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REVIEW ARTICLE

Climate Change Impacts, Vulnerabilities and Adaption Measures for Egypt's Nile Delta

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Abstract
During the last few decades there has been growing concern about the impacts of climate change. A significant number of institutions, research centers, universities and governments have funded projects in addition to work done by independent scholars and assessors studying this phenomenon, in particular, to identify vulnerability, mitigation and adaptation against associated risks. Egypt is among the international community which took part in numerous studies, research activities, conferences, seminars and meetings attempting to address climate change and its associated risks. Egypt is particularly concerned with the threat to the Nile Delta as it is considered a low-lying land at high risk. The aim of this paper is to review current and previous projects, technical reports and pilot studies, concerning risk assessments, mitigation, and adaptation strategies for climate change in Egypt. This, in turn, will aid in decision making regarding future funding and establishing of research related to climate change in Egypt. This paper will also highlight the weaknesses and strengths of policymakers solely relying on one or more of these studies.

Keywords Climate change · Egypt · Nile Delta · Vulnerability · Adaptation

1 Introduction

Climate change associated risks could pose serious threats to Egypt. Expected significant fluctuations in the River Nile flow, sea level rise (SLR) and temperature increases due to climate change are the direct threats that climate change poses on Egypt. These impacts will lead to a reduction in water supplies, loss of agriculture land, while higher temperatures could adversely affect Egypt's economy, ecosystems and human health. For more than two decades, Egypt has been conducting climate change studies. This includes the work by El-Raey et al. (1995) on vulnerability of coastal resources; Strzepek et al. (1995) on vulnerability of agriculture to changes in climate, water supply, and coastal resources; El-Shaer et al. (1996) and Eid et al. (2006) on the impacts of changes in climate on agriculture and crop production.

This paper aims to summarize the conclusions emerging from Egyptian impact assessments of potential threats as consequences of climate change. Its focus is to cover a broad range of the research conducted on climate change in Egypt, particularly concerning the Nile Delta since it is the most populated area and contributes to more than 50% of Egypt's agricultural land (FAO 2015). The Nile Delta was formed from sediments throughout the Holocene, with an average elevation of 1 m above mean sea level (MSL) (Becker 2008). Figure 1 illustrates the importance of the Nile Delta to the Egyptian economy as it reflects both sides of the Delta. It is an agricultural land but the night satellite image of the Delta reflects the fact more than 50% of Egypt's inhabitants (excluding Cairo residents) are living in the Nile Delta (Van der Most et al. 2009). The Mediterranean Sea bounds the Nile Delta from the north with a coast of 250 km in length extending from Alexandria to Port Said from west–east, respectively, which is characterized by its low-lying land with large urban centres, industrial companies, agriculture lands and tourism activities. It has five main coastal lakes: El-Mallaha, Manzala, Burullus, Idku, and Maryut (east to

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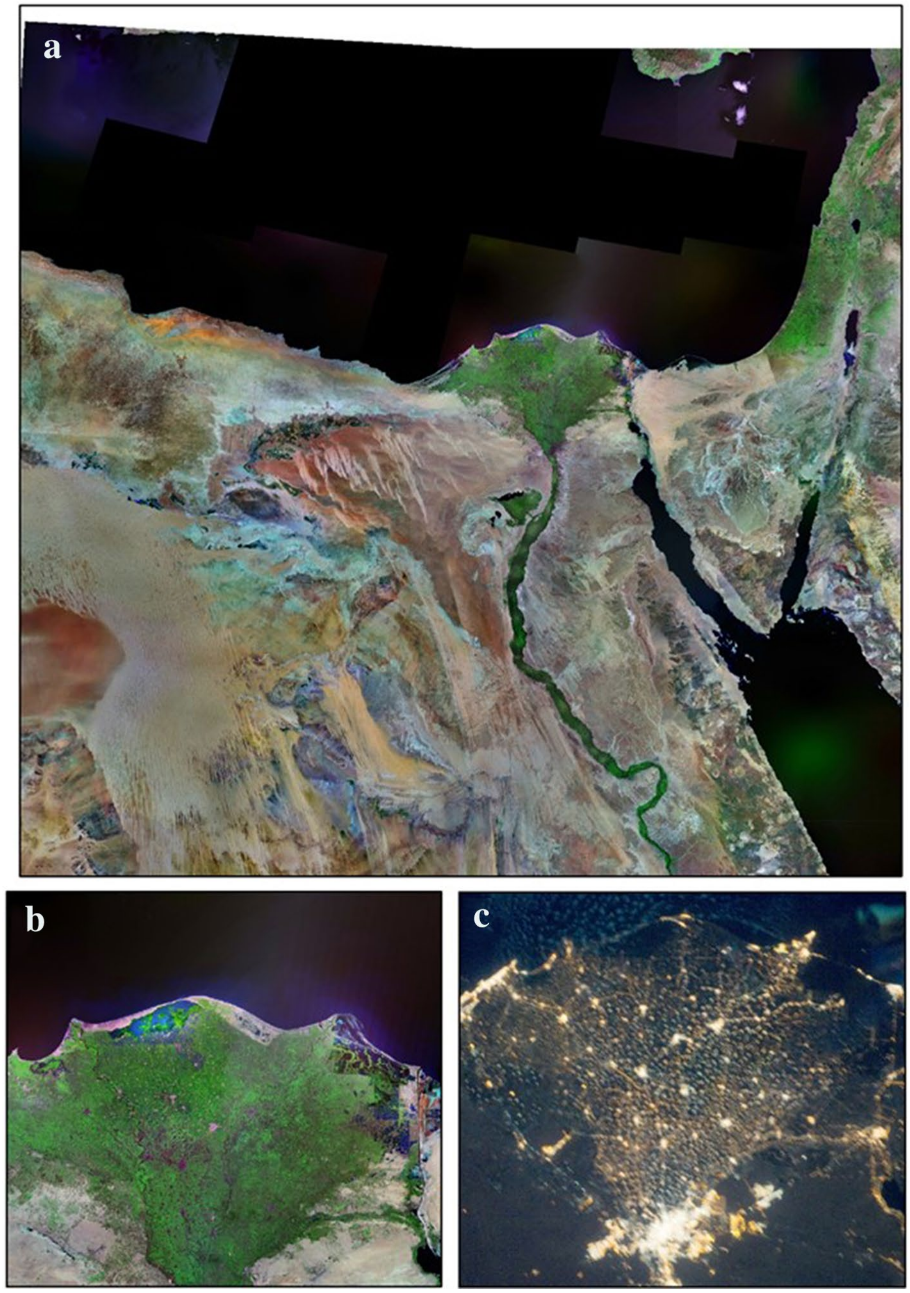

Fig. 1 **a** Landsat mosaic image of Egypt, **b** landsat mosaic of the Nile Delta and **c** night image taken by astronauts from NASA international space station

west) which all contribute more than one-third of the country's fish production (GAFRD 2010). Moreover, it has four main fishing harbors: Idku, New Burullus, El-Gamil and Port Said Fishing Port and six commercial ports: Alexandria, El-Dekheila, Damietta, Port Said and Port Said East Ports. The Delta's wetlands represent approximately 25% of Mediterranean wetlands area (Dorgham 2011). This paper will cover three main subjects, namely (1) climate change impacts, (2) vulnerability, and (3) adaptation and mitigation studies. Each section will summarize studies covering different aspects such as agriculture, fisheries, industry and socio-economics.

2 Climate Change Impacts

Egypt is one of the top countries expected to be affected by a 1 m SLR due to global warming (Fig. 2) which could inundate its coastal areas (Batisha 2012; Hassanin 2010). Egypt's Gross Domestic Product (GDP) could be significantly affected because of the sensitivity of its natural resources to climate change. Moreover, land subsidence in the Delta coastal region worsens the effects of SLR impacts. It would exert an environmental crisis such as storm surges and coastal flooding leading to shoreline

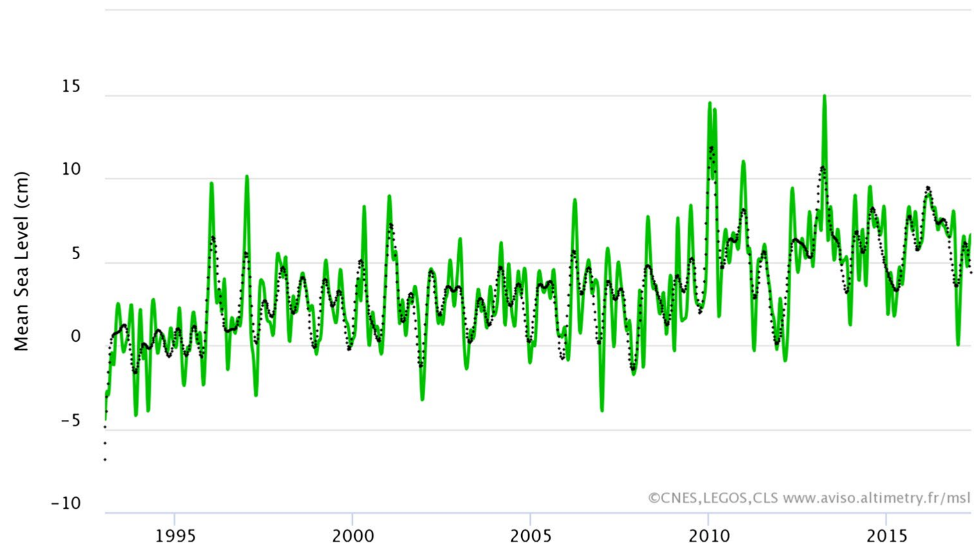

Fig. 2 The Mediterranean Mean Sea Level from the altimetry data (https://www.aviso.altimetry.fr/index.php?id=1599)

erosion, saltwater intrusion, land inundation and soil salinity (El-Raey et al. 1995; Hassanin 2010). This section summarizes the investigated current and potential impacts on agriculture, water resources, fisheries and socio-economic sectors.

The Intergovernmental Panel on Climate Change (IPCC) indicates that the primary cause for SLR is the thermal expansion of ocean waters due to glaciers melting resulting from increased greenhouse gas emissions (IPCC 1990). The mean global SLR estimated over the twentieth century was 1–2.5 mm/year (Brochier and Ramieri 2001), and from 1950 to 2000 was 1.8 ± 0.3 mm/year (Church et al. 2004). Analysis of oceanographic satellite (Topex/Poseid) data between 1993 and 2000 revealed a mean global SLR of 2.5 ± 0.2 mm/year (Cabanes et al. 2001; Cazenave et al. 2003). IPCC (2007) reported a global SLR between 1961 and 2003 with an average of 1.8 mm/year, while between 1993 and 2003; a higher rate was recorded of 3.1 mm/year. The Mediterranean SLR during the twentieth century is in line with the global SLR of 0.5–2.5 mm/year. However, this trend is not consistent throughout the whole period, i.e., it follows two different directions. From the end of the 19th century to 1960, it shows higher values than the overall trend while from 1961 to the end of the twentieth century it is consistent with the overall trend (Micha and Michal 2009). Sea level rise is the pervasive climate change impact threatening the northern Nile Delta region. In Rashid it could lead to more death of palm trees, accelerate the weathering of the buildings and historical archaeological sites and alter the ground water table levels which could lead to building and infrastructure inclination and collapse (Zaid et al. 2014). Inundation of coastal areas will result in the loss of low-lying lands, mainly agricultural and urban areas. With no mitigation and adaptation plans in place, it will affect coastal infrastructures and populations (Khafagy et al. 1992; Stanley and Warne 1993; El-Raey 1997; Ericson et al. 2006; Elsharkawy et al. 2009; Mervat and Yasser 2016).

The World Bank (2007) reported that 6.1 million coastal inhabitants could be immigrated, 4500 km^2 of cropland would be lost, which will result in Egypt GDP loss of 6% for 1 m SLR and 16% in case of 5 m SLR. Port Said tourist facilities are at risk due to their proximity to the coast. Valuable archeological places of the northern part of Suez Canal are also at risk. El-Raey et al. (1999) quantified the economic damage in Port Said as over $2.0 billion in the case of 0.5 m SLR and might exceed $4.4 billion in the case of 1.25 m SLR scenario. About 28,000–70,000 people will be immigrated, and 6700–16,700 jobs will be lost for 1.25 m SLR. For SLR scenario of 0.5 m, industry will lose about $25 million or $50 million in the case of 1.25 m, while agriculture loss will be approximately $4 million in SLR scenario of 1.25. The southwest region of Port Said is approximately 1 m above MSL, therefore, a rise in sea level of 1.25 m will affect it. While in Alexandria, local authorities expense in constructing sea walls for shoreline and beaches protection against SLR is $300 million a year (El-Raey et al. 1999).

Global warming due to increases in greenhouse gas emissions (especially CO_2) leads to an increase in temperature and change in precipitation patterns (Jonathan and Brian 2017). Temperature and CO_2 are the two most important factors playing a critical role in the plant life cycle. According the law of the minimum, growth is limited by the scarcest resource (limiting factor) (Salisbury 1992). As CO_2 concentrations increase so temperature increases, leading to greater water demand as water loss increases due to evaporation and crop water requirements. Water is a limiting factor in Egypt as the Nile flow is expected to fluctuate at all scenarios for temperature increase (Agrawala et al. 2004).

The River Nile supplies 95% of Egypt's water (Vella 2012). Accurate predictions of the Nile flow under climate change conditions are needed and have to consider interactions between temperature, precipitation and evaporation (UNESCO 2004; Conway 2005). Elshamy et al. (2009) and Kim and Kaluarachchi (2009) estimated a change of + 4% and − 15% with spreads between − 60% and + 80%, respectively, for the upper Blue Nile flow, which contributes 60% of the Nile flow. It became apparent that natural variability of rainfall would increase the frequency and strength of floods and droughts as well as rainy season shifts (McSweeney et al. 2010). Rainfall contributes 3.5% to Egypt's freshwater supply (Elsaeed 2012); changes in the tributary streams of the Nile (Ethiopian highlands and equatorial lakes) directly influence the Nile flow and thus affect Egypt's water supply (Agrawala et al. 2004). Although precipitation trends are not clear, predictions suggest a non-significant decline in annual mean precipitation. De Wit and Stankiewicz (2006) attributed the sensitivity of the Nile flow to the low discharge of the river combined with high evaporation rates.

Egypt is overpopulated with a growth rate of 2.3%. Most of the population is concentrated in only 4% of the country's land, leading to an average population density of 1435 people per km^2. With the limited possibility of developing new areas as desert reclamation projects have been of limited success, rapid population growth worsens this problem, leading to an increase in urbanization and unemployment, especially among young people. Moreover, settlements require large amounts of water for sanitary purposes but their economic viability is unclear. The unemployment rates among men and women are 8.9 and 23.6%, respectively. The high unemployment rates bring severe social inequalities and worsen the climate change consequences (CAPMAS 2016).

Egypt's current development plans will magnify the increasing pressure on land and water resources. Water shortages weaken the agriculture production system and make it less viable, particularly due to the large share of irrigated and intensive crop production in the new agriculture projects in the country (Lonergan and Wolf 2001). This is also influenced by decreasing crop yields and increasing crop water demand. According to Eid et al. (2006), rice production could be reduced by 11%, soybeans by 28%, maize by 19% and barley by 20% by 2050 as a consequence of climate change, while increases in cotton and seed yields are possible. At the same time, considerable shares of agricultural land in the Nile Delta might become unusable due to submergence or salt-water intrusion caused by SLR. This reduction in agriculture land will increase unemployment rates and the immigration to larger cities. A large percentage of the population inhabit coastal cities like Alexandria, and potential social tensions could arise, related to lack of prospects, water and sanitation conditions in slums within such cities (United Nations 2010). The larger urban environments can also become the setting for conflict, brought in from the rural areas (Maninger 2000). An example is Cairo, situated in one of the most fertile areas of Egypt; the expandable city growth intensifies a constant conflict between agricultural land use and possible improvements of living conditions in the city. Climate change impacts on agriculture threaten the country's food security given that Egypt produces only 60% of its food and only 40% of its grain requirements (Racha 2015). During the so-called "world food crisis" in 2008, Egypt was among the countries facing demonstrations as people were unable to afford basic daily needs and food supplies (Schneider 2008). Climate change could force the country to import even larger quantities of food to ensure the provision of the population, which would require good economic standing and a source of foreign income. Using food trade as a facilitator of cooperation could be an incentive for collaboration with the other Nile riparians. Another potential for societal tension could arise from possible adaptation measures to decreasing water availability. Adaptation has to entail water saving measures, especially in the agricultural sector, but also inter-sectoral reallocations, leading to shifts in the labor force needed in large-scale agriculture activities, thus affecting poorer farmers who cannot compete for water and do not have good enough qualifications to find work elsewhere (Wichelns 2002). Conflicts between the different economic sectors are also possible, particularly when a developing industry demands more water, which would be a source of water pollution, or if water usage for the agriculture sector is reduced as it can be used more efficiently elsewhere. Currently, the cost of water in Egypt is heavily subsidized and in the case of implementing a water pricing policy, unrest could occur (Abou-Ali 2003). Overall, to address water scarcity, a clear strategy and water policy are needed (Mason 2004). Crop simulation studies indicate a national decrease in production of all crops with the demand for water up by 16% (Eid and El-Sergany 1993; Eid et al. 1993). El-Shaer et al. (1996) predicted a 20% loss to a complete crop failure in the Upper Egypt regions under a warmer scenario. Climatic change, overpopulation, rapid growth rate, urbanization, industrial development and irrigation intensification increase water demand and magnify vulnerability of agriculture in Egypt. A study carried out by Abou-Hadid (2006) reported that the extreme events frequency will increase as temperature increase which in turn will destruct the crop distribution and production as well. In the case of this situation farmers may be forced to abandon their lands resulting in many socioeconomic and political consequences. As temperature increases, waterlogging and salinity may increase insect and pest infestations, increasing the risk of health problems (El-Raey et al. 1999) and catalyzing the spread of parasitic diseases. Climate change could significantly affect parasitic diseases transferred via intermediate hosts (Beugnet and Chalvet-Monfray 2013).

Significant evidence indicates that global warming plays a critical role in shifting species ranges worldwide, including vector and reservoir infectious disease species (Parmesan 2006). Climate change direct impacts on health may catalyze the spread of many parasitic diseases, physiological disorders, skin cancer, eye cataracts, respiratory ailments, heat stroke, and other heat related problems. The Egyptian Environmental Affairs Agency (EEAA 2013) pointed out that there is a lack of detailed studies containing comprehensive estimations and causations and climate change impacts on human health.

Many studies demonstrated climate change impacts on human health. Global warming affects the temporal and spatial allocation of disease hosts, which would influence the growth and breeding of these parasites (McCarthy et al. 2001). Climate change may extend certain seasons and related activities, which might result in crop exposure to new insects and pests (Singh et al. 2011). Disease prevalence towards the north could then be probable as the northern countries became warmer, disease hosts spatial distribution will extend to the north, encouraging pathogens reallocation (Shoukry and Morsy 2011). Tanser et al. (2003) predicates by 2100 a possible increase of 5–7% in the distribution of malaria and risk of exposure (person-months) of 16–28% as an overall increase. It also may lead to the reappearance of malaria in areas with insufficient health infrastructure (El-Bahnasawy et al. 2011). Temperature increase may lead to the spatial expansion of *Anopheles gambiae* to the south of Egypt. Moreover, additional implications may exist due to the presence of *Anopheles sergentii* in Toshka and Aswan (Douglas et al. 2012). Meanwhile, south of Egypt and north of Sudan land reclamation projects may take part in the expansion of anopheline towards the north (Shoukry and Morsy 2011). Slater and Michael (2012) applied ecological modeling for the potential future distribution of Lymphatic Filariasis effects on population expansion and density across Africa under climate change. They reported that 543–804 million inhabitants will be at risk of Lymphatic Filariasis and might increase to between 1.65 and 1.86 billion in 2050 accordingly to the change scenarios.

3 Climate Change Vulnerability

How is Egypt vulnerable to climate change? Before jumping to answer it might be useful to define what does vulnerability mean? Vulnerability is the state of the openness of the system to disturbances or stresses, i.e., the extent to which climate change may alter it. Vulnerability is a function of the system's sensitivity and the adaptation capacity to new conditions. Sensitivity measures how the system will respond to any new circumstances and the degree, to which it can adjust, and system processes or structures in place to the anticipated or actual changes (Kasperson and Jeanne 2001). According to the IPCC (2007), adaptation is a measure to diminish the climate change impacts on the surroundings and personnel. In climate change studies the term impact assessment is very important. It refers to a site specific practical measures of the expected climate change influence. Impact assessment requires future expectations and baseline information (Rivero 2008). Actions and measures lead to unexpected negative effects or increase vulnerability of climate change is referred as maladaptation. Although, it may benefit one group or a generation but it has negatives impacts on others. Implementation of adaptation strategies and plan without the consideration of the development plans is one of the maladaptation causes (Barnett and O'Neill 2010).

Two main reasons make Egypt vulnerable to climate change. Firstly, the Nile flow is sensitive to the amount of rainfall and variations in temperature. Temperature change affects rainfall and predictions suggest that climate change will take the form of fluctuations in levels of precipitation resulting in changes in temperature. This will result in the Nile flow suffering from moderate to extreme fluctuations, with the latter scenario most likely in the long term. Secondly, the Nile Delta is vulnerable to the impacts of storm surges and SLR resulting from climate change, particularly the relatively low elevation areas in the Delta (Batisha 2012). Sea level rise and intensified storm surges could cause severe impacts on the lower Nile Delta, parts of Alexandria and Port Said in terms of inundation, soil salination of the low-lying lands and erosion of coastal barriers (Eldeberky and Hünicke 2015). Sensitivity to climate events is demonstrated by the severe storms which struck Egypt's Mediterranean coast in recent years (December 2003, 2010, January 2011 and October 2015). These caused coastal flooding with a surge exceeding 1 m above MSL, which is much higher than the typical values reported for storm surges off the Nile Delta coast (0.4–0.5 m). This led to limited damage to some coastal structures and moderate flooding of the Nile Delta lowlands. This puts into perspective how sensitive Egypt's coastal cities are to climate change (Deabes 2003; Frihy and El-Sayed 2012). Areas vulnerable to inundation could be categorized based on topography, subsidence rate, SLR, coastal barriers, protection and groundwater levels. Eldeberky and Hünicke (2015) identified the lowland of southeast Alexandria, the southern zone of Port Said, Burullus and Manzala Lakes barriers and Ras El-bar shoreline as more vulnerable to SLR and coastal inundation.

As the largest port cities, Port Said and Alexandria are most vulnerable to SLR. Alexandria is ranked 11th worldwide regarding population exposure to coastal flooding risk by the 2070 s due to SLR and storm surges (Hanson et al. 2011), while Port Said would be most affected in North Africa and the Middle East (Dasgupta et al. 2009). Land subsidence also threatens the Nile Delta lowlands, which could increase the impacts of SLR. Wöppelmann and Marcos (2012) observed subsidence rates at Alexandria of −0.4 ± 0.2 mm/year and higher rates seen in the eastern part of the Delta, while Frihy (1991, 1992) based on tidal gauge records found the rate of subsidence of −2 mm/year at Alexandria and −2.4 mm/year at Port Said. The eastern part of Lake Manzala has the fastest rate of land subsidence along the Nile Delta coast, which will have severe impacts on agricultural activities, drainage conditions, and available groundwater. Furthermore, the tidal flow entering the lake will increase salinity, possibly affecting lake ecology and fisheries (El-Raey et al. 1999).

Archaeological evidence indicates a general trend along the Egypt Mediterranean coast of land subsidence with values ranging from −0.4 to −5 mm/year (Emery et al. 1988; El-Sayed et al. 1993), which is in agreement with dated core sections (Stanley 1990; Stanley and Warne 1993). A diverse range of subsidence rates were determined in the Nile Delta: −3.98 mm/year (Stanley and Goodfriend 1997), −4 to −5 mm/year (Stanley and Toscano 2009), and −2 to −8 mm/year (Becker and Sultan 2009). Tidal gauge data analysis revealed that SLR rate ranged from 1.8 to 4.9 mm/year (Frihy et al. 2010), and by 2100 the sea level is expected to rise by 1 m in the Nile Delta coastal zone (Dasgupta et al. 2009). For the shoreline retreat, Frihy (1992) predicts values of 294, 441 and 734 m, corresponding to SLR scenarios of 0.50, 0.75 and 1.25 m, respectively. Alexandria would lose 30% of its area due to flooding in the 0.5–1 m SLR scenario (Batisha 2012).

Zaid et al. (2014) reported that some archaeological and economic places along the Mediterranean coastal area, viz. Alexandria, Beheira and Damietta are very vulnerable to climate change impacts. The study concluded that Beheira is moderate to high; Damietta is low to moderate while Alexandria is the most vulnerable to SLR. In these cities, more than 4 million people is subject to reallocation and 0.5 million may lose their jobs. Moreover, damage will occur to the most famous priceless historical, cultural and archeological sites, resulting in a loss of tourism income.

4 Climate Change Adaptation and Mitigation

Adaptation is the actions and measures that take place in the favor of vulnerability reduction of a system contra the expected climate change effects (IPCC 2007, 2014). Therefore, it is suitable to summarize some of the existing international measures. Many detailed guidelines address planning; awareness requirements for adaptation are exist. Among these are the 1999 UN Framework Convention on Climate Change (UNFCCC 1999) outline, the International Council for Local Environmental Initiatives (ICLEI 2007; USAID 2009) dealing specifically with coastal adaptations to climate change, Shaw et al. (2007) practical perspective for climate change. UNFCCC (2005, 2008) updated outlines on adaptation tools and methodologies. Regarding Egypt in 1997 the Ministry of Environmental Affairs released a "national strategy study" on adaptation measures/tools; in the form of an index with a value ranged from 0 to 10 to point out the most vulnerable areas where 10 is the most resistant (Arab Republic of Egypt 1999).

For the first time in 1999, Egypt highlighted its required adaptation plans and for actions climate impacts and vulnerabilities in the Initial National Communication then updated it in the Second National Communication in 2010 (Arab Republic of Egypt 2010b). The content of the Initial National Communication was a result from research done between 1995 and 1999 that includes agricultural and water resources vulnerability; adaptation to SLR; and evaluation of the technologies implemented in the action plans (Arab Republic of Egypt 1999). This formulated Egypt climate change action plan.

The focus of Egypt plan was to create a greenhouse gas emissions inventory for different sectors; prioritizing policies and measures for emissions reduction; and socio-economic impact assessment of these measures; however, adaptation needs were not addressed in the Initial National Communication (Arab Republic of Egypt 1999). In 2009, the National Center for Climate Change (NCCC) was established to regulate the multi-institutional implementation of the adaptation plans and strategies. In 2010, a Second National Communication to the UNFCCC was released which pointed out sectors that are vulnerable to climate change. It also proposed intersectoral policies and actions that could benefit the adaptation efforts. Accordingly, Egypt's National Environmental, Economic and Development Study (NEEDS) for Climate Change was published, discussing measures for adaptation and mitigation, policies and strategies; the associated socio-economic cost; as well as prioritizing mitigation and adaptation actions. Moreover, NEEDS highlighted some adaptation priorities, particularly focusing on agriculture and coastal zone management (Arab Republic of Egypt 2010a). In this context, the national committee for Integrated Coastal Zone Management was established to address the potential impacts on coastal areas. It identified three top priorities for the Nile Delta, viz. water quality, shoreline changes and urbanization. A National Integrated Coastal Zone Management Strategy is also being developed, including: (1) upgrading the adaptive capacity through the establishment of institutional monitoring systems, creating a database, and increasing awareness; (2) in the planning stages and enforcing regulations for follow-up, adopting a no regrets policy; (3) conducting research regarding renewable energy, halophytic plants, and the process of desalination; and (4) considering geo-engineering activities for protection against SLR (El-Raey 2010). Through the implementation of the National Water Resources Plan (2005) Egypt could reduce the vulnerability to future water shortages by: improving the irrigation system; redesigning canal cross-sections to reduce evaporation; improving drainage; and resolving conflicts between users (Arab Republic of Egypt 2010a). Other sectors identified as being vulnerable to climate change include coastal resources, tourism, health and agriculture and food security, as identified in Egypt's National Communication (Arab Republic of Egypt 2010a). The country has also identified the following cross-sectoral actions that would contribute to the adaptation efforts (Zubrycki et al. 2011):

- Public awareness;
- The use of circulation models for predicting climate change impacts on water resources on both local and regional scales (i.e., within Egypt and the Nile Basin);
- Capacity building of researchers in all fields of climate change;
- Facilitating data and information exchange between Nile Basin countries; and
- Enhancements of precipitation measurement network in Egypt and upstream countries as well as the installation of modern early warning systems.

Egypt's NEEDS for climate change built on the work of the country's second national communication, identifying specific adaptation needs for the agricultural sector and coastal zones. These include agriculture; irrigation; socioeconomic studies; capacity building and training initiatives; and land and agricultural production. In the coastal areas, the report identifies institutional cooperation, capacity building, modeling, research, plan implementation, coral reef protection, and extreme events protection measures (Arab Republic of Egypt 2010b). Furthermore, the policy elaborates on some priority adaptation projects in these areas.

5 Conclusion

Climate change would increase temperature and reduce rainfall amounts. The significant climate change impacts on Egypt seem to be the fluctuations of the water flows in the River Nile and inundation of the coastal areas due to SLR. The Nile flow is sensitive to rainfall and temperature changes. It would reduce by 68% with a temperature increase of 4 °C. Significant uncertainty remains regarding exactly how climate change will affect the flow of the River Nile. Sea level rise also puts the Nile Delta at risk, a situation worsened by the continuing (non-climate change related) subsidence of the surrounding land (Arab Republic of Egypt 2010a). Economic projections suggest that damage caused by natural disasters and climate change related impacts between 2010 and 2030 in Alexandria could be as high as US$ 1.72 billion (in net present value), of which 18% may be directly related to climate change impacts (World Bank 2011).

Uncertainty surrounding the Nile flow indicates that any discussions on the impacts of climate change in Egypt need to take into account three scenarios: lower Nile River flow, higher flow, and unchanged high variable flow (Link et al. 2012).

There is a need for Egypt to develop new crop cultivars adapted to higher temperatures. Growing high yielding cultivars in suitable agro-climatological regions and sowing at the right time will increase crop production, thereby reducing the impact of climate change (El-Shaer et al. 1996).

Although many projects have focused on Egypt's adaptation policy, there are still gaps to fill. These shortcomings relate to the implementation of different strategies, time frames and who takes responsibility for funding and implementing. Some of these shortcomings are listed as follows:

- No clear implementation for the adaptation plan identified for health, although the risk is scientifically identified in the National Strategy for Adaptation to Climate Change and Disaster Risk Reduction developed in 2011;
- No integrated multi-sector plan;
- Lacks specific methodology for the implementation of the plans; and
- Lacks a performance management component.

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