The Potential Scenarios of the Impacts of Climate Change on Egyptian Resources and Agricultural Plant Production

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ABSTRACT

The emissions of greenhouse gases in Egypt is only about 0.58% of the total emissions of the world in the year 2015, but Egypt is one of the most affected by the impacts of climate change. By Assessment and analysis of the expected economic impacts of climate change by the 2030, the cultivated area will be reduced by about 0.949 million Acres or 8.22% of the cultivated area. This result contrasts with the case of no sinking of the delta land, the reduced crop area about 1.406 million acres, approximately by 6.25% of crop area. In addition, there is surplus in the Egyptian balance water by about 2.48 billion m3. In this case, the value of the Egyptian agriculture production will decrease by about 6.19 billion dollars, equal about 6.19% compared by presumably no sinking of the Delta land. In the case of sinking by 15% of Delta lands, with the change of the productivity and water consumption of most crops, the result will be a reduction in the cultivated area to about 0.94 million acres. Thus, there will be a decrease in the crop area by about 1.39 million acres, with deficit in the Egyptian balance water by about 4.74 billion m3 compared to the case of no sinking part of the delta land, the cultivated area will decrease by about 8.17%. The crop area will also decrease 6.18%, the value of the Egyptian agriculture production will decrease by about 12.51%. While Compared to sinking part of the Delta land to about 15% of the total Delta area without the other impacts climate change, the cultivated area will increase by about 0.06%, and the crop area will increase by about 0.08%. The value of the Egyptian agriculture production will decrease by about 5.57%.

Keywords: Climate Change, Sustainable Development, Mitigating, Environment, Global Warming

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1. INTRODUCTION

The phenomenon of climate change has become one of the issues has always been at the global level, in the light of the possible consequences of serious changes that threaten the future of the land. It was pointed out by the International Organization (WMO) that there is a rise in the global temperature by 4°C by the year 2060. Presumably, the rise will result in the rapid rise of threat to the stability of the world through the disruption of supplies of food and water; particularly in the continent of Africa. The negotiations that take place under the United Nations Framework Convention on Climate Change an important turning point global agreement on climate change after year 2020 was held in Paris in December 2015 (Fawaz and Soliman, 2015). Change in global climate resulting from human activities has already begun and the continuation of this change, as well as the prospects for the response of the international community, will not be quick. This slow response makes the climate change more serious in the future than is estimated now, with predicted more floods, hurricanes, and strong sea level rise up to about 59 centimeters during the current century (El-Raey, 2000; and FAO, 2015).

In addition, it is expected that about 33 cities in the world will have population size of up to nearly 8 million people. These population will be threatened due to the rising sea levels. There are 21 cities which are most vulnerable to the risk of sea-level rise. Alexandria in Egypt, for instance, is among those cities. Despite the fact that Egypt has been classified as one of the five countries in the world that is most vulnerable to negative impacts of climate change and the rising sea level or sinking parts of Delta and reflected in all social and economic harm, the issue of climate change was not taken seriously in Egypt (IPCC, 1994; and Worldwatch).

On the other hand, climate change is likely to involve changes in food security and territorial integrity with increasing pressure incoming sexually transmitted diseases through incubators, water, and airborne by the food itself. The implications of this significant decline in agricultural productivity, and in labor productivity, lead to the aggravation of poverty and increasing rates of mortality. Climatic changes generally bring about serious drought (see Fawaz and Soliman), which hits some areas of the world. Excessive rainfalls that cause devastating floods and torrential rains in other areas, is one example of the devastating effect of climate change. Large emissions had been around since the beginning of the industrial revolution in Europe. These emissions led to global warming. Thus, global climate changes causes the melting of the snow in the North and South poles and thus increase the water levels in the seas and oceans, and involves the risk of sinking parts of the world, especially in the low land region. Egypt is not so far from experiencing the effect of such climate changes. These effects will turn on the availability of natural resources: supply of land, food and water. It will lead to direct and far-reaching impact on the agricultural sector. These climate changes will have an adverse effect on food supply in the world. Consequently, it will lead to the rise of world food prices, and ultimately increases food cost in Egypt. Egypt will become a net importer of food; this dependency on external food source will put pressure on the state. (Fayyad, 2009).

1.1 RESEARCH ISSUE

Egypt is expected to be one of the most affected by the impacts of climate change. These changes are reflected in high temperatures, changing patterns of rainfall, rising sea levels, and the increasing frequency of climate-related disaster risks to agriculture agricultural land, water, and food security, which may cause problems and loss of Egyptian agricultural national economy.

In general, this research tries to answer to the following questions: (i) What is the impact of climate change on cultivated and crop area, productivity and consumption of water of the Egyptian major agricultural crops? and What is the impact of climate change on Egyptian water balance? (ii) Is there an impact of climate change on agricultural employment and productivity agricultural labor? (iii) What are the expected scenarios for impacts of climate change on the Egyptian agricultural production? (iv) What is the role of agriculture to overcome climate change? And what are the ways in which they can overcome or mitigate the effects of climate change on the
productivity of the major crops cultivated to reduce the impacts of climate change? (v) What are the Egyptian efforts to mitigating the impacts of climate change?

1.2 Research Objectives
This research attempts to gauge the effect of climate change on Egypt’s agricultural production by looking at the effect of climate change on crop area, productivity and consumption of water by major agricultural crops in Egypt. In addition, this paper attempts to measure the impact of climate change on Egyptian water balance. We look for the best scenario of the impact of climate change on the cultivated and crop area in Egypt by year 2030. We want to know the dangers that will befall the Egyptian agriculture production, and then explore the means that can overcome or mitigate such effects.

This research seeks to accomplished several goals. Firstly, we want to identify the phenomenon of climate change, and its local dimensions. Secondly, the paper tries to identify the impacts of climate change on the production of the most agricultural crops, and water resources in Egypt. Thirdly, explore possible scenarios of how climate change could affect agriculture in Egypt. Fourth, we proposed working methods to reduce or overcome the effects of climate change on some aspects of the agricultural sector, such as productivity of the major agricultural crops, as well as to the role of agriculture in overcoming the phenomenon in Egypt. Lastly, the paper provides recommendation on how Egyptian could mitigate the impacts of climate change.

1.3 Research Methodology
The research depends on a descriptive method to assess the current and future situation of the impacts of climate change in Egypt, particularly on agriculture production. We simulated likely scenarios to assess the impacts of climate change on the cultivated area and productivity of the most important agricultural crops and water resources in Egypt by the year 2030. We explore various possibilities of the impact of climate change on the productivity of the most important agricultural crops, land and water resources, and other aspects of the agricultural sector in Egypt.

1.4 Data sources
The research is based on data from the Ministry of Agriculture and Land Reclamation. Additional data are projected data of Egyptian agricultural development strategy for the year 2030 reported by the Central Agency for Public Mobilization and Statistics, the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and Economic Affairs of the Ministry of Agriculture. Relevant data and statistics published by some on the international information network were also used.

2.0 RESULT AND DISCUSSION
2.1 Agriculture sustainable development
Sustainable development can be defined as: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987). The ultimate goal of sustainable development is to improve the quality of life for all members of a community and, indeed, for all citizens of a nation and the world, while ensuring the integrity of the life support systems upon which all life, human and non-human. Sustainability is the goal of sustainable development – an unending quest to improve the quality of peoples’ lives and surroundings, to prosper without destroying the life-supporting systems on which current and future generations depend. Like other important concepts, such as equity and justice, sustainability can be thought of as both a destination and a journey (Parliamentary Commission on the Environment, 2004).

2.2 Quantification of the Greenhouse Gasses in Egypt
The estimates of greenhouse gas in Egypt are shown in Fig. 1. There were about 197 million tons of carbon dioxide in 2014. According to data from the Egyptian Central Agency for Public Mobilization and Statistics, the amount of emissions of carbon dioxide resulting from the consumption of oil products and gas rose by about 0.1% to reach about 197.1 million tons in the year 2014 compared with about 197.0 million tons in the year 2013. This figure rose to about 299 million tons in the year 2015, equal to 0.58% of emissions in the world, see Fig. 2.

The consumption of oil products is the main source of emissions of carbon dioxide in Egypt in the year 2014. Oil-related products emit 40.8% of total carbon dioxide. This number was followed by the transportation sector which accounted for 17.6%. In that same period, we saw a growth in the transportation sector by 16.7%. Carbon dioxide emission by other sources accounted for 2.3% of the total emissions. The average emission by the agriculture sector during the period (2012 -2014) was 15%. Expansion in agricultural activities contributed to the increase in carbon dioxide from that sector. More than 40% of methane came from the dissolution of organic materials in rice fields flooded, and that agriculture is responsible for about 80% of emissions of nitro oxide through analyzing the fertilizers.

**Fig. 1:** Amount of Emissions in Egypt (unit: million tons of carbon dioxide)

![Graph showing emissions in Egypt](image1)

*Source:* Compiled and calculated from: (1) In accordance with the inventory of greenhouse gasses, which ended in Egypt of its implementation in 1999, which was adopted on the data available for the year 1990/1991; (2) According to the estimates International Database (World Resources Institute Washington), United States, 2006; (3) Estimates of the Central Agency for Public Mobilization and Statistics, 2015; and (4) Preliminary estimates from several sources.

**Figure 2:** Amount of emissions in Egypt as percentage of total emission in the world

![Graph showing emissions as percentage of global total](image2)

*Source:* Compiled and calculated from: (1) In accordance with the inventory of greenhouse gasses,
which ended in Egypt of its implementation in 1999, which was adopted on the data available for the year 1990/1991; (2) According to the estimates International Database (World Resources Institute Washington), United States, 2006; (3) Estimates of the Central Agency for Public Mobilization and Statistics, 2015; and (4) Preliminary estimates from several sources.

Despite the fact that greenhouse gas emission by Egypt constitutes only 0.58% of total global emission, Egypt is the most impacted by the climate change. Agriculture is highly exposed to climate change, as farming activities directly depend on climatic conditions. Agriculture also contributes to climate change through the release of greenhouse gasses into the atmosphere. However, agriculture can also contribute to climate change mitigation by reducing greenhouse gas emissions and by sequestering carbon while maintaining food production. The source of greenhouse effect in the agricultural sector comes mainly from two powerful greenhouse gasses: - Methane (CH₄) from livestock digestion processes and stored animal manure. - nitrous oxide (N₂O) from organic and mineral nitrogen fertilizers.

2.3 Impacts of Climate Change on the Agricultural Production in Egypt
2.3.1 Impact of Climate Change on Agricultural Land

Studies at the University of Alexandria estimated that between (12% to 15%) of the high-quality agricultural land in the delta region will lose as a result of sinking or salinity with sea level rise by about half a meter only. Climate change led to the rise in sea level in Egypt at a rate of one meter in the past century. This rise of the sea level is particularly evident in the north coast of Egypt where 10% - 15% of the Delta is lost to the rise of salt water encroachment. Consequently, the increase salinity of the soil adversely affect crop production.

United Nations Environment Program (UNEP)’s study of the impact of sea-level rise (expected) on the Egyptian coast identified the area as most likely to be in danger of drowning in the case of sea-level rise by about 0.5 meter. It was clear that half-meter rise in sea level will lead to the sinking of a large coastal land river delta along the Nile if we do not take precaution. The most affected areas include Alexandria and the lake and South Al-Barolos which leads southward to the Mediterranean Sea.

It is clear from the studies of the topography of coastal areas on the Red Sea, the areas of a few non-agricultural land will also be affected on the Red Sea as a result of sea-level rise. The Bitter Lakes region and Suez are particularly affected. Consequently, climate change will cause the sea level to rise. This will result in sinking part of the fertile agricultural land in the northern Delta. In other parts, the underground water table will swell. This will negatively affect the entire agricultural area.

The initial expectations that the number of the population in Egypt will increase at a rate of about 1.9% annually over the next two decades, to arrive in the year 2030 to about 111 million people, while agricultural land is expected to be about 11.5 million acres in Egypt by 2030. The old land area will reach about 8.4 million acres. According to the strategy of the Egyptian Ministry of Agriculture, the target of the lately reclaimed lands will reach 3.1 million acres. The total cultivable area will reach about 11.5 million acres, and thus the average per capita from available resources cultivated agricultural land will decrease by about 3.2% in the year 2030 from that in the year 2011, as shown in the Table 3.

| Cultivated land resources | 2011 | 2012 | Change (2011-2012)% | 2013 | Change (2012-2013)% | 2030 | Change (2011-2030)% | Change (2013-2030)% |
|---------------------------|------|------|---------------------|------|---------------------|------|---------------------|---------------------|

Table No. 1: Available cultivated land resources in old and new lands by million acres in Egypt, now and in the future by the year 2030.
| Total Cultivated land resources by million acres | 8.619 | 8.8 | 2.1 | 8.94 | 1.6 | 11.5 | 33.43 | 28.64 |
| The population by million People | 80.53 | 82.55 | 2.51 | 84.63 | 2.52 | 111 | 37.84 | 31.16 |
| Average per capita from cultivated land resources by acre | 0.107 | 0.1066 | (0.4) | 0.1056 | (0.91) | 0.1036 | (3.2) | (1.92) |

Volume in brackets is negative. *Source:* Compiled and calculated: (i) The Ministry of Agriculture and Land Reclamation, Agricultural Economics Central Department bulletin, agricultural economy, 2013; (ii) Sustainable agricultural development strategy until 2030, Cairo, 2009; and (ii) World Bank, World Development Indicators, data, separate periods.

It is clear from Table 1, and Fig. 4, which shows the evolution of annual change in the average per capita from cultivated land in Egypt that this average decreasing every year, and this decline is down, where decreased by 0.4% in the (2011 -2012), decreasing risen in (2012- 2013) which amounted to about 0.91%. It is expected to decline to about 3.2% in the year 2030, compared to his counterpart in the year 2011, or about 1.92% compared to the year 2013. The reasons for the increase are: number of residents Egypt, the largest rate of increase in the cultivated area rates in the comparative periods, in addition to the impact of climate change, which affects the ability to maintain the same average per capita level of agricultural land in the year 2030, equivalent counterpart in the year 2013.

**Figure 3.** Total cultivated land in millions of acres

![Figure 3](image)

*Source:* Derived from Table 1.

**Figure 4.** Average per capita land cultivation in acres

![Figure 4](image)
2.3.2 **Impact of climate change on productivity for the major crops**

Joint experiments conducted by the Agricultural Meteorology Research and the change in the Institute for land, water and Environment Research Agricultural Research Center of climate experiments, showed that it was possible high temperature will affect the production of the most agricultural crops in Egypt. The experiments tested the effect of heat between (1.5 to 3.5°C) on the production per acre. The climate change and caused by the rise in temperature of the Earth's surface will have a negative impact on the productivity of many crops in Egypt, causing severe shortages in the productivity of most major food crops in Egypt. These experiments included 10 common crops in Egypt: wheat, barley, corn, sorghum, rice, soybeans, sunflower, tomatoes, sugarcane, and cotton. These crops represent a total cultivated area of about 8.483 million acres, representing about 54.9% of the total crop area by the year 2013 in Egypt.

The impact of climate change on productivity produces significant and influential role in plant production in Egypt. The impact affects self-sufficiency rate of these crops, the impact of the Egyptian food balance. These experiments may be used for assessing the impact of climate change, and know the future scenarios, as shown in the Table 2, and the Fig. 5. The following interpretation may be made: (i) **The productivity of wheat harvest** will be less than 9% if the temperature rose by about 2°C, and will decrease by about 18% if the temperature rose 3.5°C. (ii) **Barley crop productivity** will decline by about 18% (in the year 2050); (iii) **Corn crop productivity** will be lower by about 18% in the middle of this century (when the temperature rises 3.5°C), compared to productivity under current conditions; (iv) **Maize crop productivity** high will decrease by about 19%; (iv) **Rice crop productivity** will decline by about 11%; (v) **Soybean crop productivity** will be affected adversely under conditions of climatic changes will be the average rate of decrease in the level of the Republic in the middle of this century by about 28%; (vi) **The Sunflower productivity** will decline by about 27%; (vii) **Tomato productivity** will decrease their productivity by about 14% if the temperature rose by about 1.5°C while this shortage will reach 50% if the temperature rose 3.5°C; (viii) **Sugarcane production** would fall by about 25%; and (ix) **Climate change affects a positive impact on the productivity of cotton**, and would increase its productivity by about 17% at high temperature by about 2°C, will increase the rate of increase in this crop to about 31% when the temperature rises by about 4°C.

2.3.3 **Impact of climate change on water consumption for the major crops**

It was possible that the high degree of temperature about normal rates will affect consumption of water for the most agricultural crops in Egypt. Experiments included 10 of the most planted crops in Egypt. These crops include wheat, barley, corn, sorghum, rice, soybeans, sunflower, tomatoes, sugarcane, and cotton. Table 2, and Fig. 5 show the result of experiments with high heat between (3.5°C) on consumption of water per acre. The results are compared to water consumption under current conditions, as shown in the Table 4, and Fig. 3, as follows: **consumption of water of Wheat, Corn, Sorghum, Rice, Soybean, Sunflower, Tomato, Sugarcane, and Cotton crops** will increase by
about 2.5%, 8%, 8%, 16%, 15%, 8%, 14%, 2.5%, 10%, respectively. It is noted that consumption of water of barley crop will be reduced by about 2%. These results indicate that climate change will negatively affect to the productivity and consumption of water for the major crops in Egypt.

Table 2: Impacts of climate change on productivity, consumption of water of the most important agricultural crops in Egypt by the year 2050

| Statement crops | % of the productivity per acre | % of consumption of water | The cultivated area (thousand acres) |
|-----------------|---------------------------------|---------------------------|-------------------------------------|
|                 | 1.5 C° 2 C° 3.5 C°              | 3.5 C°                   |                                     |
| Wheat           | - (9) (18)                      | 2.5                      | 3378                                |
| Barley          | - - (18)                        | (2)                      | 78.7                                |
| Corn            | - - (18)                        | 8                        | 2139                                |
| Sorghum         | - - (19)                        | 8                        | 335.2                               |
| Rice            | - - (11)                        | 16                       | 1419                                |
| Soybean         | - - (28)                        | 15                       | 22.4                                |
| Sunflower       | - - (27)                        | 8                        | 15.2                                |
| tomatoes        | (14) - (50)                     | 14                       | 489                                 |
| Sugar cane      | - - (25)                        | 2.5                      | 329                                 |
| Cotton          | - 17 29                         | 10                       | 287                                 |
| Total           | - - -                           | -                        | 8493                                |

The volumes in brackets are negative. Source: Compiled and calculated from: The research unit Agricultural Meteorology climate change research institute of land, water and environment Agricultural Research Center.

Figure 5. Impact of climate change on productivity, consumption of water of the most important to agricultural crops in Egypt by the year 2050

Source: Derived from Table 2.

2.3.4 Impact of climate change on desertification and land degradation
Desertification is defined as: “low productive capacity of the land in the arid and semiarid land, as a result of climate change or human practices”. There is a strong and direct relationship between
desertification and climate change, where the climate change lead to a desertification while increasing the desertification necessarily lead to an increase in climate change.

Egypt is one of the countries that is affected by the phenomenon of desertification as a result climate change, or bad human practices. Climate change may lead to a decline in agricultural productive capacity of the land. The decline results from land deterioration. Indicators of land degradation include increasing the land area affected salinizati on and high level of ground water. Other indicator is desertification. All these indicators lead to abandoning agricultural land or continue farming with diminished productivity (see Parliamentary Commission on the Environment).

2.3.5 Impact of climate change on the water resources

Egypt depends mainly on the three main sources of water: River Nile, groundwater, and the rain. The River Nile is the main source of water; it contributed towards by 55.5 billion m³ in the year 2013 (see El-Raey), and the average per capita of water resources in Egypt mounted by about 663 m³ in the same year. This means that it is under the water poverty line. It is also expected that about 582 m³ in the year 2025. uses of the available water resources raised from about 66.6 billion m³ in the year 2012 to about 74.5 billion m³ in the year 2003, an increase by 23.7%. While agricultural water uses representing to about 82.6% of the total actual uses of available water resources, which is about 74.5 billion m³ in year 2012. It is expected to rise to 78.9 billion m³ in year 2017. This increase in the quantity of water includes recycled from about 0.9 billion m³ to 1.3 billion m³ in year 2012, with an increase of about 44.4% compared to year 2003. It is expected to reach 1.6 billion m³ in year 2017, and about 15.7 billion m³ per year. This is the average unconscious irrigation networks between Aswan and fields during the period (2003-2012), lost to evaporation and leakage, which requires costly investments to reduce them, as in the Table 3.

Table 3: Current and future available water resources in Egypt, according to the source future by the year 2030. By (billion m³)

| water source | 2007/2008 | 2008/2009 | 2009/2010 | 2010/2011 | 2030 | Change (2007-2011)% | Change (2011-2030)% |
|-------------|-----------|-----------|-----------|-----------|------|----------------|----------------|
| The Nile River | 55.5 | 55.5 | 55.5 | 55.5 | 57.5 | 0.00 | 3.60 |
| Groundwater | 6.2 | 6.2 | 5.6 | 6.3 | 12.9 | 1.61 | 104.76 |
| Agricultural water recycling and development of irrigation systems | 8 | 8 | 5.8 | 5.8 | 15.5 | (27.50) | 167.24 |
| Sewage recycling | 1.3 | 1.3 | 1.3 | 1.3 | 2 | 0.00 | 53.85 |
| Rainwater and Torrents | 1.3 | 1.3 | 1.3 | 1.3 | 1.5 | 0.00 | 15.38 |
| Seawater desalination | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.00 | 0.00 |
| Total | 72.36 | 72.36 | 69.56 | 70.26 | 89.46 | (2.90) | 27.33 |

Volumes in brackets are negative values. Source: Compiled and calculated from: (1) The Ministry of Water Resources and Irrigation, toward development strategy and management of water resources in Egypt during the period (2009-2017), august 2009; (2) In accordance with the inventory of greenhouse gasses, which ended in Egypt of its implementation in 1999, which was adopted on the data available for the year 1990/1991; (3) According to the estimates International Database (World Resources Institute Washington), United States, 2006; (4) Estimates of the Central Agency for Public Mobilization and Statistics, 2015; and (5) Preliminary estimates from several sources.
A study of the evolution of the total available water resources in Egypt is shown in Table 3. The available water resources decreased by about 2.9% during the period (2007 -2011), and expected to these resources are increased by 2030, so arrive about 89.46 million m$^3$, by an increase mounted by 27.33% than the total available water resources in the year 2011.

By studying of the evolution of the total water uses in Egypt, according to data in Table 4, these uses rose by about 5.15% during the period (2007 -2011). This is expected to increase by 2030, so arrive about 98.3 million m$^3$, by an increase of about 33.11% than the total water uses in Egypt in the year 2011.

### Table 4: Current and future water uses in Egypt by the year 2030. By (billion m$^3$)

| water source                  | 2007/2008 | 2008/2009 | 2009/2010 | 2010/2011 | 2030 | Change (2007-2011)% | Change (2011-2030)% |
|------------------------------|-----------|-----------|-----------|-----------|------|---------------------|---------------------|
| Agriculture                   | 60        | 60        | 60        | 60.9      | 81.3 | 1.50                | 33.50               |
| Losses by evaporation from canals | 2.1       | 2.1       | 2.1       | 2.1       | 2.1  | 0.00                | 0.00                |
| Drinking and Health use       | 6.6       | 6.6       | 8.5       | 9.55      | 13.5 | 44.70               | 41.36               |
| Industry                      | 1.33      | 1.33      | 1.35      | 1.2       | 1.3  | (9.77)              | 8.33                |
| Maritime                      | 0.2       | 0.2       | 0.1       | 0.1       | 0.1  | (50)                | 0.00                |
| Total                         | 70.23     | 70.23     | 72.05     | 73.85     | 98.3 | 5.15                | 33.11               |

Volumes in brackets are negative values. *Source:* Compiled and calculated from: (1) The Ministry of Water Resources and Irrigation, toward development strategy and management of water resources in Egypt during the period (2009-2017), august 2009; (2) In accordance with the inventory of greenhouse gasses, which ended in Egypt of its implementation in 1999, which was adopted on the data available for the year 1990/1991; (3) According to the estimates International Database (World Resources Institute Washington), United States, 2006; (4) Estimates of the Central Agency for Public Mobilization and Statistics, 2015; and (5) Preliminary estimates from several sources.

By studying the expected effects of climate change on the Nile River water during the coming years until the year 2030, it is expected that freshwater supplies from the south to the north will be lower due to high temperatures and increased evaporation rate.

The Mediterranean would invade northern part of the Nile Delta. It is moving toward south Delta because of sea level rise. The impact of climate change on the Nile sources is still uncertain. There may be an increase in the quantity of rainfall accompanied by floods in Ethiopia, Sudan, and Egypt, followed by a period of drought, or a lack of rainfall with an increase in the rate of evaporation. However, the likely scenario is increased rates of steaming with flat amount of rain on the sources of the Nile, which constitute 85% of the Nile water sources, and with increased evaporation rates less than Egypt's share of the Nile water. Noting that 20% of the quota to Egypt dissipates in the territory of the South of Sudan before entering the Nile in Egypt, with the increase in the number of the population, there will be an increase in demand for water for agriculture and industrial needs. It means a decline in the per capita share of water in the year 2030.

### Table 5: water resources and uses per capita in Egypt by the year 2030.

| statement                  | 2007/2008 | 2008/2009 | 2009/2010 | 2010/2011 | 2030 | Change (2007-2011)% | Change (2011-2030)% |
|----------------------------|-----------|-----------|-----------|-----------|------|---------------------|---------------------|
| Agriculture                |           |           |           |           |      |                     |                     |
| Losses by evaporation from canals |           |           |           |           |      |                     |                     |
| Drinking and Health use    |           |           |           |           |      |                     |                     |
| Industry                   |           |           |           |           |      |                     |                     |
| Maritime                   |           |           |           |           |      |                     |                     |
| Total                      |           |           |           |           |      |                     |                     |
| Water resources per capita by (m³) | 0.97 | 0.96 | 0.90 | 0.89 | 0.81 | (8.41) | (9.74) |
|----------------------------------|------|------|------|------|------|--------|--------|
| Water uses per capita by (m³)    | 0.95 | 0.93 | 0.94 | 0.94 | 0.89 | (0.81) | (5.64) |
| Surplus or deficit in water balance by (billion m³) | 2.13 | 2.13 | (2.49) | (3.59) | (8.84) | - | - |

Volumes in brackets are negative values. Source: Compiled and calculated from: (1) The Ministry of Water Resources and Irrigation, toward development strategy and management of water resources in Egypt during the period (2009-2017), August 2009; (2) In accordance with the inventory of greenhouse gases, which ended in Egypt of its implementation in 1999, which was adopted on the data available for the year 1990/1991; (3) According to the estimates International Database (World Resources Institute Washington), United States, 2006; (4) Estimates of the Central Agency for Public Mobilization and Statistics, 2015; and (5) Preliminary estimates from several sources.

The expected impacts of climate change on water resources in Egypt that cause global warming phenomenon in Egypt in accelerating the evaporation of Nile water, and thus, reduce the freshwater resources. In turn, it will lead to the aggravation of acute shortage of Egypt in the field of drinking water, irrigation and power generation.

**Fig. 6.** Egypt’s Water Balance

Water resources, water uses, and Surplus or deficit in water balance by billion m³. Source: Derived from tables no. (4).

**Figure 7.** Water use per capita
Water resources and demand will be affected by climate change. These effects include: (i) high temperature will lead to increased evaporation, and increasing the quantities needed by consumption of agriculture and industry; (ii) the change in patterns of rainfall will lead to a shortage of water in coastal areas; (iii) the increase in the dust industrial pollutants and consumption human consumption also increased salinity in the soil would lead to the deterioration of water quality; (iv) sea-level rise will increase the penetration of salinity in the soil and leads to the pollution of groundwater sources in coastal areas; (v) as long as decreased resources of the river, it will withdraw this lack of underground water accumulated in the River Delta was nominated; and (vi) as a result of decreased the water of the river, the Desert aquifers are not expected vulnerability to climatic changes, however, in the case of reservoirs to receive feed nominated by the river. These results agreed with the results of studies conducted on the subject, agreed with all of "sentini" (Sentini, 1991) and “strzepek” (Strzepek et al., 1996) studies about the effects of climate change on the future of the River Nile.

2.3.6 Impact of Climate Changes on the Agricultural Labor
It is expected that approximately about 6 million Egyptian citizens in the northern Delta may be subjected to displacement in the year 2030 due to the floods and high water level in the Mediterranean. Egypt had been identified as one of the five countries in the world are the most vulnerable to the negative impacts of climate change, rising sea level or sinking parts of Delta and reflected in all of the social and economic harm. It is expected lost some of agricultural lands. This loss of land would lead millions of people to leave their homestead and migrate to new areas. It is estimated that in the case of potential sea level rise 30 cm mounted, about 70.5 thousand job of the agricultural labor in the area north of Delta will be displaced (Central Agency for Mobilization and Statistics, 2014), as in the Table 6.

High temperature would adversely affect agricultural productivity, and hence affected agricultural production with the loss of a portion of agricultural land, labor shortages resulting from displacement. In addition to the declining productivity of the agricultural worker, a decrease the productivity of most crops, negatively affects Egypt's total agricultural output and food self-sufficiency ratio as a result of the increase migration.

Table 6: Estimates of losses in the agricultural labor as a result of sea-level rise in Egypt.
The increase in the sea-level

| Year | Losses in area | % of total area | The number of jobs lost (Thousand job) |
|------|----------------|-----------------|--------------------------------------|
| 18 cm | 2010 | 144 km² | 0.0144 | 32.5 |
| 30 cm | 2030 | 190 km² | 0.019 | 70.4 |

Source: Compiled and calculated from: El-raey M. (2000). (ECRP): coastal zone development and climate change drill down of climate change on Egypt.

2.4 Expected scenarios for impacts of climate change on the agricultural production in Egypt

The economic impacts of climate change by 2030 shows economic variables relating to such cultivated area, crop area and productivity of major crops will be reduced. This reduction would result from sinking of the Delta land to about 15%. In addition, we also expect to see an adverse impact on water balance in Egypt. With the evolution of each of the variables: population and agricultural intensification, in the end, to estimate the impact of climate change on agricultural production value.

The driving factors are considered when assessing the impact of climate change on sustainable agricultural development in Egypt. These variables include:

1. Cultivated area
2. Crop area
3. Population growth rate
4. An amount of water used for agriculture and other uses
5. Water quantity expected from natural sources

An estimation of the expected impacts of climate change on the agricultural production value shows that the outcome of the anticipated changes in the variables influencing the value of the output. The assessment of expected impacts was limited to plant sector, where agricultural production includes other sectors, such as fisheries and livestock. To that end, we can estimate for three scenarios:

Scenario No. 1. Assume that there is no sinking of the Delta land, and the absence of an effect of climate change on the variables in the valuation.

Scenario No. 2. Assume that there is the estimation of the expected impacts of climate change with probability sank 15% of the Delta land, assuming no changes due to climate change on other variables.

The difference between Scenario No. 2 and Scenario No. 1 represents the impact probability of sank 15% of the Delta land on the Egyptian agricultural production as the potential impact of climate change.

Scenario No. 3. Assume that there has been added to the potential impact of climate change on the productivity of most crops and water consumption.

The difference between Scenario No. 3 and Scenario No. 2 represents the effect of the potential impact of climate change on crop productivity, and crop water consumption, in addition to sinking 15% of the Delta land.

The following is an overview of these estimates, with an assumption of steady crop intensification at 1.99 in all scenarios, as in the Tables 7 & 8, accordingly, it is expected that:

In the case of potential sank 15% of Delta lands. The cultivated area will be reduced by about 0.949 million Acres, equal about 8.22% of the cultivated area compared by with the case of no sinking part of the delta land. As the result, there will be a reduction of crop area by about 1.406
million acres, approximately by 6.25% of crop area comparing in the case of no sinking part of the delta land. In addition to surplus in the Egyptian balance water by about 2.48 billion m³. In this case, the value of the Egyptian agriculture production will decrease by about 6.19 billion dollars, equal about 6.19% compared by presumably no sinking of the Delta land.

In the case of sinking 15% of Delta lands with the change of the productivity and water consumption of most crops. The result will be a reduction in the cultivated area of about 0.94 million acres, and thus decrease the crop area by about 1.39 million acres, with deficit in the Egyptian balance water by about 4.74 billion m³. Compared this result with Scenario No. 1 where the cultivated area will decrease by about 8.17%, and the crop area will decrease 6.18%, also the value of the Egyptian agriculture production will decrease by about 12.51%. Similarly, compared the result with Scenario No. 2, the cultivated area will increase by about 0.06%, and the crop area will increase by about 0.08%, also the value of the Egyptian agriculture production will decrease by about 5.57%.

Table 7: Expected scenarios for cultivated and crop area with future water resources by the year 2030 in light of the sinking and without sinking 15% of Delta lands by the year 2030.

| The statement                  | 2030 | \[2011\] Scenario (1) without sank 15% of the Delta lands | \[2030\] Scenario (2) with sank 15% of the Delta lands | Change Between (1), (2) | Change between (1), (2) % | Estimates agricultural development strategy for the year 2030 |
|-------------------------------|------|----------------------------------------------------------|-----------------------------------------------------|-----------------------|------------------------|-------------------------------------------------------------|
| The cultivated (million acres)| 8.619| 11.549                                                   | 10.6                                                | (0.949)               | (8.22)                 | 11.549                                                      |
| Crop intensification          | 1.806| 1.99                                                    | 1.99                                                | -                     | -                      | 1.99                                                        |
| Crop Area (by million acres)  | 15.57| 22.5                                                    | 21.094                                              | (1.406)               | (6.25)                 | 22.984                                                      |
| Population (by million person)| 78.69| 111                                                     | 111                                                 | -                     | -                      | 111                                                         |
| Water used in agriculture (by billion m³) | 60.9 | 81.3                                                    | 74.94                                               | (6.36)                | (7.82)                 | -                                                           |
| Water used in drinking and health (by billion m³) | 9.55 | 13.5                                                    | 13.5                                                | -                     | -                      | -                                                           |
| Other used of water (by billion m³) | 3.5  | 3.5                                                     | 3.5                                                 | -                     | -                      | -                                                           |
| Total used of water (by billion m³) | 65.72| 98.3                                                    | 91.94                                               | (6.36)                | (6.47)                 | -                                                           |
| Water resources (by billion m³) | 62.13| 89.4                                                    | 71.52                                               | (17.88)               | (20.0)                 | -                                                           |
| Balance of water (by billion m³) | (3.59)| (8.84)                                                 | (2.48)                                              | 6.36                  | (71.95)                | -                                                           |
| Value of Agricultural production (by billion dollars) | 35.112| 84.22                                                   | 78.03                                               | (6.19)                | (7.35)                 | -                                                           |

Volumes in brackets are negative. Source: Compiled and calculated from: Tables 1 to 6.

In addition, the climate change will adversely affect each crop’s productivity and the agricultural labor productivity. The expected effects on each of the cultivated and crop area, it will be seen that agricultural production will also be negative. Thus, the adequacy of agricultural
production and the ratio of self-sufficiency of different crops, and thus on the national economy, will decline.

Therefore, scenarios were expected (Scenario 2 & 3), in the year 2030, as a result of the impact of climatic changes, completely different from the Egyptian expectations of agricultural development strategy for the year 2030, did not take into account the change climate effects of expected until the year 2030. Egypt treats agricultural sustainability as key strategic targets for development in year 2030. However, the plan has not taken into account the impact of projected climate change. Climate change is important aspect for development strategy as illustrated by Scenarios No. 2 & 3.

Table 8: Expected scenarios for cultivated and crop area with future water resources by the year 2030 in light of the impacts of the climate change.

| The statement | 2030 | Change between (1), (3) | Change between (1), (3)% | Change between (2), (3) | Change between (2), (3)% |
|---------------|------|------------------------|--------------------------|------------------------|--------------------------|
| The cultivated (million acres) | 10.606 | (0.94) | (8.17) | 0.006 | 0.06 |
| Crop intensification | 1.99 | - | - | - | - |
| Crop Area (by million acres) | 21.11 | (1.39) | (6.18) | 0.016 | 0.08 |
| Population (by million person) | 111 | - | - | - | - |
| Water used in agriculture (by billion m$^3$) | 77.19 | (4.11) | (5.06) | 2.2482 | 3.00 |
| Water used in drinking and health (by billion m$^3$) | 13.5 | - | - | - | - |
| Other used of water (by billion m$^3$) | 3.5 | - | - | - | - |
| Total used of water (by billion m$^3$) | 94.19 | (4.11) | (4.18) | 2.25 | 2.45 |
| Water resources (by billion m$^3$) | 89.41 | 0.01 | 0.0 | 17.89 | 25.0 |
| Balance of water (by billion m$^3$) | (4.74) | 13.58 | - | (7.22) | - |
| Value of Agricultural production (by billion dollars) | 73.68 | (10.54) | (12.51) | (4.35) | (5.57) |

Volumes in brackets are negative. Source: Compiled and calculated from: Tables no. (1), to (6).

Prior studies agree that there are negative impacts from climate change. This problem is compounded by the expected increase of population. These changes would lead to a decline in expected agricultural production. It is estimated that climate change will result in a reduction of 12% in value of agricultural production by the year 2030. An increase of about 16% in the value of the purchase prices lose of job opportunities is also expected. An estimated at 2% of the total current employment will also be affected through migration or displacement. Climate change will reduce the Egypt's GDP by about 10% in the year 2050 (See Fayad).
2.5 Ways to face of the climate change phenomenon in Egypt

This is done through the following:

1- Some methods are known for facing of climate change. These known approaches include: Mitigation: to reduce the greenhouse gas emissions from different sectors, through of clean technology, fuel substitution, the use of renewable energies such as the wind, the sun, tubing, and vitality. Adaptation: resulting from such circumstances such as devising new strains of crops, which bear the high temperature and salinity, optimum use of water resources through the application of the policies of rations and rationalize water consumption.

2- Policy of integrated coastal areas management and development of coastal zone management. Taking into account the potential rise in sea level with the monitoring of the implementation of this policy continued monitoring (through remote sensing, for example), errors could be averted and policy makers could use the available information to plan.

3- Severe shortage of available data and information on the negative effects of climate change on different sectors of development in Egypt. The issue of the internal and external migration, and the establishment of a full database continually occurring, in advance of the study, the promotion of scientific research and technology in all issues related to climate change and develop specific plans and financing is clear.

4- It is necessary to the cultivation of wheat bear the high temperatures. Resist drought in time with a good distribution of items wheat to the geographical regions, and the expansion of winter crops such as lentils, beans, and other municipal, it is likely that these measures to prevent expected negative effects, or, at least, mitigate the negative effects (Worldwatch.org).

5- Regionalization studies of the most important means to reduce the negative impact and further improve the positive impact of this phenomenon. There have been many studies of regionalization in this regard as the result of the possibility to overcome, or, at least, alleviate the shortage in crops productivity.

6- There are many of the results of the studies conducted on the regionalization of crops, which has been a study of sensitivity under conditions of climatic changes. Use existing knowledge acquired through prior research to ease the shortage the accident, whether in crop productivity or net revenues of farm crop yield per acre or unit of water, in general, the most important results of the regionalization studies proposed the following: Develop new types of high temperature, salinity and drought and the conditions that will prevail under conditions of climate change. Plan for new types of short-term crops to reduce water requirements, as well as change the dates for agriculture. Reduce wasteful crop area in water consumption, or at least not to increase the size of (such as rice and sugarcane), and plant alternative crops are given the same purpose and water consumption season and lower growth such as the cultivation of sugar beet. Substitute other crops for planting sugar cane (in this strategy should take into account that this crop is a major crop in Upper Egypt, in addition to the factories secondary industries and employment based on this crop).

7- Irrigation water at appropriate time’s appropriate quantity in each effect in order to preserve every drop of water. The need for effective irrigation is keener under climate change condition.

2.6 The role of agriculture in mitigating the impacts of climate change in Egypt
As regards the future of agriculture under the changing climate, a range of adjustment measures can be undertaken relating to farming practices, for example, planting, harvesting and watering/fertilizing existing crops, using different varieties, diversifying crops, and implementing management practices. Mitigation has the potential to reduce climate change impacts, and adaptation can reduce the damage of those impacts. Together, both approaches can contribute to the development of societies that are more resilient to the threat of climate change.

Significantly reduce emissions of greenhouse gases resulting from agriculture through many means, the most important of which are:

*The use of coping mechanisms that resist climate change*, through specific activities such as use of crops resistant to drought or salinity, and use of water resources in the most efficient manner, in addition improvement in the management of pesticides, as well as can include changes in agricultural patterns, reducing the use of fertilizers and develop the production of rice.

*Farming can contribute to reducing emissions of carbon dioxide by absorption*. It is estimated that the contribution of crop land in carbon sink during the twentieth and thirtieth next year ranging from 450 to about 610 million tons of carbon each year. Use of effective land management, such as effective water management and erosion control, conversion of cropland in the industrial countries to permanent forest or grassland or ecological systems, living biomass crops, to plow soil for maintenance, and other farming methods can have a major role in carbon sink compensatory mechanism on the contribution of agriculture to greenhouse gases.

*It also could be that agriculture plays an in reducing the burning of fossil fuels*, it is possible to replace 20% of fossil fuel consumption in the short term using biomass fuel live Such as herbs, which fast growth, oilseeds agricultural residues provide great potential as alternatives to generate energy.

### 2.7 The Egyptian efforts exerted to face the effects of climate change

Egypt responded with efforts to cope with the challenges of climate change and improve their conditions of life. It establishes the rules of sustainable development in the world, and where that Egypt is one of the countries that is expected to be affected by the impacts of climate change, especially in agriculture, water resources, as well as drinking water, and health. Therefore, has focused on the need to activate the State policies of response measures to cope with and mitigation of the consequences of climate change. Egypt made many efforts and activities to deal with the issue of climate change, including:

- Egypt had ratified the Convention on the United Nations Climate Change and environment law No. 4 in the year 1994. It participated in all international conferences and workshops on Climate Change, to avoid imposing any international obligations on the developing countries, including Egypt, and ratification of the Kyoto Protocol and forming a national committee for the Clean Development Mechanism (CDM) in the year 2005. These efforts include the Egyptian Office and the Egyptian clean development mechanism, and the report of national reporting in the year 1999 to limit greenhouse gases and national plan of action to climate change.

- The Ministry of Electricity and Energy works on many projects in the field of New and Renewable Sources of Energy (wind-solar-water-biotechnology) and encourage projects to improve energy efficiency. The Ministry of Water Resources and Irrigation Projects works to protect the beaches (the protection of the coast), as well as the establishment of competent research institutes in collaboration with development partners. The Agricultural Research Center to conducts research on the impact of climate change on crop production and to devise new types that is heat tolerant. Finally, the establishment of the Ministry of the Environment works pilot projects to encourage the private sector to invest in clean energy projects, treatment of wastes and the establishment of forest plantations. The establishment of the Ministry of the environment is currently preparing a report national reporting II to be the basis of the updated national plan of action to climate change, and update inventories of greenhouse of various sectors.
The restructuring of the national climate change in the year 2007 led to the coordination at the national level with regard to the topics of climate change. Egypt must engage policies and strategies to deal with these issues, and to propose mechanisms for implementation.

Maximizing Egypt's benefit from the mechanisms of the Kyoto Protocol through the implementation of the clean development mechanism projects, where guest approval on a number (36). The draft in the framework of the mechanism, including sectors of New and Renewable Sources of Energy, Industry, waste treatment, afforestation, and improve the efficiency of energy conversion of fuel, natural gas, at a total cost about 1.200 million dollars, shows that these projects attracted foreign investment. They provide new job opportunities, and to contribute to the implementation of the sustainable development plans in the State.

The plan targets National Climatic Changes need to exchange information to deal with the real issues of climate change, especially those with environmental repercussion. One of its axes is the cooperation with the international community in maintaining the quality of the environment and reducing the causes of climate change. The plan includes the areas of raising the public awareness of the phenomenon and deal with economic dimensions, capacity-building, and international financial and technical assistance programs, as well as the transfer of technology, and to develop the necessary policies and programs to adapt to climate changes in all sectors, with the participation of non-governmental associations and organizations.

Finally, the Egyptian Agricultural Policy can offer a number of instruments to find adequate to answer to the challenges of climate change, a more sustainable of Egypt agriculture. Given the pressure on natural resources, agriculture has to improve its environmental performance through more sustainable production methods. Farmers also have to adapt to challenges stemming from climate change, and have to pursue mitigation and adaptation actions, (e.g.) by developing greater resilience to disasters, such as flooding, drought, and fire.

3. CONCLUSION
Climate change will adversely affect Egypt. These effects would come from high temperatures, changing patterns of rainfall, rising sea levels, and the increasing frequency of climate-related disasters. These changes pose risks to agriculture, land agricultural, water supply, and food security. The problem of research on the phenomenon of climate change, and the reasons for their occurrence, and the impact of climate change on agricultural land and productivity of the most important agricultural crops water resources, productivity agricultural worker productivity, various crops, scenarios expected effect of climate changes on the area cultivated and crop area are important for Egypt. Therefore, Research aimed to expected impacts of climate change on the agricultural land, productivity of the most agricultural crops, and water resources, as well as access to the best scenario possible expectations to the impact of climate change on the cultivated and crop area in the year 2030. We adopted the descriptive research method to find out the current situation and the future image of climate change. In addition to its effects on agriculture, as stand on scenarios to assess climate change impacts on agricultural land and productivity, water resources in the year 2030. We found that the quantity of greenhouse gases in Egypt about 197 million tons of carbon dioxide equivalent in 2014. There is the possibility of losing about 15% of the area of high-quality agricultural land in production in the delta region will lose as a result of sinking or salinity with sea level rise by about half a meter away, and it is expected that climate change will have a negative impact on the productivity of field crops. We offer the following recommendations: (1) Egypt is advised to develop new types of high temperature; salinity and drought conditions that will prevail under conditions of climate change and to develop new types of short growth season to reduce water needs, change the dates for agriculture, including appropriate to weather conditions, cultivation of new items in appropriate. (2) Reduce demand for water in planting by using alternative crops that have lower needs for water. (3) Use effective land management, such as improving fork soil water management and erosion control, plow soil for maintenance, and other farming can have a major role in carbon sink compensatory mechanism on the contribution of
agriculture to greenhouse gases. (4) Use of irrigation systems more effectively and provide better protection of coastal areas and farms, in order to mitigate the effects of climate change. (5) Make climate change data readily available in order to gain better understanding of the effect of climate change on different sectors of development in Egypt, in particular the issue of the internal and external migration, and the establishment of a full database continuing to occur. Encourage scientific research and technology in all issues related to climate change and develop specific plans and financing is clear. (6) Pay closer attention to regional studies where in order to learn how to overcome, or, at least, alleviate the shortage in crop productivity adversely affected by climate change.

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