Climate Change: The Impacts of Sea Level Rise on Egypt

Introduction

Sea level changes are caused by several natural phenomenon; the three primary contributing ones are: ocean thermal expansion, glacial melt from Greenland and Antarctica - in addition to a smaller contribution from other ice sheets- and change in terrestrial storage. Among those, ocean thermal expansion has been expected to be the dominating factor behind the rise in sea level. However, new data on rates of deglaciation in Greenland and Antarctica suggest greater significance for glacial melt, and a possible revision of the upper-bound estimate for sea level rise (SLR) in this century (Dasgupta, *et* al., 2007).

It is predicted that, with global warming, global average sea levels may rise by between 7 and 36 cm by the 2050s, by between 9 and 69 cm by the 2080s and 30–80 cm by 2100. The majority of this change will occur due to the expansion of the warmer ocean water (Roaf, *et* al., 2005). Since the Greenland and Antarctic ice sheets contain enough water to raise the sea level by almost 70 m, people will be directly affected by rising sea levels in several ways. As seas rise many areas of the coasts will be submerged, with increasingly severe and frequent storms and wave damage, shoreline retreat will be accelerated. In addition to expected disastrous flooding events caused by severe climate events such as heavy flooding, high tides, windstorms in combination with higher seas (Dasgupta, *et* al., 2007).

The impacts of SLR will not be globally uniform, because of local variations in vertical crustal movements, topography, wave climatology, long shore currents, and storm frequencies. Low gradient coastal landforms most susceptible to inundation include deltas, estuaries, beaches and barrier islands, and coral reefs. Regions at risk include the Low Countries of Europe, eastern England, the Nile delta in Egypt, the Ganges–Brahmaputra, Irrawaddy, and Chao Phraya deltas of south-eastern Asia, eastern Sumatra, and Borneo. In the United States, the mid-Atlantic coastal plain, the Florida Everglades, and the Mississippi delta will be particularly vulnerable (Vivian, 2005).

Developing countries are certainly identified mainly at risk. The consequences of SLR for population location and infrastructure planning in developing countries should definitely be reviewed by the developing world.

The paper aims to discuss the dilemma which may arise in Egypt with the diverse effects of SLR; environmentally and socio-economically. It will examine a number of environmental features affected; water resources and coastal zones. As well as highlighting the socio-economic dimensions influenced; population, agriculture, urban areas and gross domestic product (GDP).

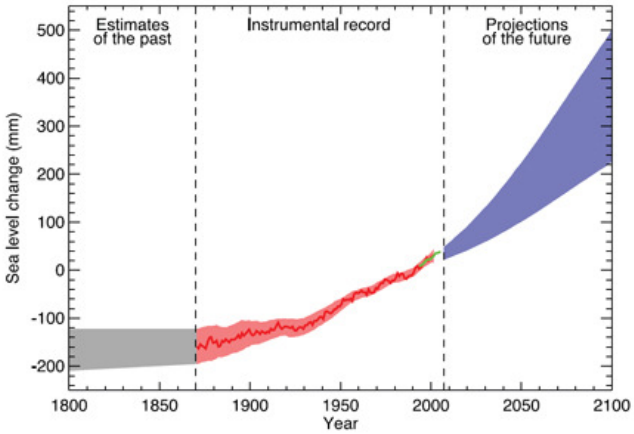

Fig 1: Past, present and predicted sea level trends *(Boko, et al., 2007)*

Vulnerability of developing countries to climate change

Vulnerability can be defined as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity” (Watson, 2001). Vulnerability to climate change is considered to be high in developing countries due to social, economic, and environmental conditions that amplify susceptibility to negative impacts and contribute to low capacity to cope with and adapt to climate hazards. Moreover, projected impacts of climate change generally are more adverse for lower latitudes, where most developing countries are

located, than for higher latitudes. Because of the high level of vulnerability, there is an urgent need in the developing world to understand the threats from climate change, formulate policies that will lessen the risks and to take action (Abou-Hadid, 2006).

The danger is greatest, where natural systems are severely degraded and human systems are failing and therefore incapable of effective response, specifically in deprived nations. Moreover, land degradation and desertification may also be exacerbated in these areas, posing additional threats to human well-being and development, added by intensified human pressures on lands and poor management. The livelihoods and food security of the rural poor are threatened by climate change with all its impacts, and the vulnerability to adverse health impacts is greater where health care systems are weak and programs for disease surveillance and prevention are lacking. In addition to multiple factors converging to make the people inhabiting coastal zones and small islands highly endangered from the causes of SLR (Leary, *et* al., 2007). Egypt's coastal zone of the Nile delta has been defined as a vulnerable zone as a consequence of SLR combined with geological and human factors.

Setting a background for Egypt

Egypt is located in the north-eastern corner of the African continent with an area about 1 million square kilometres. It is considered a developing country burdened by the scarcity of natural resources associated with extreme population growth (over 70 million people in total). The Egyptian terrain consists of a desert plateau interrupted by the Nile valley and delta. It is located in an arid - to semi-arid zone. The coastal zone of Egypt extends for more than 3,500 km and 40% of the population live there. Most of these people live in and around a number of major industrial and commercial cities: Alexandria, Port Said, Damietta, Rosetta, and Suez (El-Raey, 1999). Furthermore, the Nile delta covers the area from Cairo to the shoreline of the Mediterranean Sea, between the cities of Damietta in the east and Rashid in the west. Hot dry summers and mild winters prevail with relatively low, irregular, and unpredictable rainfall.

2a

2b

Fig 2a&b: Maps of Egypt showing the concentrated population and agriculture along the Nile valley and delta. *(Zeducorp, 2006)*

The inhabited area of the country constitutes only 4% of the total area of the country which is confined to the narrow strip of the Nile valley, from Aswan in the south to Cairo in the north. Its only source of water -the River Nile- provides more than 95% of all water available to the country. The source of this water comes from rainfall on Ethiopian hills (86%) and equatorial lakes (14%) (Eid, *et* al., 2007). The Nile delta is one of the oldest intensely cultivated areas on earth. It is very densely inhabited, with population densities up to 1,600 inhabitants per square kilometre; only (2.5%) of Egypt's land area, the Nile delta and the Nile valley, is suitable for intensive agriculture. Most of the 50 km wide land strip along the coast is less than 2 m above sea-level and is protected from flooding by a 1 to 10 km wide coastal sand belt only, shaped by discharge of the Rosetta and Damietta branches of the Nile.

This protective sand belt is facing rapid erosion, which has been a serious problem since the construction of the Aswan dam (Inman, *et* al., 1992), (Fanos, 1995), (Stanley J., 1996), (Stanley *et* al., 1998) & (Douglas, 2005). Rising sea level is expected to destroy weak parts of the sand belt, which is essential for the protection of lakes and the low-lying reclaimed lands. The impacts will be very serious as one third of Egypt's fish catches are made in these lakes. SLR will change the water quality and affect most fresh water fish, flood valuable agricultural land, and salinate essential groundwater resources. (Fahmy, 2007) Egypt is potentially one of the countries most at risk from the effects of SLR, as will be discussed.

The impact of SLR on environmental and socio-economic aspects in Egypt

From the World Bank (WB) report, Dasgupta has noted that Egypt is considered one of the top five countries expected to be mostly impacted with a 1-m SLR in the world (Dasgupta, *et* al., 2007). Several general analyses of the potential impact of SLR on the Nile delta coast have been carried out. As a result, areas of high vulnerability in the Nile delta and possible socio-economic impacts have been generally defined. These high-risk areas include parts of Alexandria and Beheira governorates, Port Said and Damietta governorates, and Suez governorate. In addition, several other smaller areas, such as those near Matruh governorate and north of Lake Bardaweel, have also been identified as risked zones. The effects of SLR on the environmental and socio-economical aspects of these areas are discussed in the following section (El-Raey, 2009).

3a

3b

3c

Fig 3 (a,b,c) Satellite maps of Nile delta, showing the potential impact of SLR with a- the occurring status in 2002, b and c - the coastal inundation with a 0.5 and 1m SLR.
(Simonett, 2002)

First: Environmental aspects affected by SLR

Water resources

Egypt is one of the African countries that has proved vulnerable to water stress caused by climate change. The water used in 2000 was estimated at about 70 km3 which is already far greater than the available resources (Gueye *et* al., 2005). Both water supply and demand are expected to be affected by climate change and SLR. A combination of salt water intrusion due to 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 unpredictable and it is difficult to expect whether rainfall is increasing or decreasing. The demand for water in Egypt is dominated by three major user groups: agricultural irrigation, domestic use, and industry. The agricultural sector consumes about 85% of the annual total water resource. It is therefore likely that any effects of climate change on water supply and demand will be dwarfed by a much larger increase in demand due to population growth (El-Raey, 1999)(El-Gindy, *et* al., 2001).

One of the most outstanding impacts of SLR on the water resources is that it will increase the occurrence of saline intrusion with contamination of groundwater resources in the coastal zone. The eastern part of Lake Manzala appears to subside at a rate of 4.5 mm yr^{-1}, (Stanley,*et* al.,1993) faster than any other region along the Nile delta coast. SLR is expected to cause a landward shift of the salt wedge and to increase the rate of saline seepage to the topsoil of the delta. This may have a serious impact on agriculture and drainage conditions, and potentially on available groundwater resources in the upper Nile delta. In addition, the salinity in Lake Manzala may increase because of the stronger influence of tidal flows penetrating the lake. Changes in the salinity conditions of the lake may affect its ecology and fisheries and the accelerated SLR will enhance the increase in salinity (El-Raey, *et* al., 1999).

As for the Nile Basin, it was found that there is no clear indication of how the Nile river flow will be affected by SLR, due to uncertainty in projected rainfall patterns in the basin and the influence of complex water management and water governance structures (Bates, 2008). Furthermore, it is important to mention that decrease of water resources might increase friction among countries sharing the same water resources (e.g. Nile and Euphrates), and might lead to political unrest (El-Raey, 1999).

Coastal Zones

Egypt's coastal zones constitute particularly important regions economically, industrially, socially and culturally. In addition to increased tourism activities, a tremendous move towards building new industrial complexes has always been in progress, particularly in the coastal zones. The coastal zones of Egypt extend for over 3500 km in length along both, the Mediterranean Sea and Red Sea coasts. The Mediterranean shoreline is most vulnerable to SLR due to its relatively low elevation. The coastal zone of Egypt is therefore particularly vulnerable to the impact of SLR, salt water intrusion, the deterioration of coastal tourism and the impact of extreme dust storms. This in turn will directly affect the agricultural productivity and human settlements in coastal zones (El-Raey, 2009).

Before construction of the High Aswan Dam, the Nile delta shore was in a fluctuating equilibrium between sediment supplied by the river and the transport along the coast. (Douglas, 2005). During the last decades, after the construction of the High Aswan dam, sediment input in the delta has been strongly reduced. This resulted in serious shore erosion and salt-water intrusion which changed the delta from river- to wave-dominated (Jelgersma, 2005) & (Ericson, *et* al. 2006). Currently, the Nile delta experiences erosion waves driven by the currents of the east Mediterranean gyre that sweep across the shallow shelf with speeds up to 1 m/s., Moreover, the construction of human-made waterways for irrigation and transportation has trapped an already depleted sediment supply to the Nile delta. This entrapment of sediment is a key contributor to coastal erosion and land loss occurring in the Nile delta and the Nile's two projections, Rosetta and Damietta (Inman, *et* al., 1992), (Fanos, 1995), (Stanley J., 1996), (Stanley *et* al., 1998), (El-Raey, 1999)

At present, erosion is a significant environmental problem affecting Damietta city's coastal zone, which has retreated more than 500m in over 10 years (1983 to1995) (SEAM, 2005). Erosion along the tip of the Damietta projection has adversely affected homes to the east at Ras El Bar. However, a number of protective structures have been constructed along this projection to reduce shoaling in the river entrance. Continuous SLR is expected to enhance rates of erosion of the northern coast and Nile delta (El-Raey, *et* al., 1999).

Second: Socio-economic effects of SLR

The coastal zone of Egypt suffers from a number of serious problems, including rapid demographic growth, land subsidence, excessive erosion rates, water logging, soil salination, land use interference ecosystem pollution and degradation, and lack of appropriate institutional management systems (El-Raey, 1999). In turn, this will affect the management and access to archaeological sites; reduce tourism, and result in socio-economic impacts on the inhabitants of these areas.

Population

Egyptian coastal population are undeniably exposed to the effects of SLR, with its accompanying flooding as the population is expected to double before the year 2050, if the present growth rate is maintained. SLR is expected to affect Egypt in many ways; with just a one-meter rise in the Mediterranean Sea, the Nile delta stands to suffer tremendously; 6.1 million people are predicted to be displaced and 4,500 square kilometres of cropland will be lost (Dasgupta, *et* al., 2007). A correspondingly rapid growth in agricultural and industrial output will be required to sustain this population. Loss of beaches will reduce the number of tourists in coastal areas, forcing tourism dependent individuals and communities to abandon their settlements and look for jobs elsewhere. This may probably lead to increased unemployment inducing political and civil unrest. Moreover, increased water logging and salinity may catalyse insect and pest problems causing health problems (El-Raey, 1999). Reducing vulnerability to such threats is a major challenge to sustainable development and land use strategies. Coastal defence engineering is costly, while managed coastal retreat implies sacrificing private property and usable natural resources (Jobbins, 2008).

In his pilot study, El-Raey used available land-use data and topographic and socio-economic data to calculate the approximate numbers of people expected to be affected by SLR in 2000, 2010, 2030 and 2050. Estimation of the socio-economic impact due to loss of land and jobs was performed and results of the impact on population and loss of employment for several affected cities were published. He has also estimated that a SLR of 0.5m in Alexandria will cause a displacement of almost 1.5 million people and the loss of about 200,000 jobs by the middle of this century (El-Raey, 1999).

In the World Bank Report, Dasgupta inferred that the absolute impact of SLR and intensified storm surges on coastal population will be particularly severe in Egypt with potential inundation risk for additional 2.67 million people. It was also noted that Egypt's population would be most severely impacted by SLR within the Middle East and North Africa region. With a 1m SLR, approximately 10% of Egypt's population would be impacted. Most of this impact takes place in the Nile delta which will have 20% of it affected with a 5m SLR (Dasgupta, *et* al., 2009).

Agricultural and Food Resources

In the Policy Research Working Paper published by the WB in April 2009, it was deduced that the large incremental impact of storm surges on "agricultural areas" in the Middle East and North Africa (MENA) region arises mostly in Egypt (326%) and Algeria (143%). The increase of impact on agricultural areas is significant for this region, mainly because Egyptian and Algerian cropland in surge zones would increase from the existing estimated 212 km2 to approximately 900 km2 with SLR and intensified storm surges. It was also noted that in the MENA region, the percentage increase in surge zones when compared to current surge zones is largest for Egypt (83.6%). The surge zones of Egypt will almost double as a result of SLR and intensified storm surges, increasing from (7.4%) of the coastal area at present to (13.6%) (Dasgupta, *et* al., 2009).

Another aspect which affects agriculture is that precipitation in Egypt is only significant in the northern Mediterranean coast, where average annual rainfall is roughly 180mm, and is extremely low in the rest of the country's desert territory as with the impacts of climate change, Egypt's climate is expected to get drier and warmer thus pressures on agriculture will definitely intensify (Abou-Hadid, 2006). Agriculture is restricted to the fertile lands of the narrow Nile Valley the flat Nile delta characterized by high-production agriculture, high urban water demands, and rapidly growing population. Water for irrigation, supplied entirely through the river Nile, varies due to changes in freshwater availability and to competition among water users (Leary, *et* al., 2008). Moreover, climate change will probably affect water resources requiring reduction in irrigation water and that might pose another problem for agricultural production (Eid, *et* al., 2007). Demand is expected to increase on crop yields, making the country more open to deficits in food production resulting from climate change.

Also, expected higher prices for food imported from developed countries will exacerbate the situation (El-Raey, 1999).

In summary, expected climatic change, population increase, urbanization and industrial development as well as irrigation intensification constantly increase water demand and can intensify the vulnerability of agriculture in Egypt (Abou-Hadid, 2006). Also, the increase of temperature and frequency of extreme events will reduce crop yield as well as causing changes in the agricultural distribution of crops. Furthermore, it will negatively affect marginal land and force farmers to abandon them increasing desertification and unemployment associated with loss of income consequently political unrest.

Gross Domestic Product

It was concluded in the report by the WB that Egypt's GDP would be significantly impacted by SLR. It has been ranked the third country in the world with affected GDP, with (6.44%) impact with a 1 m SLR. This is partly explained by the impact of SLR on Egypt's agricultural extent, as the agricultural sector plays a significant role in the Egyptian national economy, contributing about (20%) of the GDP. It supplies the overall food needs of the country and provides the domestic industry with agricultural row materials. Also, agriculture helps in financing economic and social development through the net capital outflow from agriculture to the other sectors of the economy. Indeed, most of the impact of SLR on the agricultural sector of the MENA region will take place in Egypt which wouldl experience a severe impact. It is expected that with a 1m SLR, approximately (12.5%) of Egypt's agricultural extent would be impacted; this percentage reaches (35%) with a 5m SLR. Its agricultural sector may thus experience severe disruption as a result of SLR and will negatively affect the GDP (Dasgupta, *et* al., 2007).

This is expected at a time when Egypt will in any case experience population pressures unless its birth rate falls dramatically. Livestock and fisheries are also vulnerable to the impacts of climate change; hence changes in climatic conditions and SLR will affect populations and various species differently. 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. Also, changes in the ecological system of lakes will reduce fish catches and drive away a large portion of fishermen and their dependants thus adding to the negative impacts of SLR on GDP (Palmer, 2008).

Urban areas

As for the urban areas affected; Egypt is ranked the fifth in the world concerning the biggest impact of SLR on the total urban areas, as noted by Dasgupta 2007. It has been mentioned that the impact reaches approximately (5%) with a 1m SLR, (6 to 7%) with a 2m SLR, and approximately (10%) with a 5m SLR (Dasgupta, *et* al., 2007). According to The WB report, the impact of SLR and intensified storm surges on specific urban centres of the developing world was examined and the top 10 major cities worldwide that are located in storm-surge zones were listed. Port Said city, Egypt, was found to be the first in the MENA region to be mostly affected.

Moreover, scientists predict the Mediterranean will rise by a range of 30 centimetres to one meter by the end of the century but still a one-meter rise in the level will possibly submerge Alexandria (Thomas, 2008b). This highlights the potentially deadly exposure of its inhabitants, since storm water drainage infrastructure is often outdated and inadequate in such low-income urban centres. The risks may be particularly severe in poor neighbourhoods and slums, where infrastructure is often nonexistent or poorly designed and ill-maintained (Dasgupta, *et* al., 2009). Generally, fundamental and low-lying installations in Alexandria and Port Said are threatened by SLR and the recreational tourism beach facilities are endangered of partial and even full loss.

National and International responses to the impacts of SLR on Egypt

The problem of climate change is being taken seriously by the Egyptian authorities. Low lying land in the Nile delta region is considered to be especially at risk from the effects of any SLR

resulting from global warming. In particular, the cities of Alexandria, Rosetta, and Port Said, which are major industrial and economic centres, are expected to experience serious environmental impacts, if no action is taken (El-Raey, 1999). In the coastal city of Alexandria, authorities are spending US$300 million to construct concrete sea walls to protect beaches from rising seas. Furthermore, Egypt's Ministry of State for Environmental Affairs (MSEA) is preparing a "National Strategy Study" on adaptation, including a vulnerability index to pinpoint the most endangered regions (Davis, 2007). Furthermore, The Egyptian Environmental Affairs Agency (EEAA) mentioned that several measures could be utilised to deal with the impact on the coastal zone corridor, including beach nourishment (deposition of sand onto the beach), construction of breakwaters, setting regulations to restrict development in vulnerable areas, changes in land use and Integrated Coastal Zone Management (ICZM), which embraces the general principles of environmental management adopted by United Nations Conference on Environment and Development (UNCED. (El-Raey, *et* al., 1999) (El-Raey, 2009)

The Egyptian government is taking several actions in cooperation with global communities to protect the risked areas and to decrease the effects of the climate change by serious research work and setting new environmental regulations (Fahmy, 2007). It has been stated that the Egyptian government had been working for the past 30 years on sea erosion reduction and shore protection measures, particularly by constructing dams in the Nile delta. Furthermore, institutional water bodies in Egypt are working to achieve targets by 2017 through the National Improvement Plan which aims to impede some of the negative impacts of SLR on water resources. It has planned to improve water sanitation coverage for urban and rural areas, develop wastewater management, and optimise the use of water resources by improving irrigation efficiency and agriculture drainage-water reuse (Bates, 2008).

According to El-Raey, who criticised that the contingency plans suggested by the government aim to protect the tourism industry in the first place but are not directly related to the impact of climate change and SLR. He stated that additional adaptation measures are needed to target climate change and that this will be less expensive for the tourism industry than losing the beach completely (Thomas, 2008a).He mentioned that for Egypt to mitigate and adapt to the effects of SLR, the Egyptian government will have to respond effectively to the following urgent needs; establishing a strong coastal monitoring, assessment and law enforcement system hence identifying and protecting vulnerable areas. In addition to the need for activating ICZM Committee and incorporating of the climate change component in the EIA, promoting awareness and community resilience, and creating new opportunities at safe areas (El-Raey, 2009).

Another evident action taken by the Egyptian government is the 10 Year Development Plan prepared for a number of governorates considering several crucial suggestions for mitigating and adapting to the expected SLR on Damietta governorate. It suggests stricter land use planning and management to mitigate the possible negative effects of development. It also encourages greater coordination between governorate bodies responsible for enforcing environmental policies, urban and developmental planning and regulations to improve the quality of

Fig 4 Sea barriers at Damietta, insufficient for combating the rising sea levels. *(Russmerritt, 2008)*

coastal protection measures and overall development. It also introduces measures to reduce coastal zone erosion such as; raising environmental awareness amongst governorate staff and private developers and developing an action plan to prevent erosion, managed by the Shoreline Protection Authority to protect Damietta's coastline from further erosion (SEAM, 2005).

Fig 5 Rising water levels in the Mediterranean Sea are causing the barriers that line Alexandria, Egypt's Eastern Harbour, to slowly break down.
(Hansen, 2008)

Fig 6 Bibliotheca Alexandrina, one of Alexandria's remarkable landmarks, endangered by SLR.
(Bibliotheca Alexandrina , 2005)

An article in the Middle East Times, by Joseph Mayton mentioned that experts warn that Egypt could be on the receiving end of a natural disaster of substantial proportions. Although numerous scenarios are being studied by scientists, two things appear certain in all of them: Alexandria, Egypt's second largest city on the Mediterranean Sea coast is expected to disappear and North Africa will be facing trouble for years ahead. The Egyptian Minister of State for Environmental Affairs, Maged George, stated to a parliamentary committee in Cairo that many of the towns and urban areas in the north of the Nile delta will suffer from a rise in the level of the Mediterranean with effect from 2020, and about 15 percent of delta land is under threat from the rising sea level and its seepage into the ground water. He said that joint studies by his ministry and the United Nations have assessed the situation is urgent, adding that Egypt is planning to start an international campaign to look for proper solutions (Thomas, 2008b). While a cost assessment for contingency measures has not yet been conducted in Egypt, the 2007 IPCC report advised that adaptation costs for climate change would be much lower than post-event expenses.

Under the provisions of the United Nations Framework Convention on Climate Change (UNFCCC), some work has begun on National Adaptation Programmes of Action (NAPAs). These are intended to facilitate the identification of priority activities, including adaptation to SLR, for the least-developed countries. To date however, only 8 countries have developed comprehensive NAPAs, unfortunately, Egypt is not amongst them. The adaptation science agenda is suggested to have two primary goals; one is to generate and provide scientific knowledge, working in partnership with decision-makers and other stakeholders that can be used to decide and implement vulnerability reducing adaptations. A second goal is to build capacity and partnerships for generating, evaluating, integrating, communicating, and applying knowledge for adaptation. The world has not previously faced a crisis on this scale, and planning for adaptation has to begin instantaneously.

Conclusion

The African continent is particularly vulnerable to the impacts of climate change because of factors such as widespread poverty, recurrent droughts, inequitable land distribution, and overdependence on rain-fed agriculture. Northern Africa's adaptation capacity is challenged as it comes in conjunction with high development pressure, increasing populations, water management that is already regulating most of available water resources, and agricultural systems that are often not adapted to local conditions. Limits to adaptation of socio-economic and agricultural systems in the North African region are evident in recent history. Although

adaptation options, including traditional coping strategies theoretically are available, in practice the human, infrastructural, and economic response capacity to effect timely response actions may well be beyond the economic limits of some countries (Watson, *et* al., 1997). Furthermore, the overall magnitudes for the developing world are sobering; within this century, hundreds of millions of people are likely to be displaced by SLR; accompanying economic and ecological damage will be severe for many. Also, the international resource allocation strategies needs to recognize that some countries will be little-affected by SLR, while others will be so heavily impacted that their national integrity may be threatened. Due to the scarcity of available resources in developing countries, allocated aid should respond to the degree of threat.

Adaptation plans are mainly focusing on increasing the adaptive capacity of the different systems, by changes in processes, practices, or structures to reduce climate risks (Watson, 2001). In developing countries, the priority of these plans is the high vulnerable systems to climate change. Therefore, the high vulnerability of the agricultural sector put it on top of the priority list of adaptation plans. Adaptation to climate change in Egypt is a major issue from the perspectives of food production, rural population stabilization, and distribution of water resources. Previous studies have addressed adaptation in a top-down approach, evaluating theoretical options with little relation to current agricultural management. There is a need to incorporate the value of the management knowledge for formulating adaptation measures for agriculture in a bottom-up approach as this is the major sector acutely skewed by SLR. However, to date, there is little evidence that the international community has seriously considered the implications for population location and infrastructure planning as a means of adapting to the impacts of SLR in many developing countries including Egypt (Dasgupta, *et* al., 2007).

Acronyms

EEAA	Egyptian Environmental Affairs Agency
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
GHG	Green House Gas
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
MENA	Middle East and North Africa
MSEA	Ministry of State for Environmental Affairs, Egypt
NAPA	National Adaptation Programmes of Action
RSLR	Relative Sea Level Rise
SLR	Sea Level Rise
UKCIP	United Kingdom Climate Impacts Programme
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change

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