which indicates the severity of the risks:

> "…Examples include severe epidemics of tomato late blight (*Phytophthora infestans*) witnessed heavily in Southern Egypt last year. *Tuta Absoluta* was also reported by farmers in focus groups conducted in Southern Egypt to have increased in recent years but they know no solution…. Furthermore, *downy mildew* is also reported by Southern Egypt farmers in focus groups to have increased in this region, which was non-existent in some distinct spots in the area."

Currently, extreme weather events and the prevalence of pests and diseases have caused serious damage to crop production. The frequency of these events had increased significantly during the past decade. For example, during the excess rainfalls in November and December 2015, many agricultural lands in Egypt were seriously impacted and lost crop production. For instance, eighty hectares in Damanhur and 13,000 hectares in Kafr Dewar in Beheira Governorate were completely destroyed; these farms had crops of sugar beet, wheat, potatoes, and artichokes. The government tried to compensate the farmers by giving them a total of 6,000 hectares, but the compensation was not equal to the losses of the farmers. These incidents show that the government was

not ready or equipped to face extreme weather events. Moreover, there are limited financial solutions for farmers, which prevent farmers from adopting new initiatives. He explained that solutions are limited to micro-finance and micro saving, which many farmers are unaware of. It is a major problem in the agricultural sectors because when a farm is exposed to a heat wave, for example, farmers lose their revenues and might not be able to secure an income for their families. The lack of an insurance system makes farmers insecure to continue working in agriculture and increases the risks on their income on personal and aggregate levels.

Southern Egypt farmers also face the addition challenge of increased evapotranspiration, which causes higher demands for irrigation, which would consequently decrease the crop production. Furthermore, based on the historical data obtained from Egyptian Meteorological Authority (see annex 1), southern Egypt was exposed to the worst heat shocks across Egypt. This trend is expected to continue over the upcoming decades (NCR, 2010). As explained by in WFP's 2011 project document:

> "Heat and frost waves are generally more frequent, intense, and unpredictable in southern Egypt. Resulting crop failures have been on the rise in the zone. Although no official data is published to quantify crop losses from more erratic weather, failures of fruits and vegetables, and the effect on prices, have been widely reported in the media, and are of increasing concern to producer groups".

There were several solutions proposed in the national communication report (2015) and recommended by experts in the field, during their interviews. All the solutions revolve around a cropping mix adaptation and a reduction in CO_2 emissions. Crop rotation was an approach followed in Egypt from the 1950s to the 1980s. The objective of this system was to avoid planting the same crop on the same land over a period of years. This technique has proven to make land more productive and fertile because it provides the soil with natural fertilizers and nutrition that benefits the next planted crop.

According to a respondent, an engineer, *"the removal of crop rotation was the worst decision that has happened to the Egyptian agricultural sector"*. The agency is working with local NGOs to encourage farmers to follow the crop rotation methodology in order to increase productivity and the products' quality. The current legal framework does not put any obligations on farmers to follow any particular crop rotation. However, the Ministry of Agriculture in cooperation with international organizations and NGOs is attempting to raise the farmers' awareness and encourage them to do follow a crop rotation plan to gain the maximum benefits from their land.

Crop mix and drought-resistant crops and varieties are another effective strategies that would assist in preserving water resources and maintaining crop production as much as possible. As previously discussed, crops will demand higher quantities of water as temperature increase, while water resources are expected to decrease over time. The changing the crop mix and drought-resistant crops and varieties are effective techniques to adapt to climate change. However, Egypt is not yet fully active in this regard and does not possess a clear policy that regulates the crop mix or drought-resistant crops according to climate change. The literature supports the crop mix strategy as several experts suggest altering the crop mix to save irrigation water (McCarl et al, 2015). The major results of the experts' study show that sugarcane should be completely eliminated from the Egyptian agricultural sector. In addition to this, other water-consuming crops like rice and cotton should be reduced as well to allow for other crops on the same land.

Raising farmer's awareness is crucial to implement effective policies. A respondent of WFP explained that, "*although farmers were aware of the effects of climate change, many of them were not aware that there were practical solutions to increase crop production again.*" The interviewee also explained that many of the farmers who

were working with them used to think, "*climate change was a test from God",* which was inevitable and unchangeable. This reflects the culture and the extent to which those farmers are illiterate of Climate Change issue. It also reflects the lack of awareness provided to those farmers. WFP in cooperation with local NGOs organized meeting and training sessions with farmers in Southern Egypt to explain the diverse techniques farmers could use to combat climate change. An example on this was the agricultural thermometer. This machine measures the temperature of hay, grain, root vegetables and other crops. Farmers used it to determine the water level required according to the weather conditions and get prepared to weather events. By following this technique, farmers would be able to monitor their plants' growth, save water, and protect their crops from dryness. Therefore, this is another indication that farmers have a relatively low awareness level, as they do not know how to counter the climate change problems.

From the above data and the literature review, it could be perceived that there is a lack of adaptive policies in the agricultural sector. Moreover, there is a lack of awareness among farmers on the practical solutions to climate change. For this reason, implementing adaptive policies and launching a targeted awareness campaign for farmers would elevate the crop production and end many of the current problems.

5.5 Water Management and Irrigation

Egypt is under the poverty line of water. Also, the country is currently facing regional stress to decrease its share in the Nile waters. The Nile River is the only source of fresh water for Egypt, besides a minimal percentage of the fresh water coming from the underground water. Also, the construction of the Grand Renaissance Dam in Ethiopia has intensified the situation among Egypt, Ethiopia, and Sudan. Although the three countries have progressed in the negotiations, however, the current negotiations are

still inconclusive, while the construction of the Renaissance Dam is ongoing. Therefore, Egypt water policies have political and social dimensions, which increase the complexity of the situation and urge the country to adopt national policies for increasing water efficiency and better water management.

Water management and irrigation are critical elements in Egyptian food production and availability as nearly 60 percent of the country's food is provided through crop production and livestock. The food production was highly influenced by the availability of water from the Nile. The respondent of WFP supported this study with a report, which further explains the dependence of food production in Egypt on the Nile River. Table 6 presented by WFP (2011) shows that Nile flows were extremely sensitive to climate change. If the temperature increases by four degrees, precipitation was expected to be reduced by 20 per cent and the Nile flow may decrease by 98 percent as a result. Egypt was expected to face water shortages, which will decrease the water share per capita by 50% by 2060 (McCarl, 2015). This means that Egypt water resources, which is under poverty line, is at risk to meet the demands of the people and the demands of the agricultural sector, which consumes the majority of water resources.

Table 6: Climate Change and Nile flows

Climate Change, °C	Change in Precipitation, percent	Change in Nile Flows, percent
+4	-20	-98
+2	-20	-88
0	-20	-63
+4	+20	-68
+2	+20	+1
0	+20	+71

Source: (WFP, 2011)

Irrigation inefficiency puts Egypt under higher stress; Egypt is one of the countries that are under the water poverty line, and it is still using furrow irrigation. This type of irrigation is the most practiced in Egypt. And since, climate change is a long-term issue that is expected to have enormous effects on Egypt's water resources. Therefore, the Government of Egypt should urgently consider adaptive policies to reduce these effects. In fact, as shown in table 7, the Ministry of Water Resources and Irrigation in 2005 designed the National Water Resources Plan to introduce certain measures to be taken in that regard. Although this plan has been designed since 2005, farmers, who were interviewed by WFP in Upper Egypt, have shown their dissatisfaction with the problems of water management, which led to water insufficiency and affect crop production. Water mismanagement is still a form of poor irrigation and drainage systems that affects soil quality and productivity across Egypt.

Table 7: The National Water Resources Plan

1- Physical development of the irrigation system;
2- Efficient and reliable water distribution;
3- Better water regulation of water;
4- Increased crop and livestock productivity and elevated farmers' income;
5- Empowerment and involvement of stakeholders;
6- Conflict resolution among users;
7- Usage of new technologies;
8- Reform of canals cross sections to decrease evaporation damages;
9- Cost recovery systems;
10- Enhancement of drainage;
11- Modification of cropping pattern.

However, there are not any water management polices that counter the climate change effects. The government's inaction due to a lack of the lack of financial resources to uphold the new technologies and develop new sophisticated systems, as Egypt is already suffering from budget deficit and decrees in reserves. ARC's specialist confirmed by stating that "*Egypt has a clear political will but without clear policies and strategies to well articulate the climate change issue."* Egypt is part of all international conventions regarding climate change; also the President in many speeches mentioned the climate change clearly. The Government had other priorities than climate change at the top of the list due to budget deficits and political instability. Consequently, climate change issues have not yet been given the required attention. The majority of the respondents agreed that Egypt has no choice but to develop its water resources; the country is under the water poverty line and costly solutions might be the only solution to avoid thirst and drought. There is low awareness on the droughts' risks, which Egypt can reach in the near future. At this stage, "*no known technology or method is able to bring Egypt's its fertile land back, the land would die and Egyptians will lose almost 40 to 50% of their food resources (university professor said)".* For these reasons, water resources development and climate change adaptation policies adoption are urgent to prevent potential drought and save souls from hunger and thirst.

5.6 Technological Advancements and Global Food Security

As discussed in the literature, Egypt's food security does not rely only on the agricultural sector; it is highly dependent on imports from other countries such as, the United States, France, Russia, Brazil, Canada, Australia, and the Netherlands. Given the importance of imports, therefore, we can never separate the food security of Egypt from global food security. Egypt imports 40% of its food and 60% of its wheat; it is the biggest wheat importer in the world. The United States and Russia are the biggest cereal exporters to Egypt, costing approximately $2 billion yearly.

From the literature and the interviews, we are quite sure that the global food production is at risk. And, even the countries Egypt relies on them to provide food are facing climate change and food security challenges. Both Russia and the United States of America are expected to face a decrease in their crop production. On the long term, these countries may not have surplus to export. According to UNDP expert, explained during his interview with, *"this is the real risk, which fears the whole world. The world worries to reach a status where the food production is not enough for the people around the globe".*

However, high hopes among the scientific to solve the current and the future hunger and thirsts risks. Current scientific research is working to discover a method of water desalination that is cost effective. Desalinized water for drinking can be produced in an economically viable way, but desalinized water for irrigation is still very expensive (Bates, 2008). According to UNDP's environmental specialist, *"the whole world is waiting for this moment. There will be no food or water issues, we will drink and irrigate our lands from seas and oceans."* Genetically engineered climate-resilient seeds are another pending breakthrough. There is a big debate in the climate change

and food security field over genetically engineered seeds, and experts are divided on the pros and cons.

The world is in a race against time to find a solution to feed people and prevent the expected agricultural and food crisis. Due to the urgency of this matter, some scientists and experts around the globe believe that genetically modified organisms (GMOs) are our way out. However, although many experts perceive GMOs as the potential solution to climate change and the food insecurity crisis, others are very concerned. Many scientists argue that there is no proof that that seeds increase production yields or are more resilient to climate change. Moreover, scientists doubt the new scientific findings and consider them unreliable. Another strong criticism is that seed companies give more attention to commercial seeds such as corn. In fact, rice is the most popular meal for the developing world, and the most vulnerable regions.

For example, the amount of production the GMOs can produce. There was a question of sufficiency. There were doubts that these products could reach needy people during a food crisis. And, as previously discussed in Chapter 2, "Food security depends not only on adequate availability of food, but also and importantly on adequate access to food" (Saab, 2015, p. 1). Therefore, there are noticeable efforts in the world to face the hunger crisis. This gives Egypt and other developing countries a hope because technological advancements could positively affect global food security without any harm to human's heath.

From the above data and the literature review, we can infer that there is a lack of awareness on this issue, technological transfer and a lack of cooperation among stakeholders, which hinders progress. There are many organizations and different stakeholders who are ready to cooperate and increase their efforts in this field; however, Egypt lacks a comprehensive legal framework and action plan that coordinate and integrate

the efforts of the diverse institutions. Moreover, the role of governments is still classified as weak in relation to the urgency and seriousness of current environmental problems, since it is not yet integrated in the legal framework nor well-communicated to diverse stakeholders. Like most developing countries, Egypt lacks efficient and strong adaptive environmental policies to counter major risks; this deficiency is due to the weakness of local government, repression of citizens and civil society, and a lack of collective action (Hardoy & Satterthwaite, 1991; Sušnik, 2015).

Chapter 6: Conclusions and Recommendations

6.1 Conclusions

Climatic predictions have become a reality; the average world temperature is increasing and the world has been witnessing now extreme weather events, which directly affect the people and their lives. We expect to witness hunger, thirst and destroyed infrastructure in many parts of the world. Not all countries face the same risk; developing counties like Egypt are more exposed to the possibility of severe economic and serious costs due to climate change. Therefore, adaptation to vulnerabilities is essential to help citizens in developing countries to secure their income, daily activities, overcome extreme weather events, and face market changes. As discussed, there are many studies have shown that climate change pressures Egypt to face extreme risks, especially in the agricultural sector. The main problem lies in the implementation framework and the national polices, as there is no evidence that the current agriculture and climate change strategy are able to address these stressful factors.

The case of Egypt is similar to the challenges of other developing countries, as UNFCCC (2009) described. Egypt's economy and food production relies highly on the agricultural sector, since 40 % of the labor force is employed in agricultural related activities and 60% of its food production comes from agriculture. Egypt is also suffering from weak institutions, lack of agriculture resources, limited cultivated lands, scare water, poor water management, and lack of new technologies. In addition, there is a lack of the lack of clear legal and implementation frameworks. However, the case of Egypt is more complicated because Egypt depends on irrigation, not rainfall, which puts the country in a tougher situation because of its scarce water resources and financial problems. In addition, the population growth is rapid and nearly 40 percent of the

population is below the poverty line. Therefore, transformation in the agricultural sector is vital to meet the growing food demand, protect the people's livelihood, and confront the prospective threats.

6.2 Recommendations

UNFCC countries are exerting efforts and learning the best practices to address their current gaps and inefficiencies. There is not one recipe for all countries. Countries' priorities differ; some countries focus on mitigation policies, others on adaptation or food production. It depends on the countries' priorities and the areas that need development throughout this study, the importance of both food production and agricultural adaptation policies were highlighted due to Egypt's current needs. All the recommendations presented are aligned with Egypt's deficiencies and UNFCCC standards concerning to climate change and agricultural sector.

6.2.1 Primary actions

1. Building an evidence information base:

Egypt does not have information system that collects, analyzes, or interprets data, with regards to climate change and agricultural sector. Therefore, many decisions and policies are based on insufficient evidence. Narrowing the gaps and gathering sufficient data will assist policymakers to design better policies in the country. Sufficient comprehensive information and trusted sources will assist Egypt to maximize its' benefits and minimize its costs'. Examples for information and data collection and interpretation include:

- Evaluation of adaptation needs, and the mitigation possible of agriculture.
- Development of weather, crop, and pest forecasting and mechanisms for data collection and distribution of relevant information to farmers.

- Improving the agricultural research systems and integrating climate change into the current agricultural research programs.

2. Implementation framework and national polices

Egypt developed a national strategy to confront the risks of climate change. The strategy is built upon best practices; however, there are not any national policies to assist in the implementation of this strategy. New national polices should assist adopting of the strategy and the practices, address the current gap in the agriculture, and increase the cooperation among diverse institutions and stakeholders. These policies could include both incentives and regulatory measures:

- Identification of obstacles that could stop farmers from implementing the polices- such as risk aversion is this right term or cultural beliefs - and how to tackle them.
- Identification of policy options and incentives that allow adoption of the new national polices, and potential methods to guarantee accomplishment.

6.2.2 Capacity building

Improving the capacities of the stakeholders in the agricultural sector would help farmers, local communities, and institutions to make use of the existing knowledge, best practices, and technologies. Therefore, it is essential to enhance the local capacities find synonym through creative and innovative methods, such as, establishing field schools to teach farmers the new agricultural methods, enhanced use of the mobile phones for obtaining weather forecasts, and knowledge management networks. Moreover, enhancing the capacities may be another synonym of the national and local institutes, such as: the Ministry of Agriculture and Agricultural Research Center would help the policy makers to manage programs across diverse sectors and institutions.

6.2.3 Technology transfer

Technology has proved to assist developing countries to work under new climate change conditions. It also provides sustainable solutions through integrating new technologies to agriculture Adopting new technologies would assist Egypt to have, as UNFCCC convention suggested (see annex 1):

- Resistant crop varieties;
- Efficient water use and improved irrigation systems;
- Low-density planting, adjustment of sowing dates and crop rotation;
- Improved drainage; and
- Integrated pest management.

6.3 Future possible research

The available data was not comprehensive enough to analyze all aspects of food security; however, it highlighted some of the important issues that require further research. Therefore, further research is needed on many aspects. First, more investigations are required to analyze the impact of climate change on food accessibility and utilization. Also, the degree of which the services offered by government agricultural offices benefit workers in the agricultural sector is a potential topic for investigation check this sentence something is wrong. Also recommended for future research are further interviews with governmental official in different sectors, to assess their level of awareness and involvement in climate change and food security issues.

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Annex 1: Tables and Figures

Table 8: African farmers perception of climate change

Variable	% of respondents
(a) Temperature	
Increased temperature	51
Decreased temperature	5
Altered climatic range	9
Other changes	7
No change	14
Don't know	6
(b) Precipitation	
Increased precipitation	5
Decreased precipitation	50
Changed timing of rains	32
Frequency of droughts	16
Other changes	5
No change	13
Don't know	4
Number of responses	**8,208**

Source: (Gbetibouo, 2009).

Table 9: African farmers perception of climate change

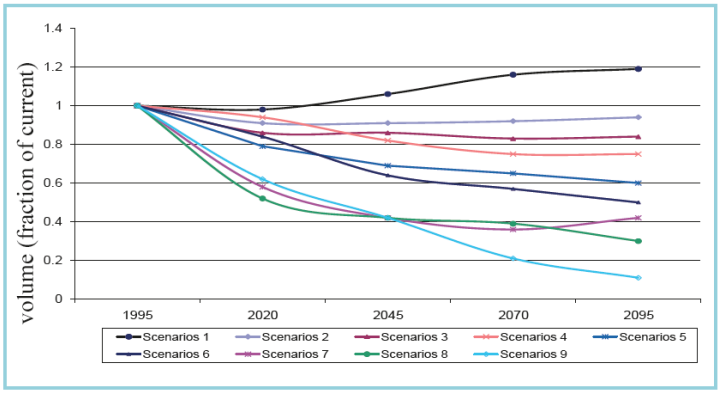
Variable	% of respondents
Different crops	11
Different varieties	17
Crop diversification	8
Different planting dates	16
Shorten length of growing period	13
Move to different site	4
Change amount of land	3
Crops to livestock	2
Livestock to crops	1
Adjust livestock management practices	1
Farming to non-farming	9
Non-farming to farming	1
Increase irrigation	10
Change use of chemicals, fertilizers and pesticides	5
Increase water conservation	18
Soil conservation	15
Shading and shelter	21
Use insurance	7
Prayer	5
Other adaptations	22
No adaptation	37
Number of responses	**8,217**

Source: (Gbetibouo, 2009). 8

Table 10: Temperature data from the Egyptian Meteorological Authority over 40 years. Source: (WFP, 2011)

Zone	Governorate	Mean Temperature
Lower Egypt	Alexandria	20.2 °C
	Port Said	20°C
	Behera	20.7°C
	Damietta	20.2°C
	Kafr El Shiek	19.2°C
	Gharbia	20.4°C
	Dakahlia	20.9°C
	Sharkia	20.7°C
	Monofia	21.2°C
	Qualiobia	21.1°C
	Ismailia	20.4°C
	MEAN	**20.48**°C
Middle Egypt	Giza	20.5°C
	Beni Suef	21.5°C
	Fayoum	22°C
	Menia	21.1 °C
	MEAN	**21.28**°C
Southern (Upper) Egypt	Assuit	22.9°C
	Sohag	22.9°C
	Qena (and Luxor)	24.9°C
	Aswan	26.9°C
	MEAN	**24.4**°C

Figure 2: Scenarios of changes in Nile flows



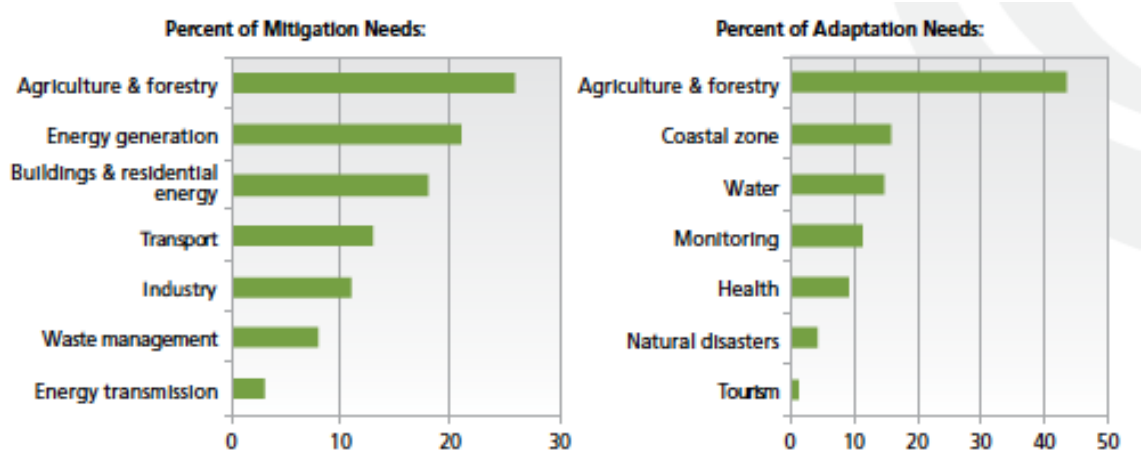
Source: (Strezpek et Al., 2001)

Table 11: Technology Needs Identified by Developing Countries

Examples of Technology Needs for Mitigation in Agriculture	Examples of Technology Needs for Adaptation in Agriculture
• Crop waste gasification • Improved cultivation methods • Production/management of soil nutrients • Rational application of fertilizer • Drip irrigation • Biodigesters (manure management) • Solar (photovoltaic) and wind water pumps • Solar energy for processing agricultural products • Modification of livestock feed	• Tolerant/resistant crop varieties • Efficient water use and improved irrigation systems • Low-density planting, adjustment of sowing dates and crop rotation • Improved drainage • Integrated pest management • Sustainable grazing and herd management • Heat-tolerant livestock breeds • Networks of early warning systems

Source: (UNFCCC, 2009)

Figure 3: Needs Identified by Developing Countries



Source: (UNFCCC, 2009)

Annex 2: Interview Questions

Basic Information:

Position: _____

Organization: _____

Years in Current Position: _____

Years in Current Organization: _____

Date of Interview: _____

1. What areas are worst hit?
2. Is this a security issue?
3. What are the current adaptation policies and strategies?
4. Which of them do you think are the most effective?
5. To what extent are we ready to face climate change?
6. How can NGO and other organization help the government?
7. What policies could we implement or change to help reduce the negative impact that climate change has had on water & food supply?
8. Do you think that hybrid crops are the best way to counteract the increasing occurrence of droughts, floods, etc.?
9. What are some alternatives?
10. Do we have any positive outcomes from climate change?
11. How does this relate to other security issues?
12. Do you think people can fight over resources in the near future?

Table 3: List of respondents

International organizations
Environment Specialist, Assistant Resident Representative, UNDP.
National Program Coordinator, WFP.
Regional Program Officer for Disaster Risk Management and Climate Change, World Food Program.
Government
Soil Science, Irrigation and Water Management specialist, Agricultural Research Center, Egypt.
Water Requirements and Field Irrigation Research Department Soils, Water and Environment Research Institute, Agricultural Research Center.
Civil Society: Private sector, Non-governmental agencies, and academia
Director of a national pesticides company.
Vice president of a well-known real estate company, which works on the construction of huge projects on the North Coast.
Founder of the Water Institute for Nile. She works, as well, as an Environmental Consultant, consulting for organizations including the International Finance Corporation (IFC), GIZ, UNDP, and the UNFCCC. She has been engaged in the UNFCCC international climate change negotiations for the last 5 years focusing on climate change.
Assistant professor, Environmental Specialist, engineering department, Arab Academy, Cairo.

PHD student, Environmental issues, Egypt.
Communication associate, International Organization, Cairo.
University graduate, Sustainable Development, Alexandria.

Coding System:

Themes	Description	Evidence from the Data
Risks of climate change on the agriculture.		
National policies and implementation framework		
Institutional capacities		
Stakeholders cooperation		
The possibility to reduce climate change impact on the agricultural sector.		