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RESEARCH ARTICLE

Extreme weather events and negative impacts on Egyptian agriculture.

Khalil A.A.¹ and M. K. Hassanein².

1. Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC), Egypt
2. Field Crops Research Institute, (ARC), Egypt

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Abstract

Agriculture sector is highly sensitive to climate variability and weather extremes. Extreme weather events are increasingly threatening the farmers and agricultural production, it causing serious losses and damages increasingly gradually in Egypt. The aim of this study is to investigate and identify the extreme weather events which occurred in Egypt and its impact on agriculture. The most significant extreme weather events during the recent past years have been chosen in this study. These events have had negative impacts either in terms of cost to the economy especially on agriculture production, loss of life, or displacement and long term impact on the national income in Egypt. This study focuses on four extreme weather events which have been occurred in the recent past years (extreme heat and cold temperatures, extreme wind, and extreme precipitation). The weather data were collected from central laboratory for Agricultural climate, Agricultural research center, and analyzed in order to identify the extreme weather impacts on Egyptian agriculture. The results indicated that, the duration and frequency of extreme weather in Egypt have increased in the recent past years. The data show increasing the hotter and colder extreme events over the Egypt during recent years. Extreme weather has many adverse impacts on Egypt society and environment, affecting human health, infrastructure, agriculture and ecosystems. Egypt is one of the most vulnerable countries to the potential impacts and risks of extreme weather events.

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Introduction

The extreme weather or climate event term refers to “an occurrence of a value of a weather or climate variable beyond a threshold that lies near the end of the range of observations for the variable” (IPCC, 2012). In a complex system such as the Earth’s climate, extreme events recur in an irregular fashion, and the timing is unpredictable. The greatest challenges in understanding extreme phenomena often involve their intrinsic irregular nature and the small samples of extreme values available, both these aspects are important to keep in mind in analyzing extreme events. Zwiers *et al.* (2012) provided a descriptive perspective of extremes: ‘a characteristic of extremes is that they are understood within a context – and thus seasonal or annual means may be “extreme” just as an unusual short-term event, such as a daily precipitation accumulation, may be extreme’ (QysteinHovet *et al.* 2013). During the last several

Corresponding Author:- Khalil A.A

Address:-Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Center (ARC),
 Ministry of Agriculture and Land Reclamation (MALR), Egypt.

decades, there has been an increasing frequency and severity of extreme weather events (Riebau and Fox 2005). Extreme weather events can have severe detrimental effects on crop yield, and therefore, agricultural production. Most crops are sensitive to direct effects of high temperature, decreased precipitation, flooding, and untimely freezes during critical growth phases. Other effects on crops are indirect, through influences on soil processes, nutrient dynamics, and pest organisms (Raymond P. Motha 2011). Extreme weather events, which are predicted to occur more frequently in a warming climate, are likely to affect crop yields, field explained. The special report of IPCC "Managing the risks of extreme events and disasters to advance climate change adaptation (SREX)" predicts a tenfold increase in extreme heat this century under a moderate carbon dioxide emissions scenario. Extreme weather events, which occur in every agricultural region of the world, cause severe crop and livestock damage. Extreme weather events can in fact impact crops both via negative impacts on plant physiological processes and direct physical damage, as well as by affecting the timing and conditions of field operations. For instance, above-threshold temperatures and precipitation lows, leading to heat and drought stress, can negatively affect crop photosynthesis and transpiration (Porter and Semenov 2005), as well as increased pest and disease incidence; and extreme temperature events may also hinder fruit setting and development, critically lowering yield potential (Tubielloet al. 2007). On the other hand, heavy rain, hail storms and flooding lead to crop failures by physically damaging crop canopies, or via anoxic soil conditions limiting root and plant function. Extremely wet conditions can also delay key field operations such as planting and harvesting (Marijn van der Velde 2012). This paper brings together the evidence by event type, focusing on agricultural impacts and highlighting economic consequences where recorded. The aim of this research is to identify the extreme weather events and evaluate the damages in agriculture which occurred in Egypt under extreme weather events during the recent past.

Material and Methods:-

The most notable events during the last years are four extreme weather events during the recent past years (extreme heat and cold temperature, extreme wind, and extreme precipitations), as these are most widely reported in the research and media remain closest to the forefront of the memory of the country affected.

Extreme heat temperature

Based on historical daily temperature data during 1990 - 2015, two extreme heat temperatures have been happened during the recent past years, the first one during the year of 1998 and the second one during the year of 2010 as most important extreme events during recent years and resulted significant negative impact on the strategic crops production. The weather data were collected from central laboratory for Agricultural climate, Agricultural research center, Ministry of Agriculture and Land Reclamation, Egypt.

Extreme heat temperature during 1998

The extreme heat temperature and its impact on rice production were identified by comparison the data of average temperature and rice production at Kafer El-Sheakh Governorate during 1998 and 1999 years. The data of this extreme obtained from (khalil, 2004).

Extreme heat temperature during 2010

The weather data of maximum, minimum and average temperatures during 2010 and normals was collected for 11 Governorates represent different agro-ecological zones in Egypt and the comparison between temperatures during 2010 and normals has been done to studying it with the wheat grain yield in these zones which has been collected from agricultural statistics, Economic Affairs Sector, Ministry of Agriculture, Egypt.

Extreme cold temperature

The case of extreme cold temperatures in this study is representing in January 2008 cold wave. The data of maximum and minimum temperatures during this month and normals were obtained from Central Laboratory for Agricultural Climate and the damages of crops percentage was collected from agricultural statistics (Economic affairs sector- Ministry of agriculture and land reclamation).

Extreme wind

The changing in wind during November 2004 and its impacts on agriculture due to locust attack on different agricultural regions in Egypt. The data of wind direction during 16 and 17 November 2004 was obtained from ECMWF/ERA-Interim data (<http://apps.ecmwf.int/datasets/data/interim-full-daily/>) and the information about locust attack from different reports and media to show the relationship between locust attack and wind direction.

Extreme precipitations

Two cases in the extreme precipitations will be discuss in this paper first one is the snow balls during 2011 over Behera and the second one is the flash-floods in 2010 over Sinai and in 2015 over Alexandria. The data for extreme precipitations were collected from different reports, and media.

Results and Discussion:-

Egyptian agriculture faces serious risks from climate variability; caused significant negative impacts on the current yield of the major crops and other environmental conditions might this have disastrous consequences, in terms of reducing present production and the concomitant reduction of farmers' incomes. In addition, substantial negative impacts are also expected in the country's food security balance. Some of extreme weather event has been observed over the whole territory of Egypt during the recent past years and its impacts on agriculture, in the following the most important impacts of extreme weather event and its impact on agriculture:-

Extreme heat temperature:-

The field crops growth rate and phenology stages is dependent upon the temperature surrounding the crops and each crop has a specific temperature range represented by a minimum, maximum, and optimum. The change in optimum temperature by warming or cold and intensity of extreme weather events may lead to significant reductions in crop yields, expanded ranges of crop pests and altered transmission dynamics of insect pests and plant diseases increase.

Extreme heat temperature and crop production

Rice crop: Egypt is one of the most productive rice crop countries, Kafr el-sheikh governorate Produces 30% of the rice production in Egypt. Rice is highly sensitive to extreme high temperatures, particularly during flowering stage, the heat stress can caused complete sterility, and the high temperatures during ripening can lead to reduced grain filling. The damages observed in rice grain yield caused by extreme heat temperature at Kafer El-Sheakh Governorate in Egypt during seasons 1998 and 1999 are presented in (figures 1 and 2). The comparison between mean temperature from 1st April to 31th October in 1998 and 1999 for growth season was indicated that the season 98 was warmer than season 1999 and this led to decrease the production of rice grain yield during season 1998 as comparison with season 1999 by using the same cultivars. In cereal crops, both grain weight and grain number appear to be impacted by heat stress, with a decline in grain number directly proportional with increasing temperatures during flowering and grain filling (**Mahmoodet al., 2010**).

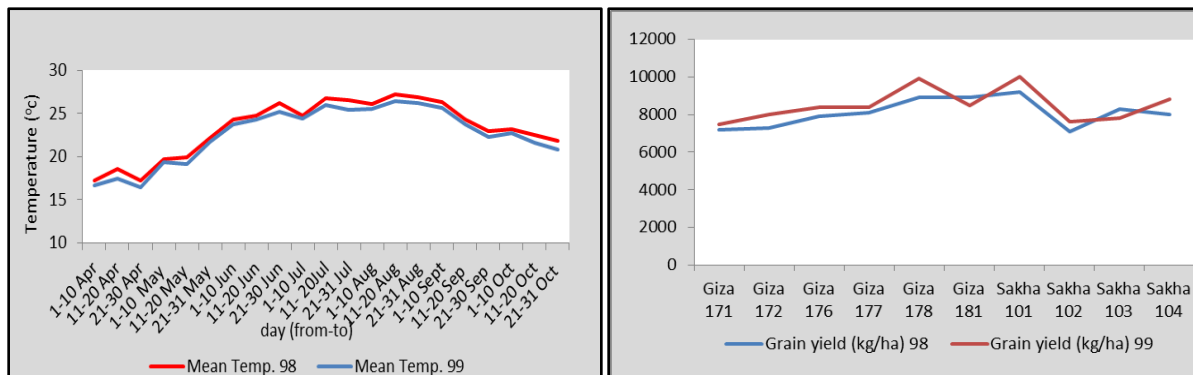


Figure (2): Comparison between rice grain yield (Kg/ha) in two seasons 1998 and 1999 at Kafr El-Sheakh Governorate

Wheat crop: Wheat is the most important grain crop in Egypt and the total grain production represents about 42 % self-sufficiency from consumption. Egypt is also the world's biggest wheat importer. According to NOAA scientists, 2010 tied with 2005 as the warmest year of the global surface temperature record, beginning in 1880. The results indicated that increase the minimum, maximum and mean temperatures in the winter, of 2010 at different stations in Egypt were above the normal (Table 1).The average increase temperature in 11 Governorates represents Agro-ecological Zones in Egypt above the normals is 2.2 °C during winter 2010. The extreme increase temperature caused decrease in wheat yield in Egypt during season 2010 as compared with season 2009. Upper Egypt Governorates gave the highest decrease in wheat yield -21.2% and the Nile Delta Governorates gave the lowest decrease -8.2%. Warmer temperatures (minimum and maximum temperature) could also reduce yields. Crops tend to grow faster in

warmer conditions will lead to an accelerated phenological development and reduce growing periods and reduction the net photosynthesis as well as a change in environmental agricultural zones and increase the number of generations of insects. The damages observed in wheat yield caused by extreme heat at all Governorates in Egypt during season 2010 are presented in (Table 2). Increasing mean temperatures during the growing season have been reported to reduce grain yields (Lobell and Ortiz-Monasterio 2007; Hassaneinet al., 2012).

Table (1): The difference between Minimum, Maximum and Mean temperature in winter 2009–2010 above the normal rate

Governorates	Minimum temperature	Maximum temperature	Mean temperature
Algharbia	3.5	1.9	3.1
Mnofia	2.5	0.8	1.7
KafreElshikh	2.5	0.1	1.7
Sharkia	2.2	0.8	1.4
Alkaliobia	3.6	3.3	3.3
Giza	2.1	2.7	1.3
Fayoum	2.8	1.5	2.6
Minya	4.2	1.6	2.9
BaniSwaif	2.0	2.7	2.3
Asyout	1.5	3.2	2.4
Kena	0.4	1.9	1.2
Average	2.5	1.9	2.2

Table (2): Wheat productivity (Total Varieties) from 2006 to 2010 and Different percentage between grain yield in two seasons 2009 & 2010

Location	Wheat grain Yield (Ardab/Fedan)					Different % during 2009 & 2010
	2006	2007	2008	2009	2010	
Lower Egypt	18.7	18.6	18.7	18.2	16.7	-8.2
Middle Egypt	18.2	19.0	18.6	18.9	16.6	-12.2
Upper Egypt	17.8	17.9	17.9	18.0	14.1	-21.9
Within the valley	18.4	18.5	18.5	18.3	16.2	-11.6
Out the valley	14.2	14.2	14.8	14.8	12.8	-13.7
Average	18.0	18.1	18.2	18.1	15.9	- 11.8

Extreme cold temperature and crops production

The damages observed in crops yield caused by extreme cold at different Governorates in Egypt during 2008 are presented in (figures 3 and 4). The minimum and maximum temperatures during January 2008 were below the normals as shown in figure (3) which caused damages in the most of crops during this season. Citrus crop gave the highest damage 50% and potato crop gave the lowest damage 2% see figure (4).

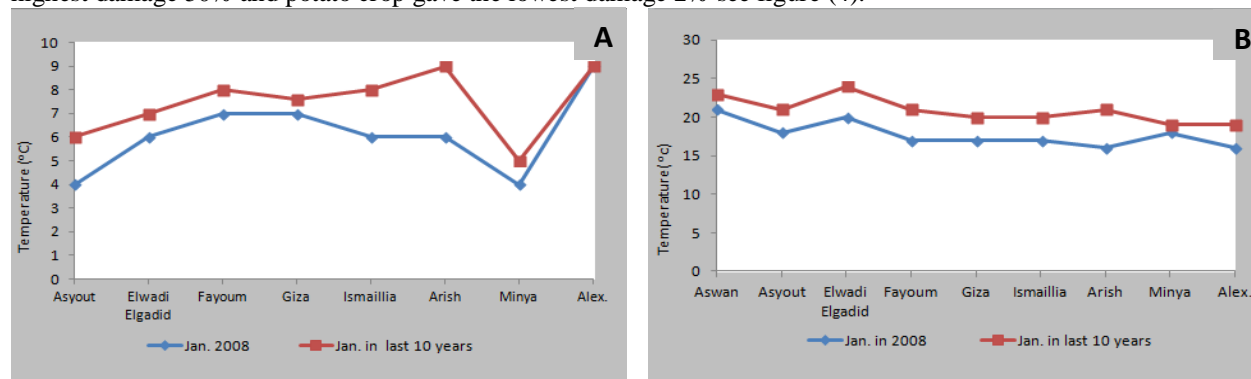


Figure (3): Comparison between minimum (A) and maximum (B) temperatures during January 2008 and normal.

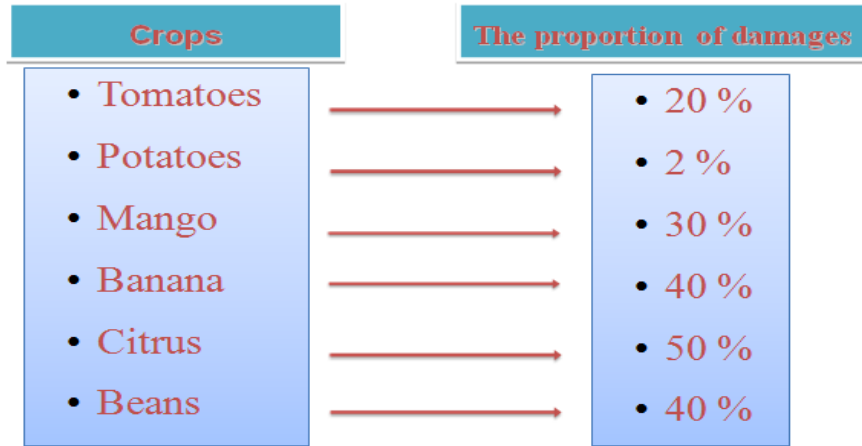


Figure (4): The proportion of damages for crop yield

Extreme wind and Locust attack

In 17 November 2004, the highly agricultural region around Delta and was invaded by a swarm of insects covering a 60 km front along the Mediterranean coastas shown in figure (5), an event which hasn't been happened from 50 years from this date. The extent of the damage has not been quantified. The information available in that time was locust in Sudan and will enter to Egypt from its south direction, so the agriculture ministry in Egypt sent the protection team to spray pesticides over border with Sudan to prevent damage by the locusts but the locust attacked from west direction. The locust movement depends mainly on wind direction, and by analyzing the wind direction during 16 and 17 Nov. 2004 we found that it was western wind as shown in figure (6).



Figure (5): Locust attack Egypt during 2004

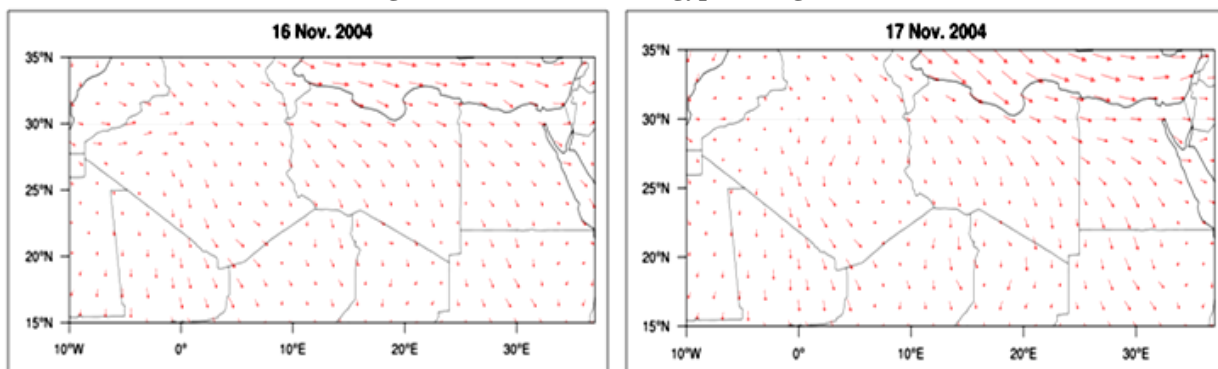


Figure (6): Wind direction on North Africa during 16 and 17 Nov. 2004

Extreme precipitations

Snow balls

In a phenomenon not seen in Egypt years ago fell large amounts of snow balls on the Albostane village of Behera Governorate in 3rd April 2011 during a bad weather wave, caused damage to fruit crops and vegetables cultivated on an area of 1445 acres. This wave led to mob of 600 farmers, owners of this land who depend on these crops as a main source of their income in front of the WadiNatrun police station, (**Rosael_youssef, 2011**). Analyzing of weather data in Albostane village indicated that the minimum temperature during this period was lower than normals and precipitation fell but not reach to snow form conditions. For that, the ministry of agriculture was formed a committee from different institutes of agricultural research center to investigate the truth of farmers story and reporting the situation of agricultural lands and they confirming their story about the event occurrence and observing the resultant damage. All farmers said that “*The wave has been happened and continued for about 20 minute*” and this interpreter why this event hasn’t been observed in analyze the weather data during this period.

Flashfloods

During January 2010, heavy rain exceeding 80 mm/day, led to the worst flash-floods in Egypt since 1994 (**Attaher and Medany, 2011**). The floods affected the Sinai Peninsula, Red Sea coast and the Aswan Governorate in southern Egypt, and led to 15 deaths and hundreds of homes destroyed. Approximately 3500 people were evacuated and material losses were estimated at US\$25.3 million (**Attaher and Medany, 2011**). Also during October 2015 heavy rain reached to above the normal and led to the worst disaster in Alexandria which caused deaths of some people and hundreds of homes destroyed. Approximately a lot of shops were evacuated and many material losses. In general, today’s weather covers a range of extremes. Recent research has shown that the temperature distribution of seasonal means would likely be different in the absence of anthropogenic emissions (**Christidis et al., 2011**). Most current studies are limited in their ability to capture the uncertainty in regional climate projections, and often omit potentially important aspects such as extreme events and changes in agriculture due to this extreme. Many numerous studies related to the change in temperatures and its impacts on different crops yield by using simulation model were discuss the change in major crop production due to changes in temperatures.



Figure (7): Sample photos of snow balls damages on crop and vegetables cultivated



Figure (8): Heavy rain in Sinai Peninsula 2010.



Figure (9): Heavy rain in Alexandria 2015.

Extreme Weather Events are having significant impact on agriculture and food security which is the main source of income to a large section of the rural population (Swaminathan M. S. and Rengalakshmi R., 2016). Extreme weather events can affect agricultural production significantly, for instance heat waves and droughts (Ciais et al., 2005 and van der Velde et al., 2010), also hail storms (Sanchez et al. 1996), excessive cold, and heavy and prolonged precipitation (Rosenzweig et al., 2002). Extreme weather events can in fact impact crops both via negative impacts on plant physiological processes and direct physical damage, as well as by affecting the timing and conditions of field operations (van der Velde et al., 2011). The frequency and magnitude of extreme weather events are expected to increase under climate change (Solomon et al., 2007). The former minister of agriculture, Salah Abdel Moaminsaid that “Egypt is station of locusts migration stations, and there are two directions in its migration, one from southwestern border of Mauritania, Chad and Libya then Tunisia, Algeria and Morocco, and the second from the south-eastern border, and this comes from Eritrea and Sudan and crosses the Red Sea coast to Saudi Arabia, and in the normal circumstances of calm wind the locusts don’t enter to Egypt because the locusts movement depending mainly on strong wind action” (Ik.ahram, 2013). Egypt is one of the most vulnerable countries to the potential impacts and risks of climate change. Agriculture in Egypt is expected to be especially vulnerable because of hot climate. Further warming is consequently expected to reduce crop productivity. Numerous studies showed that, with changes in temperature of 1.5°C and 3.5°C by reduction the yield from 11 to 31 % in wheat (Hassaneinet al., 2012).

Finally the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) anticipates with 'high confidence' that 'projected changes in the frequency and severity of extreme climate events will have more serious consequences for food and forestry production, and food insecurity, than will changes in projected means of temperature and precipitation' Extreme Weather Events and Crop Price Spikes in a Changing Climate (**Easterling et al., 2007**).

Conclusion

This study confirms that increased extreme weather events during the last past years in Egypt. The hottest and coldest days during extreme events have become even hotter and colder. Egypt is one of the most vulnerable countries to the potential impacts and risks of extreme weather events. It is imperative that innovations are developed in the field of disaster preparation. With early warning system and new technology it is easier for farmers to prepare their fields for the effects of natural disaster.

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