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Impact of the Global Climate Change on Land Degradation in Egypt

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Abstract: Indications of serious changes in the world's climate have been evident over the past few decades. Recently, studies have shown how grave the problem is, as well as the magnitude of its negative impacts on all sectors of development. According to these studies, human activity has led to a rise in the earth's average temperature at a rate of 0.3 to 0.4 degrees every 10 years, which is unprecedented in recorded history. This rapid and continuous rise in temperature has been traced to the increase in greenhouse gases in the earth's atmosphere. Projections made by the International Panel on Climate Change (IPCC) indicate an expected rise in average temperatures of between 2.0 to 4.5 0C by the end of the present century. A rise in sea levels of between 9 to 59cm is also projected, which would lead to unprecedented changes in an environment that has remained stable over many eras. The high increase in the population growth rate and rapid spread of urbanization in Egypt are the cause for concern due to the resultant increase in air and water pollution. Population growth has obviously intensified demand for resources, including water, energy, and waste disposal and sewage services. The rise in temperature is expected to further exacerbate the dearth in drinking water, increase pressure on land resources, and lead to a rise in the incidence of sand and dust storms. Furthermore, the global rise in sea levels added to expected local land subsidence (a result of tectonic movements and continued pumping of petroleum and ground water, estimated at another 30cm within the next 100 years), will lead to a loss of many low-lying coastal areas and to salt water intrusion into a number of coastal wells. The combined effect will also lead to a rise in the water table in coastal regions that would ruin the agricultural productivity of low- lying areas. The adverse effects of climate change also include an increase in the frequency and severity of sandstorms, and longer periods of drought followed by more intense flooding. This is expected to lead to public health problems, including the spread of epidemics, especially in poorer regions.
Keywords: *Climate change, land degradation, Desertification.*

INTRODUCTION

Climate is an important factor of agricultural productivity. The fundamental role of agriculture in human welfare concern, has been expressed by many organizations and others regarding the potential effects of climate change on agricultural productivity. Interest of this matter has motivated a substantial body of research on climate change and agriculture over the past decade. Climate change is expected to influence agricultural and livestock production, hydrologic balances and other components of agricultural systems.

Temperatures start to rise where large parts of the planet become drier and deserts spread. Others receive more rain and floods come. The oceans warm up and expand, washing over islands and coastlines. Fierce storms occur where they never did before. Crops fail and vulnerable communities abandon their homes to migrate elsewhere. As the climate changes faster than ever before in human history, a crowded and troubled world struggles to cope.

Reality of climate change scenario will this grim climate change scenario become reality? While the climate has always varied naturally, scientists now believe that industrial and agricultural emissions of carbon dioxide and other gases may cause a permanent, one-way change in climate. Atmospheric concentrations of these gases, which help to create a natural "greenhouse effect" that keeps the planet warm enough for human life, have risen dramatically over the past 100 years. This could lead to higher temperatures and new climate patterns in the coming decades and centuries.

Many questions remain, and researchers are working hard to answer them. But while scientific certainty is still some years away, the world's government have decided that the risks are simply too big to be ignored.

As the home is one of the oldest civilizations on the planet, Egypt's concern about global climate change and its consequences on sustainable development comes as no surprise. Scientific evidence and

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climatic records have sharpened the focus on the relationship between the concentrations of greenhouse gases (GHG) in the atmosphere and the rise in global temperatures. The rise in sea level threatens Egypt's long coastal stretch on the Mediterranean and the Red Sea with potential damages too, not only the tourism industry, a major contributor to the Gross Domestic Product (GDP), but also to the entire ecosystem. Predicted socioeconomic implications due to human migration, land loss, and soil salinity cause significant concerns. With 95 percent of Egypt's fresh water needs supplied from the Nile River, the country's vulnerability increases with any changes in rainfall patterns throughout the Nile Basin. Egypt is facing these challenges responsibly and taking proactive measures to protect its future generations from serious threats. Egypt has prepared a National Action Plan on Climate Change to coordinate its efforts to face this serious and important challenge, to maintain its sustainable economic development, and to provide a safe environment for its future generations. The industrial revolution, based on the use of coal as energy resources, signaled the start of ever-increasing emissions of carbon dioxide gas into the atmosphere as a by-product of fossil fuel combustion processes. In addition, the clearance by burning of large areas of tropical forest has further enhanced levels of atmospheric carbon dioxide. The result is a well documented increase in levels of CO2 in the air from below 280 ppm (parts per million) at the beginning of this century, to over 350 ppm in the early nineties.

GLOBAL CLIMATE CHANGE

Definition of global climate change: Climate change is a long-term shift in the statistics of the weather (including its averages). For example, it could show up as a change in climate normal (expected average values for temperature and precipitation) for a given place and time of year, from one decade to the next. It is knows that the global climate is currently changing.

The last decade of the 20th Century and the beginning of the 21st have been the warmest period in the entire global instrumental temperature record, starting in the mid-19th century.

The causes of global climate change

Climate change is the result of changes in our weather patterns because of an increase in the Earth's average temperature. This is caused by increases in greenhouse gases in the Earth's atmosphere. These gases soak up heat from the sun but instead of the heat leaving the earth's atmosphere, some of it is trapped, making the Earth warmer. Climate change is also known as global warming. [1,2] declared that climate change is caused by the release of:

a) Greenhouse gases

The presence of greenhouse gases in the atmosphere is a natural component of the climate system and helps to maintain the Earth as a habitable planet. Greenhouse gases are relatively transparent to incoming solar radiation, allowing the sun's energy to pass through the atmosphere to the surface of the Earth. The energy is then absorbed by the Earth's surface, used in processes like photosynthesis, or emitted back to space as infrared radiation. Some of the emitted radiation passes through the atmosphere and travels back to space, but some is absorbed by greenhouse gas molecules and then re-emitted in all directions. The effect of this is to warm the Earth's surface and the lower atmosphere. Water vapor (H_2O) and carbon dioxide (CO_2) are the two largest contributors to the greenhouse effect. Methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs) and other greenhouse gases are present only in trace amounts, but can still have a powerful warming effect due to their heat-trapping abilities and their long residence time in the atmosphere. Without the greenhouse effect, Earth's average temperature would be -0.4°F (-18°C), rather than the present 59°F (15°C).

b) Carbon dioxide (CO_2): Primarily, deforestation due to agricultural expansion and land speculation was caused a major source of carbon emissions. When natural vegetation is converted into agricultural land, a large proportion of the soil carbon can also be lost as plants and dead organic matter are removed. This event contributes approximately a third of the total CO_2 emissions globally. Therefore, CO_2 is also released during the burning of agricultural crop waste, for example, during the burning of cereal straw, sugar cane stubble and rice straw. In many countries, it is a common practice to burn large quantities of crop residue, which results is killing of insects and other pests as well as disease-causing organisms and neutralizes soil acidity.

c) Methane (CH_4): Methane (CH_4) is the most significant greenhouse gas released within the agricultural sector. Most of the methane releases come from paddy fields (91%) and less significantly from animal husbandry (7%) and the burning of agricultural wastes (2%). The quantification of rice paddy emissions has proven difficult as the emissions vary with the amount of land in cultivation, fertilizer use, water management, density of rice plants and other agricultural practices. Among many Asian countries, China is a very large source of CH_4 emissions. Livestock and associated manure management causes 16% of the total annual production of CH_4. These emissions are a direct result of the ability of buffalo and cattle to utilize large amounts of fibrous grasses that cannot be used as human food, or as feed for pigs and poultry. Buffalo and cattle contribute about 80% of the global CH_4 emissions from domestic livestock annually.

d) Nitrous Oxide (N_2O): Most of the agriculture-based N_2O emissions come from nitrogen fertilizer usage, legume cropping and animal waste. Some N_2O emissions are also released during biomass burning. Many farmers use nitrogen fertilizers on their fields to enhance crop growth. The crop takes up most of the nitrogen, but some of them leach into surrounding surface and ground waters and some of it enters the atmosphere. The nitrogen flux depends on the microbial activity in the soil. For example, wet rice absorbs only one-third of the nitrogen in the fertilizers. The rest of nitrogen is denitrified and diffused into the atmosphere, which is contributing to global warming. However, the amount of N_2O emitted is much lower in volume than the amount of CH_4.

e) Sulfate aerosols and black carbon

Sulfate aerosols and black carbon are two important additional examples of anthropogenic forcing. Sulfate aerosols, which enter the atmosphere naturally during volcanic eruptions, are tiny airborne particles that reflect sunlight back to space. Industrial activity has recently increased their concentration in the atmosphere primarily through the burning of fossil fuels containing sulfur. Anthropogenic emissions of sulfate aerosols have been associated with a net cooling effect. Black carbon is soot generated from industrial pollution, traffic, outdoor fires, and the burning of coal and biomass fuels. Black carbon is formed by incomplete combustion especially of coal, diesel fuels, bio fuels and outdoor biomass burning. Soot particles absorb sunlight, both heating the air and reducing the amount of sunlight reaching the ground.

[3], described some of the principal causes of increasing climate variability and climate change (ICV & CC) are a mixture of external and internal factors to the climate system. Continued warming of global climate is expected to occur if atmospheric greenhouse gases keep increasing, with global climate models projecting an increase in mean temperature by 1–3°C by 2100. Volcanic eruptions that inject significant amounts of sulphate aerosols into the stratosphere cause a cooling of global climate in the order of 0.5°C for a period of 12–24 months. The ENSO (El Niño/Southern Osciallation) is the major cause of climate variability on seasonal to interannual time scales. Since 1976 El Niño episodes of the Southern Oscillation have increased in frequency, and become more extreme.

Climate of the future, choices for the present

[4] mention that the climate of the Earth has never been stable, least of all during the history and evolution of life on Earth. Recent glacial periods, for example, have been (globally) 4°–5°C cooler than now, and some interglacial have been (perhaps) 1°–2°C warmer. These prehistoric changes in climate were clearly natural in origin and occurred on a planet inhabited by primitive societies with far smaller populations than at present. Indeed, the regularity of the diurnal and seasonal rhythms of our planet has always been overlain by inter-annual, multi-decadal and millennial variations in climate, over whatever timescale climate is defined. Ecosystems and species have moved, often freely, in response to such past changes and have evolved within this climatic history. The causes of contemporary and future changes in climate, their rate and their potential significance for ecosystems and for the human species, however, are all notably different from anything that has occurred previously in history or pre-history. Evidence of global warming is plentiful and includes data on satellite-measured sea level change (2 mm rise per year from 1993–2003), lengthened growing season (by two to three weeks in the past 15–20 years) and

increased precipitation intensities resulting in increased flood risk during winter in the northern hemisphere.

CLIMATE CHANGE IN EGYPT

Climate change is probably the most serious problem that Mankind may face. Mohamed and Samir [5], concluded that the majority of environmentalists consider it the second most potential risk that may impact the globe after a nuclear war. Climate change is a multifaceted phenomenon that would encompass a variety of changes such as precipitation pattern, and rising sea level. Egypt is particularly vulnerable to climate change as rising sea level is likely to inundate some parts of the Nile Delta around its North Coast. Detailed studies in the field are rather meager. Some preliminary studies were conducted at the southern part of the Suez Canal to assess the vulnerability of that area to climate change and sea level rise. The total cultivated area in the study zone is in the range of 21260 acre. The vulnerable area is flat and slopes gently towards the east and is divided into four areas according to the contour lines above the sea level:

a) The area extends between zero and one meter level, comprises 11% of the study area. The relative rise of sea level of 0.5 m would affect the soil productivity. In case of 1.0 m rise, the whole cultivated area in this stretch would be inundated and flooded with saline water and the agricultural activity would change.

b) The area extends between 1- 2 m. level, comprising 16.6 % of the study zone has been classified with accelerated sea level rise ASLR of 1 m. as area of changes whereas the cultivated area must be upraised to increase the depth of the water table to acquire the suitable soil conditions to acquire the soil conditions suitable for the current cropping system or to replace it with crops tolerant to new soil conditions.

c) The area extends between 2-3 m. level, comprising 18.8% of the study zone. Growing fruit trees and other permanent crops would disappear and should be replaced with shallow rotted annual crops.

d) The area of above 3 m. height represent the rest of the study zone, comprises 53.1 % of the study zone. The area would not be affected by (ASLR). The rise in temperature and humidity in the area would favor the growth of fungus and bacterial species that may induce plant diseases.

In Egypt, an inventory of greenhouse gases emissions and sink for Egypt has been compiled using the default technology. Energy is the sector producing the highest ratio of CO2 in Egypt, as it accounts for more that 85% of total emission. Emission records of CO_2 from energy sector for the last 10 years has increased regularly, however the ratio of this sector emission in comparison to other sector has been maintained throughout. For methane, agriculture is the main source of emission in Egypt. Waste is the second largest sector; all energy sectors are the third sector, while industrial process is the least. For nitrous oxide emission, agriculture has the biggest share of 62% of the total national emission, followed by all energy sector which accounts for 35%, while industrial process is the smallest.

Egypt is potentially one of the countries most at risk from the effects of climate change. It is located in an arid - to semi-arid zone. The inhabited area of the country constitutes only 4% of the total area of the country (1 million km2), and the rest is desert.

The coastal zone of Egypt extends for more than 3,500 km and is the home of more than 40% of the population. Most of these people live in and around a number of very important and highly populated industrial and commercial cities: Alexandria, Port Said, Damietta, Rosetta and Suez.

IMPACTS OF CLIMATE CHANGE

Impact of climate change on air quality

Air quality is strongly dependent on weather and is therefore sensitive to climate change. Recent studies have provided estimates of this climate effect through correlations of air quality with meteorological variables, perturbation analyses in chemical transport models (CTMs), and CTM simulations driven by general circulation model (GCM) simulations of 21st-century climate change. Daniel and Darrell [6], review these different approaches and their results. The future climate is expected to be more stagnant, due to a weaker global circulation and a decreasing frequency of mid-latitude cyclones. The observed correlation between surface ozone and temperature in polluted regions points to a detrimental effect of warming. Coupled GCM–CTM studies find that climate change alone will increase summertime surface ozone in polluted regions by 1–10 ppb over the coming decades, with the largest effects in urban areas and during pollution episodes. This climate penalty means that stronger emission controls will be needed to meet a given air quality standard. Higher water vapor in the future climate is expected to decrease the ozone background, so that pollution and background ozone have opposite sensitivities to climate change. The effect of climate change on particulate matter (PM) is more complicated and uncertain than for ozone.

Impact of climate change on livestock production

Maria [7], examined the economic impact of climate change on livestock production in Kenya. He estimated a Ricardian model of net livestock incomes and further estimate the marginal impacts of climate change. The Ricardian results show that livestock production in Kenya is highly sensitive to climate change and that there is a non-linear relationship between climate change and livestock productivity. The estimated marginal impacts suggest modest gains from rising temperatures and losses from increased precipitation. The predictions from atmospheric ocean general circulation models suggest that livestock farmers in Kenya are likely to incur heavy losses from global warming. It is concluded that in the long term, climate change is likely to lead to increased poverty, vulnerability and loss of livelihoods. Several policy interventions are recommended to counter this impact.

IMPACT OF CLIMATE CHANGE ON LAND DEGRADATION

Global warming is expected to affect Egypt in many ways. In particular, water resources, agricultural resources, land degradation, salinity soils, waterlogging Soil fertility, agriculture and coastal zones are expected to be adversely affected. Water resources, both water supply and demand are expected to be affected by climate change.

Salinity

A combination of salt water intrusion due to Sea Level Rise (SLR) and increased soil salinity due to increased evaporation are expected to reduce the quality of shallow groundwater supplies in the coastal areas. Rainfall measurements in coastal areas are contradictory and make it difficult to predict whether rainfall is increasing or decreasing.

Siwa region, located in the north Western Desert of Egypt, has been recently subjected to severe soil salinity problems. Masoud and Koike [8], declared that the monitoring and analysis of the recent land cover dynamics through the integration of remote sensing and GIS could provide base information for documenting salinity change trends and for anticipating further degradation where the absence of long-term salinity records is an obstacle. The results confirmed an acceleration in the rate of soil salinization and vegetation loss after the year 2000. Further, this was found to be related to the relative climate warming and the improper drainage systems set up after the year 2000 in addition to the absence of an effective water resource management plan. Recommendations and measures that may prevent or ameliorate the exacerbation of these problems are proposed.

Waterlogging

The coastal zones of Egypt extend for over 3500 km in length along Mediterranean Sea and Red sea coasts. The Mediterranean shoreline is most vulnerable to sea level rise due to its relatively low elevation. The wetlands of the Nile Delta constitute about 25% of the total area of wetlands in the Mediterranean region, and produce over 60% of the fish catch of Egypt. Egypt's coastal zones constitute particularly important regions from economic, industrial, social and cultural points of view. In addition to increase tourism activities, a tremendous move towards building new industrial complexes is in progress at this time. The coastal zone of Egypt suffers from a number of serious problems, including a high rate of population growth, land subsidence, excessive erosion rates, water logging, salt water intrusion, soil salination, land use interference ecosystem pollution and degradation, and lack of appropriate institutional management systems. Realizing the importance of this zone, the Egyptian government has already taken steps towards reducing the impact of these problems.

Sea level rise

Sea level rise (SLR) due to climate change is a serious global threat. Benoit et al [9], reported that continued growth of greenhouse gas emissions and associated global warming could well promote SLR of 1m-3m in this century, and unexpectedly rapid breakup of the Greenland and West Antarctic ice sheets might produce a 5m SLR. The authors also have assessed the consequences of continued SLR for 84 developing countries. Geographic Information System (GIS) software has been used to overlay the best available, spatially-disaggregated global data on critical impact elements (land, population, agriculture, urban extent, wetlands, and GDP) with the inundation zones projected for 1-5m SLR. The results reveal that hundreds of millions of people in the developing world are likely to be displaced by SLR within this century, and accompanying economic and ecological damage will be severe for many. At the country level, results are extremely skewed, with severe impacts limited to a relatively small number of countries. For these countries (such as Vietnam, Egypt, and The Bahamas), however, the consequences of SLR are potentially catastrophic. For many others, including some of the largest (such as China), the absolute magnitudes of potential impacts are very large. Among regions, East Asia and the Middle East and North Africa exhibit the greatest relative impacts.

Analysis of the response to climate change and sea-level rise requires a link from climate change science to the resulting impacts and their policy implications. Robert [10], explored the impacts of sea-level rise, particularly increased coastal flooding due to storm surges. These results suggest that sea-level rise could be a significant problem if it is ignored, and hence it needs to be considered within the policy process considering climate change in terms of mitigation (reducing greenhouse gas emissions) and adaptation (improved coastal management and planning) needs.

As part of a broad assessment of climate change impacts in Morocco, an assessment of vulnerability and adaptation of coastal zones to sea-level rise was conducted. Maria [7], indicated that 10% and 24% of the area will be at risk of flooding respectively for minimum (4 m) and maximum (11 m) inundation levels. The most severely impacted sectors are expected to be the coastal defences and the port, the urban area, tourist coastal infrastructures, the railway, and the industrial area. Shoreline erosion would affect nearly 20% and 45% of the total beach areas respectively in 2050 and 2100.

In Egypt, a scenario of sea level rise (SLR) of 0.5m, 1.0m, and 2.0m, over the next century was assumed. Analysis of the GIS data for the three scenarios indicates the capability of the technique to map vulnerable areas and to quantitatively assess vulnerable sectors in each area. It illustrates that, if no protection action is taken, the agricultural sector will be the most severely impacted (a loss of over 90 percent), followed by the industrial sector (loss of 65 percent), and the tourism sector (loss of 55 percent) due to a SLR of 0.5m. Estimation of the socio-economic impact due to loss of land and jobs is possible using employment statistics relevant to each sector and taking future growth rates into consideration. It is estimated that a SLR of 0.5m in the governorate of Alexandria alone would cause a displacement of almost 1.5 million people and the loss of about 200 000 jobs by the middle of the next century, if no action were taken. Work is in progress to identify and assess vulnerable sectors in each district of the governorate, [11].

Mahmoud et al [12], used Landsat Enhanced Thematic Mapper imagery (ETM) of 2002 and aerial photography of 1955, combined with published charts and field observations were used to interpret geomorphological changes in the coastal zone between Kitchener drain and Damietta spit in the northeastern Nile Delta previously recognized as a vulnerable zone to the effects of any sea-level rise resulting from global warming. The interpretation resulted in recognition of several changes in nine identified geomorphological land types: beach and coastal flat, coastal dunes, agricultural deltaic land, sabkhas, fish farms, Manzala lagoon, saltpans, marshes and urban centers. As the consequence of human activities the size of Manzala lagoon has been reduced to less than 50%.

Sestini [13], demonstrated the potential impact of sea level rise on Nile Delta. Rising sea level would destroy weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed lands in the Nile delta of Egypt (Mediterranean Sea (Fig 1). The impacts would be very serious: One third of Egypt's fish catches are made in the lagoons. Sea level rise would change the water quality and affect most fresh water fish. Valuable agricultural land would be inundated.

El-Raey et al [14], A scenario of sea level rise (SLR) of 0.5m, 1.0m, and 2.0m, over the next century was assumed. Analysis of the GIS data for the three scenarios indicates the capability of the technique to map vulnerable areas and to quantitatively assess vulnerable sectors in each area. Table 1 presents gross percentage loss for each scenario of SLR. It illustrates that, if no protection action is taken, the agricultural sector will be the most severely impacted (a loss of over 90 percent), followed by the industrial sector (loss of 65 percent), and the tourism sector (loss of 55 percent) due to a SLR of 0.5m.

Estimation of the socio-economic impact due to loss of land and jobs is possible using employment statistics relevant to each sector and taking future growth rates into consideration. Results of the impact on population and loss of employment are shown in Table 2. It is estimated that a SLR of 0.5m in the governorate of Alexandria alone would cause a displacement of almost 1.5 million people and the loss of about 200 000 jobs by the middle of the next century, if no action were taken. Work is in progress to identify and assess vulnerable sectors in each district of the governorate.

Table 1. Potential loss of areas, population and land use due to SLR over Alexandria Governorate (by percentage).

Elevation	SLR 0.5 m	SLR 1.0 m	SLR 2.0 m
Area	51	62	76
Population	50	64	79
Agriculture	93	95	100
Industry	65	70	90
Residential	45	50	75
Municipal Services	30	50	70
Commercial Areas	20	25	35
Community Facility	15	20	30
Archeological Sites	48	55	70

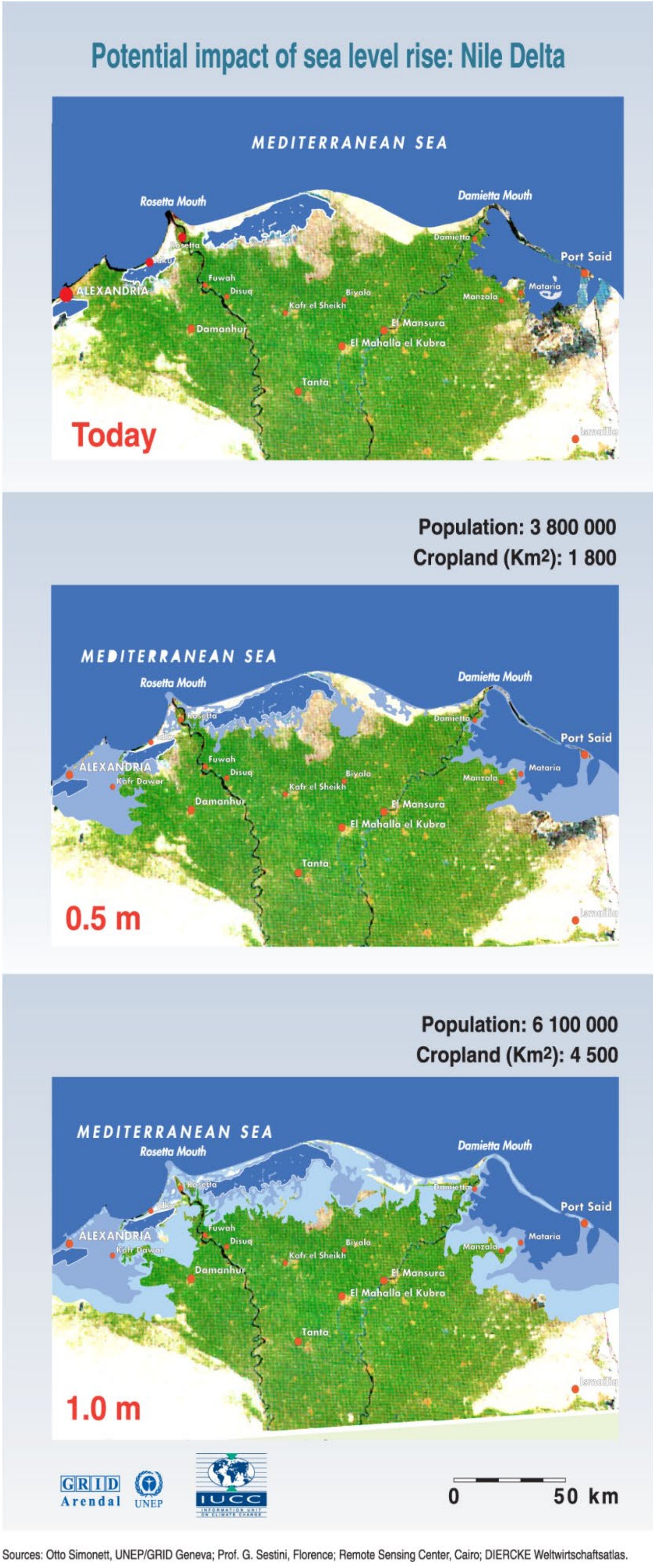

Figure 1. Potential impact of sea level rise, Nile Delta.

Table 2. Population expected to be displaced and loss of employment due to SLR in Alexandria Governorate

Year	2000 (SLR(5cm)	2010 (SLR=18cm)	2030 (SLR=30cm)	2050 (SLR=50cm)
-Area at risk (km^2)	32	144	190	317
-Population to be displaced (Thousands)	57	252	545	1,512
-Loss of Employment:				
a- agriculture	0,336	1,370	3,205	8,812
b- tourism	1,359	5,737	12,323	33,919
c- industry	5,754	25,400	54,936	151,200
-Total loss of employment	7,449	32,509	70,465	195,443

At Port Said Governorate results indicate that beach areas are most severely affected (hence tourism), followed by urban areas. The agriculture sector is the least affected sector. It is estimated that the economic loss is over $ 2.0 Billion for 0.50 m SLR and may exceed $ 4.4 Billion for 1.25 m SLR.

Impact of climate change on soil fertility

A field experiment was conducted from 2001 to 2002 on decertified cropland with gradients of wind erosion and accumulated sand to investigate changes in soil and crop growth properties resulting from desertification in the Horqin sandy land.

Zhao et al. [15], indicated that the soil environment degraded significantly and crop growth and biomass were seriously restrained by wind erosion. In the severely eroded cropland, soil clay, organic matter, total N and P, available N and P, average soil moisture decreased by 59.6%, 71.2%, 67.4%, 31.4%, 64.5%, 38.8% and 51.8%, respectively. Erosion increased soil pH from 8.66 to 8.92; delayed plant life cycle by 6 days, decreased plant height and diameter by 15.5% and 29.1%, and decreased above and below ground biomass and seed yield by 87.3%, 47.9% and 96.5%, respectively. Effects of a little accumulated sand were fewer on soil properties and crop growth and seed yield compared to wind erosion, severe accumulated sand effects on the cropland remain to be studied further.

Zhao et al [16] to investigate changes in soil C and N contents in relation to land desertification. Four primary results were derived from this work. First, land desertification characterized by wind erosion resulted in a significant decrease in soil fine particles (clay + silt) with a corresponding increase in sand content. In comparison to non-desertified land, soil fine particle content decreased by up to 89.2%, and sand content increased by up to 47.2%, in the severely desertified land. Second, the organic C and total N in soil were mainly associated with the soil fine particles, and decreased significantly with desertification development. Organic C decreased by 29.2% and total N by 31.5% in the severely desertified land compared to the non-desertified land. Third, the decrease in organic C and N content was greater in desertified grassland than in desertified farmland. Fourth, the changes in organic C and total N content had a significant positive correlation with the soil fine particle content ($P < 0.01$) and a significant negative correlation with coarse sand content ($P < 0.01$), indicating that land desertification by wind erosion is mediated through a loss of soil fine particles, with a resultant decrease in soil organic C and total N.

Impact of climate change on crops

Climate change could strongly affect the wheat crop that accounts for 21% of food and 200 million hectares of farmland worldwide. Rodomiro et al [17], reported that future climate scenarios suggest that global warming may be beneficial for the wheat crop in some regions, but could reduce productivity in zones where optimal temperatures already exist. For example, by 2050, as a result of possible climate shifts in the Indo-Gangetic Plains (IGPs) – currently part of the favorable, high potential, irrigated, low rainfall mega-environment, which accounts for 15% of global wheat production – as much as 51% of its area might be reclassified as a heat-stressed, irrigated, short-season production mega-environment. This shift would also represent a significant reduction in wheat yields, unless appropriate cultivars and crop management practices were offered and adopted by South Asian farmers. Under the same climate scenarios, the area covered by the cool, temperate wheat mega-environment could expand as far as 65°N in both North America and Eurasia.

Saleh et al. [18], studied the Effect of air temperature under climate change conditions on potato productivity in Egypt .These studies were conducted at three locations, Sakkara, at Giza; Bosaily, at Beheira and Nobaria, at Beheira, with two cultivars (Valor and Nicola cv's) grown on three planting dates: (Date 1: Oct. 1, Date 2: Oct. 10 and Date 3: Oct. 20) during 2003-2004 and 2004-2005 cropping seasons in order to investigate the production of potato (Solanum tuberosum L.) under the years 2003 to 2005 and under climate change scenario in the years 2025, 2050, 2075 and 2100 by using a simulation model. The average temperature is projected to have an increase between 1.1 and 2.9°C during potato winter season for the years 2025 to 2100. For this period, potential potato yield is likely to decrease by 6 to 22% (without adaptation) and by 2% to 16% (with adaptation, sowing date). In the winter season, climate change will likely lead to delay the time of planting from October 1st to November 1st to avoid the heat stress. Under the current and climate change conditions it is projected that the lowest yield decrease will be at Nobaria location and the highest reduction at Bosaily location, but the production of Valor cultivar will be higher than Nicola cultivar. It is shown that the shifting of planting date and locations and the use of heat-tolerant potato cultivars could be used to mitigate the effects of climatic change in Egypt.

Farag et al. [19] pointed that the wheat crop was grown for six seasons (2000 and 2005) in the Ismailia Governorate, Egypt. Two steps were investigated under this study. The first was validating SIRIUS crop model by using wheat cultivar "Sakha93" under central pivot irrigation system. Agro-metrological data was recorded by using automatic climate station. The actual collected data of wheat such as irrigation, fertilization and other agriculture applications were obtained from private farm. The climatic data from 2000 to 2005 was used as inputs in SIRIUS model. Also, the field measurements on soil, vegetative characteristics and yield component were used as a basis for validating the performance of the crop model. The accuracy of a crop model was judged by simulating the production level. The validation results indicated that the difference between simulated and observed dates of flowering, beginning of grain fill and the end of grain fill and maturity varies from 1 and 7 days, whereas, the deviation between the simulated and measured yield measured from 2000 to 2005 exceeds the ±25% interval only in 2000. The obtained results showed that, the increasing of CO_2 concentration leads to increase in the yield of wheat, while increasing temperatures had a negative effect. The increase of wheat production as a result of increasing CO_2 was less than the reduction rate in wheat yield as a result of increasing temperature.

The climatic factors are known to affect plant growth, yield and quality. Assem et al. [20] determined the effect of temperature on the economics of tomato, potato and cucumber crops grown in different climatic zones during the period of (1990-2005). The study showed that the increase in average air temperature by 1°C above the normal in March in northern Delta region caused a decrease in total yield by about 0.75 ton per feddan. Such an increase in temperature in February in Upper Egypt decreased yield by 0.48 ton per feddan. An increase in average air temperature of January by 1°C above normal in North Sinai caused an increase in total yield by 0.61 ton per feddan, where as the total yield decreased by 0.74 ton per feddan, when the same increase occurred in March. The total summer tomato yield decreased by 0.33, 0.36 and 1.53 ton per feddan in south Delta, middle Egypt and south Sinai, respectively, as a result to the increase in average air temperature above the normal of March, April and July by 1°C .

Based on the mentioned previous simulation studies, climate change could decrease national production of many crops (ranging from -11% for rice to -28% for soybean) by the year of 2050 compared to their production under current conditions. Yield of cotton would be increased in comparison with current climate conditions. At the same time, water needs for summer crops will be increased up to 8% for maize and up to 16 % for rice by the year 2050 compared to their current water needs.

El-Marsafawy [21] studied the potential impact of climate change on the yield and crop of sunflower oil productivity in the main agricultural regions of Egypt. OILCROP-SUN model, embedded in the Decision Support system for Agrotechnology Transfer (DSSAT3.5) was used for the crop simulations with current and possible future management practices. Equilibrium doubled CO_2 climate change scenarios were derived from the CCCM and GFD3 general circulation models (GCMs). These scenarios predict consistent increases in air temperature, small increases in solar radiation and precipitation changes that will happened in the future. The calibration and validation test was carried out in the present study. Simulation of sunflower productivity was carried out for 30 years (for Middle and Upper Egypt) and 26 years (for Delta) under the normal weather conditions and climate change conditions. The results revealed that the two climate change scenarios considered resulted in simulated decrease in sunflower yield at the three sites. The change percent of seed yield in Delta, Middle and Upper Egypt reached about -21, -27 and -38% under climate change conditions compared to their production under current conditions, respectively. At the same time, water consumptive use will be increased about 5 and 12% in Delta and Middle Egypt, respectively, while in Upper Egypt, it will be decreased about 0.5% as a result of high reduction in yield under climate change conditions compared to their current water consumption.

DESERTIFICATION

Desertification of the arid lands of the world has been proceeding--sometimes rapidly, sometimes slowly--for more than a thousand years. It has caused untold misery among those most directly affected, yet environmental destruction continues. Desertification is not only one of the world's greatest environmental challenges; it is also a major impediment to meeting basic human needs in drylands. It puts at risk the health and well-being of 1.2 billion people in more than 100 countries. Many of the world's poorest people are also those most directly affected by desertification.

For the interactions between climate and desertification [22], adverted that the deserts are known to mankind, but the term desertification has always been an elusive concept. It is now defined in the United Nations Convention to Combat Desertification (UNCCD) as land degradation in the dry lands (land falling within arid, semi-arid and dry sub-humid areas) resulting from various factors, including climatic variations and human activities. This definition, which is now being used worldwide to describe desertification and its impacts, leads to the need to consider carefully the two-way interactions between climate and desertification. Dramatic changes in agricultural practices during the last several decades are one of the main driving forces for land degradation in the dry lands and examples of land degradation are given for several regions around the world. It is equally important to consider the impact of dry land climates on soils and vegetation and the impact of climate change on desertification. It is important to adopt uniform criteria and methods to assess desertification and encourage monitoring of dry land degradation in all the regions around the world. To better understanding the interactions between climate and desertification, it is also important to identify the sources and sinks of dryland carbon, aerosols and trace gases in dry lands.

Drylands cover about 41% of Earth's land surface and are home to more than 38% of the total global population of 6.5 billion. Some form of severe land degradation is present on 10 to 20% of these lands, the consequences of which are estimated to affect directly some 250 million people in the developing world, an estimate likely to expand substantially in the face of climate change and population growth [23].

On the other hand [24], pointed out that, for the dry season (April–September), by the 2050s, North Africa and some parts of Egypt, Saudi Arabia, Iran, Syria, Jordan and Israel, are expected to have reduced rainfall amounts of 20–25% less than the present mean values. This decrease in rainfall is accompanied by a temperature rise in those areas of between 2 and 2.75°C. For the same period, the temperature in the coastal areas of the Mediterranean countries will rise by about 1.5°C.

Desertification on Saudi Arabia [25] referred to the extant of the desertification on Saudi Arabia and added to the desert is the process that turns productive deserts into non-productive deserts as a result of poor land-management. Desertification reduces the ability of land to support life, affecting wild species, domestic animals, agricultural crops and humans. The reduction in plant cover that accompanies desertification leads to accelerated soil erosion by wind and water. South Africa is losing approximately 300–400 million tons of topsoil every year. As vegetation cover and soil layer are reduced, rain fall impact and run-off increases.

Egypt is located in the severely dry region extended from North Africa to West Asia, the wind erosion is considered one of the important land desertification processes in areas exceeding 90% of the state area in western desert, eastern desert and particularly Sinai. These areas are characterized by a fragile ecosystem, scarcity of vegetation cover and severe drought. Studies indicate that wind erosion ratio in Egypt is about 5.5 ton/hectare a year in oases areas in western desert and 71- 100 ton/hectare a year in areas of rainfed agriculture on northwest coast showing wind erosion risks in these areas wavering between moderate and severe, [26]. During rain falling periods in winter season, the water erosion in north coast, Red Sea, Aqaba Gulf and south Sinai coasts and some of eastern desert valleys areas, is considered one of the most grave desertification processes in these areas as studies are indicating that water erosion impact in Egypt on lands is low to severe [27].

On the other hand, [28], studied the desertification impact assessment in Egypt using low resolution satellite data and GIS. In this study, desertification processes and their impact on land cover changes in Egypt from 1992 to 2000 were analyzed using low-resolution satellite data. It was found that agricultural land increased by about 14.3% during the study period, in particular, around the Nile River Delta and around the Northern Lakes of Egypt. The newly cultivated lands were extracted mainly from desert and salt marshes. At the same time, parts of the agricultural lands were turned into degraded land due to desertification and urban expansion.

The effect of rising sea levels on coastal zone of Egypt

Egypt's Nile Delta Mediterranean coastline is one of the areas that will be most affected by the rise in sea levels, as a large portion of it is itself below sea level and is subsiding. Within the Delta itself, or close to it, lie some of the most important Egyptian cities, such as Alexandria, Rosetta and Port Said. Further west, on the coastline, are Marina and Marsa Matrouh.

A detailed study of these cities was undertaken making use of satellite images and Geographic Information Systems (GIS) techniques and assuming specific scenarios of sea level rise. This resulted in a number of estimates of expected losses.

Alexandria : A rise in sea levels of about 50 centimeters, assuming no protection work is undertaken, will lead to the loss of a number of tourist beaches and flooding of some agricultural and industrial areas.

Rosetta : Increased loss of coastline areas; the destruction of a large portion of Rosetta's historic Islamic monuments; the flooding of a large portion of the agricultural land adjacent to the coast.

Port Said : The city lies in the midst of large body of water, if protection projects are not undertaken, large areas close to the coast near the Suez Canal will be lost.

Marsa Matrouh : Considered relatively secure even though the study indicates that many beaches and the museum built at the location of Rommel's World War II command centre may be immersed. Marina Tourist Village : There are indications that some of its low-lying areas and those on the coastline will be in danger of flooding with seawater.

It is clear that a number of important economic and commercial centres in Egypt will be exposed to the adverse effects of climate change, with the coastal cities of the Nile Delta, in particular, being most affected. It is urgent that strategic adaptation policies and plans are put in place and strong institutions and systems of supervision to enforce environmental laws, are established.

CONCLUSION

Climate change could influence agricultural production adversely due to resulting:

* Geographical shifts and yield changes in agriculture.
* Reduction in the quantity of water available for irrigation and loss of land through sea level rise and associated.

The yields of different crops and geographic limits may be altered by changes in soil moisture, temperature, precipitation, cloud cover, as well as increases in CO_2 concentrations. The lowest rainfall and high temperature could reduce soil moisture in many areas, particularly in some tropical and mid-continental regions, reducing the available water for irrigation and impairing crop growth in non-irrigated areas of many regions.

In addition to changes in the frequency of extreme climatic events, changes in rainfall and temperature could be damaging and costly to agriculture, the negative impacts can be summarized in the followings:

1. The coastal zone of Egypt is seriously vulnerable to the effects of sea level rise and changes in weather patterns from both the physical and the socio-economic points of view.
2. Large areas of the governorates of Alexandria, Behaira, Kafr El-Shiekh, Port Said, Damietta and Suez, are particularly vulnerable to sea level rise. Other vulnerable areas include Lake Bardawil, coast of Obeyedh near Matruh and the coasts of the Bitter lakes. Many other areas on the Red Sea are also vulnerable.
3. The impacts of accelerated sea level rise (ASLR) through direct inundation, salt water intrusion, deterioration of ecological systems and associated socio-economic consequences, have been addressed.
4. Impacts resulting from changes in the precipitation pattern, shortages of fresh water resources, loss of already scarce vegetation cover, increased desertification and associated socio-economic impacts, have yet to be studied in depth.
5. The techniques and methodologies for vulnerability assessment of Egypt's coastal zones are reasonably well identified (e.g. IPCC methodology based on remote sensing and GIS). Although a quantitative pilot study has been carried out for one or more of the vulnerable areas (e.g. Alexandria governorate, Port Said ...), current data on land use and elevation are needed before reaching a final overall assessment of the potential impacts of climate change on the coastal zones of the country.
6. A program based on a strategic policy for coastal protection and adaptation must be advanced and implemented.

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