

Climate Change Adaptation Needs for Food Security in Egypt

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Abstract: Climate change will affect all four dimensions of food security, namely food availability (i.e., production and trade), access to food, stability of food supplies, and food utilization. The vulnerability of the agriculture in Egypt to climate change is mainly attributed to both biophysical and socioeconomic parameters. This study is to investigate climate change impacts based on field study results and projects activity outputs during last decade in Egypt. An analysis of climate risks for crops in food-insecure regions in Egypt was conducted to identify adaptation priorities, based on statistical crop models and climate projections for 2030, from different general circulation models. Results indicate that Egypt, without sufficient adaptation measures, will likely suffer negative impacts on several crops that are important to large food-insecure human populations. Adaptation planning in agriculture is designing and applying of national adaptation strategy for the agriculture sector. The strategy is facing a group of barriers and limitations (eg. existing scientific, information and policy perceptions, poor adaptive capacity of the rural community, lack to financial support, and absence of the appropriate institutional framework).

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1. Introduction

Egypt appears to be particularly vulnerable to climate change, because of its dependence on the Nile River as the primary water source, its large traditional agricultural base, and its long coastline, which is already undergoing both intensifying development and erosion (Rosenzweig et al 2002; World Bank Report 2007).

The first and second Egyptian communications reports (EEAA 1997), which were prepared by the Egyptian Environmental Affairs Agency (EEAA 2006) submit to the United Nations Framework Convention on Climate Change (UNFCCC), reported that Egypt is one of the most vulnerable countries to the potential impacts and risks of climate change, even though it produces less than 1 % of the world total emissions of greenhouse gases. More than 95 % of the water budget of Egypt is received from the River Nile which is generated outside Egypt's territory. Numerous studies showed that River Nile is very sensitive to temperature and precipitation changes (Riebsame 1995). Agriculture in Egypt is expected to be especially vulnerable because of hot climate. Further warming is consequently expected to reduce crop productivity. These effects are exacerbated by the fact that agriculture and agro-ecological systems are especially prominent in the economics of Egypt as one of the African countries (Riebsame 1995).

More studies were made to assessment the potential impacts of climate change on crop

productivity and crop water use under different agro-climatological zones in Egypt (Abou Hadid 2006 and El-Marsafawy et al 2007). Table 1 summarized the studies result of impact of climate change on the productivity of some major crops in Egypt up to 2050's. From these results it can be concluded that, climate change could decrease national food production from 11 % to 19 %.

Adaptation is a key factor that will shape the future severity of climate change impacts on food production (Easterling 2007). Although relatively inexpensive changes, such as shifting planting dates or switching to an existing crop variety, may moderate negative impacts, the biggest benefits will likely result from more costly measures including the development of new crop varieties and expansion of irrigation (Abou Hadid 2006). These adaptations will require substantial investments by farmers, governments, scientists, and development organizations, all of whom face many other demands on their resources. Prioritization of investment needs, such as through the identification of "climate risk hot spots" (Burton and van Aalst 2004), is therefore a critical issue but has received limited attention to date.

2. Study Area and Methodology

2.1 Time scale

Several different criteria were considered for the study time scale. First is the importance of the crop to a region's food-insecure human population

[hunger importance (HI)]. Second is the median projected impact of climate change on a crop's production by 2030, assuming no adaptation. For this analysis, the study generates multiple (i.e., 100) projections of impacts based on different models of climate change and crop response, in order to capture relevant uncertainties.

2.2 Major food-insecure crops

Three major food-insecure region identified (e.g. wheat, maize and milled rice), each of which (i) comprise groups of country with broadly similar diets and agricultural production systems and (ii) contain a notable share of the country's malnourished individuals as estimated by the Food and Agriculture Organization (**FAO 2012**). The use of projected malnourished populations in 2030 rather than current population values had a very small influence on the rankings.

2.3 Climate change to 2030

Global average temperatures are projected to rise by about 1°C by 2030 (i.e. well outside the natural range). Higher latitudes will warm more rapidly than lower ones and land areas will warm more rapidly than the oceans. Consequently, average temperatures in the higher latitudes may rise by 2°C, possibly double the increase in the tropics (**IPCC 2001**). Parts of Central America, South Asia, northern and southern Africa and Europe could suffer appreciable falls in available water resources.

To project climate changes for the crop region, along with their uncertainties, general circulation models (GCMs) output were used (Model simulations under SRES (Special Report on Emissions Scenarios) emission scenarios corresponding in MAGICC/SCENGEN the emissions scenarios are referred to as a reference and policy scenarios (**Wigley and Raper 2011 and Tubiello 2005**). Data which generated are represented in one scenario A1. These scenarios are described by **IPCC 2001** as follows: The A1 scenario describes future regions of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies.

2.4 Evaluating climate change impacts

Depend on the obtained results from most of studies a several options exist for evaluating climate change impacts across a suite of crops. The data sets on historical crop harvests were used. The model's strength came primarily from a (typically negative) temperature effect on yield.

The probability distribution of production changes for 2030 were estimated (the average from 2020 to 2039 relative to that from 1999 to 2009) for each crop using a Monte Carlo procedure that propagated both climate and crop uncertainties. To

facilitate comparison between crops and regions, we expressed production changes for all crops as a percentage of average values for 1999 to 2009.

3. Results and Discussion

3.1 Impact of climate change on some strategic crops in Egypt

Climate change impact studies that were based on field studies, predicted a reduction in the productivity of the major crops in Egypt. Tables (1 & 2) show the impact of climate change on some major crops in Egypt as a summary of several local studies. These changes in crop productivity are mainly attributed to the projected temperature increase, which affect the grain filling periods and have detrimental effects on sensitive development stages such as flowering, thereby reducing grain yield and quality. Crop-water stress is the other factor causing productivity reduction under climate change.

Impacts of climate change on wheat showed that increasing in temperature will reduce length of growing cycle and the time needed to full tillering in addition to the final yield. This subsequently will reduce the amount of grain yield; accelerate time for maturity and harvesting. For +1.5°C scenario, reduction in grain yield, as predicted by the model, will be in average among cultivars of 12% at Sakha location, 9% at Sids location and 11% at Shandaweel location. Scenario of +3.5°C will reduce grain yield within an average of 27% at both Sakha, Sids locations, and 31% at Shandaweel location. We can conclude that reduction in wheat grain yield at the three locations has high probability in the future with accelerating growing cycle, especially at +3.5°C, which needs to define earlier sowing suitable dates and adaptive agronomical practices (**Hassanein et al 2012**).

Pests and disease remain important factors affecting negatively the crops productivity. The severities of pests and disease impact on the productivity are projected to increase under climate change conditions. The recent scientific observations concluded that the severity of some pests and disease affecting the strategic crops have increased in the last few decades (**Abolmaaty et al 2010 and Yones et al 2011**). This increase in severity is mainly attributed to both climatic and socioeconomical reasons.

The impact of climate change on the pests and disease in relation to crops productivity, is studied in limited scientific trials, but not yet well studied at the national level under Egyptian conditions. For example, severe epidemics of tomato late blight (*Phytophthora infestans*) emerged in the last few years. In practice, an epidemic onset is expected to lead to 2-4 additional sprays to be applied at the coming decades of the 2025-2100's (**Fahim et al 2007**

and Fahim et al 2010). Furthermore, it is a challenge for potato late-blight researches in the future to find a balance between reduction use of pesticides usage and the pressure to increase pesticide utilize due to changes in climate and challenging the pathogen populations. Another study indicated that, the severities of current cultivars of wheat to leaf rust caused by *Puccinia triticina* and stripe rust disease caused by *Puccinia striiformis* increase with increasing temperature, which is projected under climate change conditions (Abolmaaty 2006). Some studies found that, generation numbers of *Tuta absoluta* under climate change conditions increased especially in Qena governorates (south Egypt). However, the expected generation numbers of the pest at 2050 and 2100 are be 12-14 and 13-15 generations per year, respectively (Abolmaaty et al 2011).

The limited investigations in pests and disease concluded that it is a challenge for the agricultural

sector in the future to find a balance between the environmental protection demands for reducing use of pesticides and the pressure to increase pesticide use due to climate change. Furthermore, the possibility of emergence of foreign species endeavouring the local environment species of pest and diseases under climate change conditions is one of the high risks that may face the agriculture production in the future.

Despite the effects of long term projected changes in temperature, the agriculture in Egypt is less sensitive to climate variability, due to the reliance on irrigated agriculture system. Yet, heat and cold waves cause several harmful impacts in crops productivity, especially for fruits and vegetables. A recent study found that the intensity of the heat and cold waves increased in the past 20 years, this represents more risks for the growers [8].

Table 1: Change in major crop production (excess or deficit) in Egypt by the year 2050 due to climate change.

Crop	Current conditions			Climate change conditions	
	Base Yield (t/ fed)	Area (Mfed)	Total Yield (Mt)	Change %	Deficit or excess (Mt)
Wheat	2.732	2.920384	7.977051	-18	-1.435869
Maize	3.39	1.860363	6.306052	-19	-1.198150
Rice	4.091	1.769782	7.240519	-11	-0.796457

Source: Hassanein M. K., 2010. Climate change risk management in Egypt, Food Security FAO project UNJP/EGY022 report number 6.1.2.1. pp 92.

Table 2: Projected changes in crop production of some major crops in Egypt under climate change conditions

Crop	Change %		Reference
	2050s	2100s	
Wheat	-15%*	-36%**	Medany and Hassanein 2006
Rice	-11%		Eid and El-Marsafawy 2002
Maize	-19%		Eid et al 1997
	-14%	-20%	Hassanien and Medany 2007
Soybeans	-28%		Eid and El-Marsafawy 2002
Cotton	+17%*	+31%**	Eid et al 1997
Potato	-0.9 to -2.3%	+0.2 to +2.3 %	Medany and Hassanein 2006

* Temperature increase by 2°C; ** Temperature increase by 4°C

3.2 Adaptation to climate change impacts on main crops in Egypt

Crop production and cropping systems studies concluded that changing sowing dates and management practices were among the important adaptation measures oriented to ameliorate the harmful impact of the climate change on the crop yield (Abou Hadid 2006).

Investigation of impact of climate change on the national cropping pattern, (Hegazy et al 2008) tried a range of temperatures over a range of cultivars of major crop species indicated that sowing dates could be managed in order to allow maximum

predicted planting area in a given region in Egypt. For instance, the current maximum area suitable for cotton planting may show few variations over the coming hundred years. In this case, the sowing dates should be changed from the hotter months (February to April) to the cooler months (January to February).

Changing sowing dates could increase the flexibility of the farming system to face temperature and water requirements increase due to climate change, as a single factor effect. This adaptation option is facing some implementation difficulties related to the overall crop calendar arrangements, and it may be limited by the marketing opportunities,

which may not match the new harvesting dates, especially for cash crops. The acceptability of changing planting date option needs further studies regarding the conflict with other existing crops as the Egyptian cropping system is based on 12-month cycle (El-Marsafawy 2007).

The study of Medany et al 2009 Concluded that changing cultivars and changing crop pattern are the most promising adaptation measures that should be applied at the national level, to overcome the harmful impacts of climate change in crop production.

Furthermore, in order to adapt to the expected disease severity in major crops, breeding of disease tolerant cultivars is urgently needed. At the same time, monitoring system for the current and new races of plant pests and diseases in the country is highly required. Furthermore, application of deficit irrigation measures is more acceptable during water shortage circumstances, compared to reduction of irrigated area (Medany et al 2009).

3.3 Chaining in the main crop commodities self-sufficient in Egypt towards to 2030 under different scenarios

Self-sufficiency in strategic crops shown in Table 3 and Figure 1 indicated that, under future climatic changes conditions towards to 2030 (with no action scenario), it can be predicted that if the agricultural area and production as the same current,

self-sufficient with wheat, maize and milled rice could reach 33.6, 24.8, 86.9 % compared to 57.4, 53.9, and 160.0 % under current conditions. In addition, increasing in population growth rate and the shortage in water supply as well as the rising in sea level with its effect on salinization of North Nile Delta which could decrease the total agriculture area, the situation in food security will more and more seriously in the future.

Yield declines for the most important crops. Climate change will have varying effects on irrigated yields across regions, but irrigated yields for all crops in Egypt will experience large declines. Climate change will result in additional price increases for the most important agricultural crops—rice, wheat, and maize.

On the other hand, with positive action against risks of climate change on self-sufficiency in strategic crops Table 3 shown that under increase of agricultural area and production with 10% (depend on SADS 2030), self-sufficient with wheat, maize and milled rice could reach 49.4, 36.7, and 133.7 %, respectively.

Therefore, it is vital that action be taken now to counter this threat. Actions should include measures to reduce agriculture's role as a driving force for climate change, through the reduction of GHG emissions, as well as measures to mitigate and adapt to climate change.

Table 3: Estimated rates of self-reliance and self-sufficiency in the main food commodities, under climate change with action and no action of adaptation

Main food commodities	Current production of 2011			2030 estimates*** with no climate change impact		
	Prod.* (1,000 tons)	Requirements (1,000 tons)	Self-suf.(%)	Prod. (1,000 tons)	Requirements (1,000 tons)	Self-Suf. (%)
Wheat	8407	14650	57.4	8407	18709	44.9
Milled rice	5675	3528	160.9	5675	4664	121.7
Maize	6876	12827	53.6	6876	20600	33.4
People population	83 millions			106 millions		
	2030 estimates*** with climate change + no adaptation action			2030 estimates *** with climate change + adaptation action		
	Prod. (1,000 tons)	Requirements (1,000 tons)	Self-suf(%)	Prod. (1,000 tons)	Requirements (1,000 tons)	Self-Suf (%)
Wheat	6279.8	18709	33.6	9247.7	18709	49.4
Milled rice	4052.17	4664	86.9	6242.5	4664	133.8
Maize	5103	20600	24.8	7563.6	20600	36.7
People population	106 millions			106 millions		

Sources of row data: * FAOSTAT | © FAO Statistics Division 2013

** CAPMS| Central Agency for Public Mobilization and Statistics 2013 *** SADS 2030 | Sustainable Agriculture Development Strategy Towards 2030

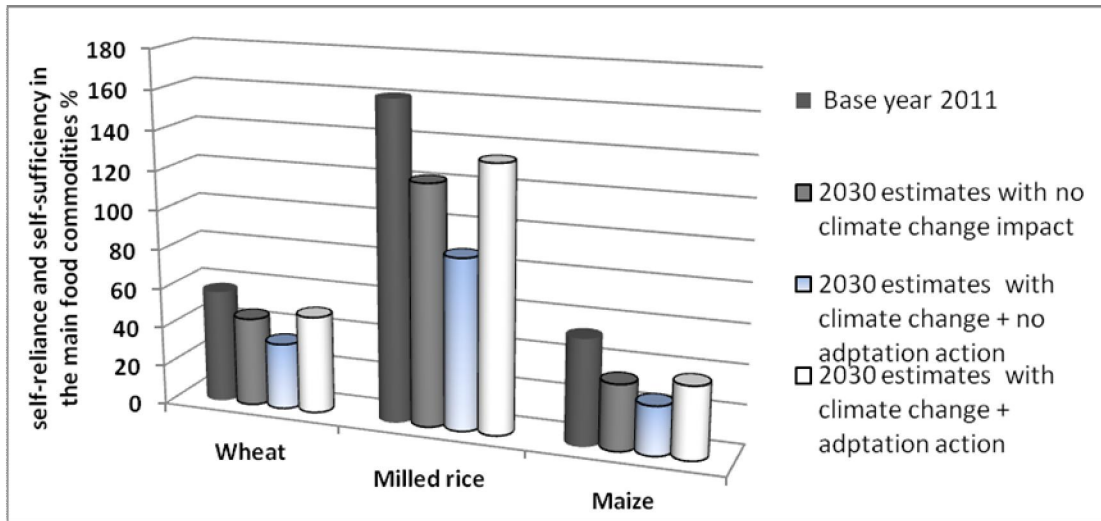


Figure 2: Chaining in the main crop commodities self-sufficient in Egypt towards to 2030 for different scenarios.

3.4 Recommendation for research topics & needs of climate change to food security

Depend on most of studies results and projects activity outputs conducted in Egypt, significant attention needs to be given to the following topics:

- Assess the impact of climate change on the productivity of the major crops, with wide scale assessments covering the Egyptian agricultural map.
- Study the impact of climate change in agriculture water-use.
- Study the impact of climate change on soil degradation and land use change, with special attention to the agricultural hotspots in the Nile Delta region.
- Study the impact of climate changes on the pest and disease cycles and severities, host plants disease resistance, epidemics evolution, and native pests and diseases migration.
- Study the impacts of climate change on livestock, aquaculture and fishing.
- Study the impact of extreme weather events, on terms of heat and cold waves and sand storms, in the productivity of plant and livestock production.
- Developments of risk assessment tools and identify agricultural hotspots in Egypt to assess the risks of agriculture sector under the projected climatic changes and extreme weather events.
- Encourage academic and on the job training of the subject and provide the necessary professional assistance through technical, local and foreign consultants, short courses, web applications, seminars and workshops.
- Develop national emission factors and methodologies, in order to conduct more accurate determinations of GHGs emissions from agriculture sector.
- Conduct mitigation studies of GHGs emissions from different agricultural sources, with special attention to paddy rice, soil management, livestock, animal waste management systems, and agricultural waste burning.
- Study the economics of mitigation from the different GHGs sources from agriculture sector.
- Study the vulnerability and the adaptation of the cropping pattern and systems at farm, regional and national levels.
- Conduct wide scale assessment of field crops stress- tolerant varieties development, in terms of heat, water shortage and salinity stresses.
- Study the vulnerability and the adaptation of the on-farm irrigation system at farm, regional, and national levels.
- Study the possible adaptation measures to face the agricultural land loss due to SLR effect.
- Develop adaptation measures of soil maintenance, under different agricultural systems, with special attention to the hotspots agricultural locations in Egypt.
- Develop integrated adaptation scenarios of plant protection, based on integrated crop management (ICM) and biological control concepts.
- Develop integrated adaptation scenarios for livestock, fishing and aquaculture.
- Conduct comprehensive studies of the adaptation requirements, costs, inter-sectors

relationships and feedbacks of the agriculture sector and rural communities.

4. Conclusion

The potential decreases in food production up to 2030 are relatively small and most countries should be able to compensate for climate change impacts by improving agricultural practices. Priority should be given to raising the resilience of agricultural ecosystems, increasing the cropped area, and raising and diversifying yields through improved access to genetic resources and technologies. Moreover, the growing income should make it possible for many of them to choose between greater food imports and greater mitigation and adaptation by agricultural sector to overcome climate change impacts.

Up to 2030, the most serious and widespread agricultural and food security problems related to climate change are likely to arise from the impact on climate variation, and not from progressive climate change, although the latter will be important where it compounds existing agro-climatic constraints. However, the more frequent extreme events will not necessarily increase food insecurity in all situations, given the other economic and social changes taking place. Institutional changes are going to be as important as or more important than technological ones. Institutional actions will be needed to raise national preparedness and reduce rural and urban poverty to enable vulnerable low-income groups to purchase all of their basic food requirements. Policies for agricultural development will need to emphasize the importance of improving not just the production capacity of agricultural ecosystems but also their diversity and resilience. It is vitally important to initiate the institutional and technological changes now, because of the long lead times for the development of new technologies and for the improvement of road and rail links between food-deficit and surplus areas, and between ports or railheads and isolated rural areas.

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