Chapter 6
Egypt: Land Degradation Issues with Special Reference to the Impact of Climate Change

Kh. Darwish, M. Safaa, A. Momou, and S.A. Saleh

Synopsis A general survey of the land degradation issues that affect Egypt from the arid regions of the south and east to the coastal zones along the Mediterranean and Red Sea coast. Land Degradation in the agricultural zone east of the Nile Delta is examined. The potential effects of climate change on the coastal zone of Egypt provides the principal focus. Mitigation and adaptation measures are outlined.

Key Points

- Only 4 % of Egypt is arable, most of it along the floodplain of the Nile but two other important zones exist. The area east of the Nile Delta and the El Fayoum Depression. Land degradation is a risk to the limited areas of cultivated land. The complex ecosystem of the Nile, which has nurtured civilizations for millennia, has already been deeply affected in the last 60 years by the construction of the High Dam in the southern city of Aswan. The giant project managed to regulate the often devastating effect of the Nile's yearly floods, but it also deprived lands of crucial nutrients and minerals.
- The dominant feature of Egypt's Northern Coastal Zone is the low lying delta of the River Nile, with its large cities, industry, agriculture and tourism. The Delta and the narrow valley of the Nile comprise 5.5 % of the area of Egypt but over 95 % of its people of which 25 % live in the Low Elevation Coastal Zone (LECZ) areas. In this context, the Nile Delta and Mediterranean Coast includes 30–40 % of Egypt's agricultural production, half of Egypt's industrial production, mainly in Alexandria, Damietta and Port Said.
- Due to the concentration of much of Egypt's infrastructure and development along the low coastal lands and the reliance on the Nile delta for prime agricultural land, coastal inundation or saline intrusion caused by anthropogenic climate change induced sea-level rise will have a direct and critical impact on

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Egypt's entire economy. Observations confirm that sea-levels are already rising in the Nile delta due to a combination of factors including coastal subduction and reduced sediment loads due to the construction of the High Aswan Dam upstream. Land subsidence is currently estimated at 1–5 mm/year.

- The coastal zone of Egypt extends for more than 3,000 km and is the home for 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. 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 salinization, 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.
- 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. Its only source of water, the River Nile, provides more than 95 % of all water available to the country. The source of this water lies far to the south, from rainfall on Ethiopian hills (86 %) and equatorial lakes (14 %). Most of the population of Egypt (over 60 million people in total) is associated with the agricultural sector which constitutes 20 % of gross national products and consumes about 80 % of the water budget.
- Egypt is taking the issue of climate change seriously. The Nile Delta and coastal zones are prone to flooding due, in part, to rising sea levels. Climate change will potentially negatively affect agricultural productivity as a result of increased average temperature. Human health is also at risk due to climate change. The increased temperatures might lead to the outspread of vector-borne diseases. Coral reefs are one of Egypt's natural resources that climate change adversely affects. Egypt seeks the help and support of the international community to mitigate the impact of climate change.

Keywords Sea level rise • Climate change • Tourism • Population pressure • Irrigation • Land reclamation • Desert research Center • Wind power • Nile River • Nile Delta • Sea water incursion • Aswan dam • Lake Nasser • Oasis • Temperature rise • Rangelands • Biodiversity • Desertification • Salinity • Sodicity • Sudan • Libya • Israel • Mediterranean Sea • Red Sea • Gulf of Suez • Gulf of Aqaba • El Fayoum • Sinai Peninsular • Cairo • Alexandria • Rosetta • Lake Moeris • Coastline

1 Geography of Egypt

Egypt covers an area of approximately 1,001,450 km^2 and is bordered by Israel, the Gaza Strip, in the north-east, the Red Sea in the East; Sudan in the south; Libya in the west; and the Mediterranean sea coast in the north. Egypt is the third most populous

country in Africa, the 30th largest country in the world and the most populous in the Middle East. The Red Sea, the Gulf of Suez, and the Gulf of Aqaba to the east endow the country with a coastline stretching over 3,000 km in all. The majority of the 80 million people live on, or near, the banks of the Nile River. Only 5.5 % of the total land area is actually used by the population,– the area that borders the Nile River as well as a few oases, the other 94.55 % being uninhabitable desert. The Nile river virtually bisects the desert and the area to west is known as the Western desert or the Libyan desert, with the area to the east, as far as the Red Sea being called the Eastern desert. The Libyan Desert is characterized by massive sand dunes and eight great depressions. The desert itself is sparsely inhabited with relatively small population centers growing up around oases, notably the El Fayoum (see below).

The highest elevations in Egypt are in the southern part of the country. The southern regions of the Sinai Peninsula are also mountainous. Temperatures in most of Egypt range from 26–30 °C in summer and from 12–20 °C in winter. The Mediterranean coast enjoys a cooler temperature in comparison to the rest of the country. Frequent dust storms called 'Khamaseen' blow south–north in summers. Rainfall is scanty and unpredictable. The higher elevations in the Sinai Peninsula face snowfall occasionally in winters. Most of Egypt is an arid desert with little or no vegetation. The Nile, the longest river in the world, flowing from the south to the north, cuts through this desert plateau and renders the county habitable. In fact, the Nile endows its delta with fertility unheard of in desert regions. The river Nile is fed by the White Nile, the Blue Nile and the Atbara rivers of central Africa. The Nile enters Egypt near Wadi Halfa in Sudan.

Lake Nasser to the south of Egypt is a man-made reservoir resulting from the construction of the Aswan Dam across the Nile. The Aswan Low Dam was constructed at the First Cataract of the Nile in 1902. The High Dam was constructed between 1960 and 1970. The region extending from the Aswan Dam to the city of Cairo is referred to as the Nile Valley. The region further up north is the Nile Delta (see below). Low-lying, flat, and rich in silt deposits, the Nile Delta's agricultural products support the entire country. The Nile is said to have had seven distributaries creating the fan-shaped valley. At present only two of these distributaries, the Damietta and the Rosetta carry the Nile waters to the Mediterranean Sea.

2 Agro-ecological Zones and Land Use

Egypt, with land extending over one million square kilometers under arid and hyper-arid climatic conditions, is endowed with varied agro-ecological zones with varied and specific attributes of resource base, climatic features, terrain and geomorphic characteristics, land use patterns and socio-economic implications (Fig. 6.1).

The zones could be identified as follows:

1. North Coastal Belts: Including North West coastal areas and Northern areas of Sinai.

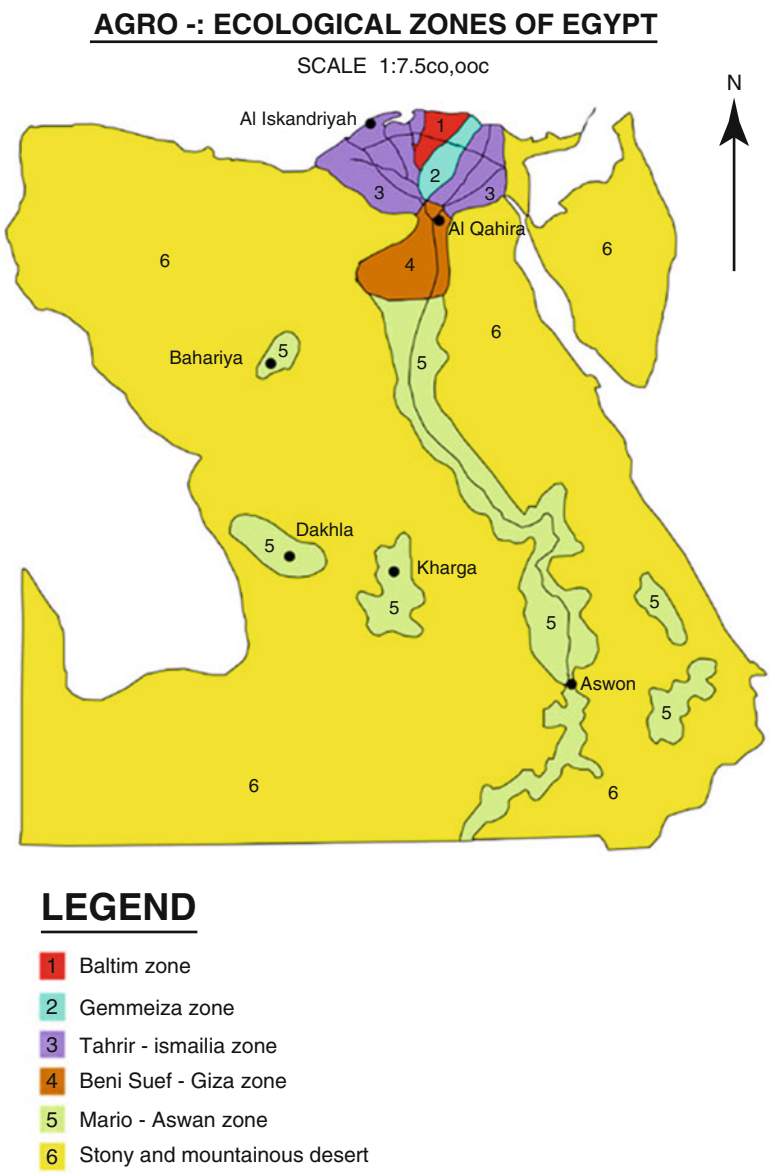

Fig. 6.1 Agro-ecological zones in Egypt

2. The Nile Valley: Encompassing the fertile alluvial land of Upper Egypt, the Delta and the reclaimed desert areas in the fringes of the old Nile valley.
3. The Oases and Southern Remote Desert Areas: Including Uwienate, Toshki and Darb El-Arbien Areas and Oases of the Western Desert.

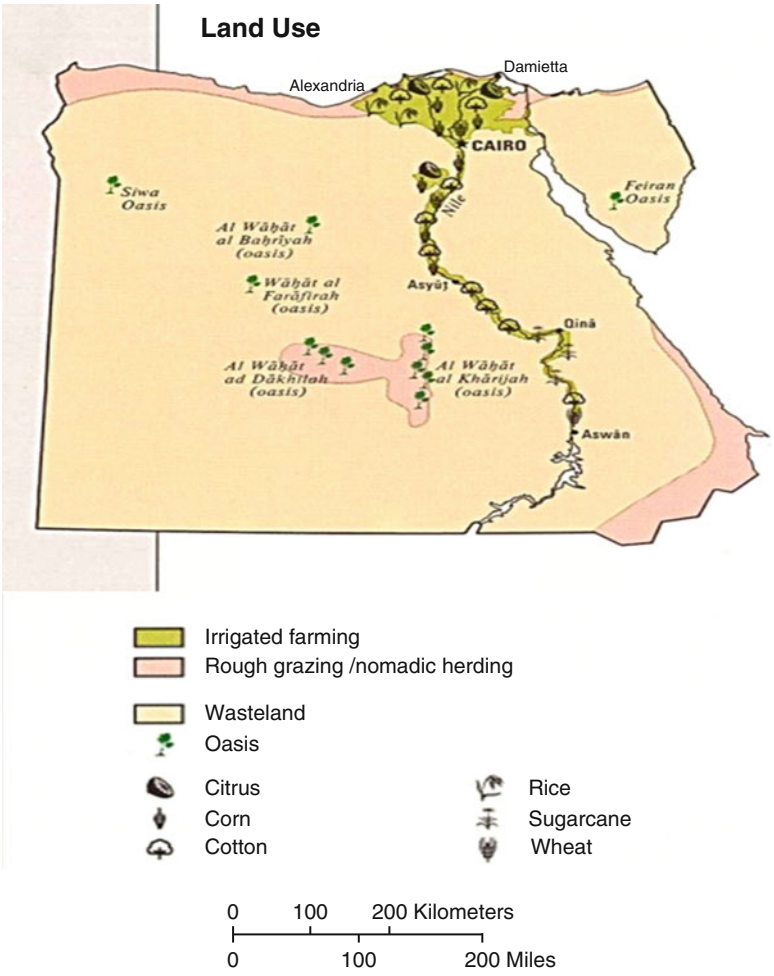

Fig. 6.2 Land use map of Egypt

4. The Desert Inland: Including the plateau and dry valleys of Sinai and elevated areas in the Southern Eastern Desert (Fig. 6.2).

3 Land Degradation in Agricultural Zones

Land degradation is a risk to the limited areas of cultivated land. The complex ecosystem of the Nile, which has nurtured civilizations for millennia, has already been deeply affected in the last 60 years by the construction of the High Dam in the

Fig. 6.3 Satellite view of Nile Delta and part of the Mediterranean coast

southern city of Aswan. The giant project managed to regulate the often devastating effect of the Nile's yearly floods, but it also deprived lands of crucial nutrients and minerals. Only 4 % of Egypt is arable, most of it along the floodplain of the Nile but two other important zones exist. The area east of the Nile Delta and the El Fayoum Depression.

3.1 Nile Delta

The Nile Delta is low-lying, flat, and rich in silt deposits. The recognized landforms comprised; old deltaic plain, eolian plain and depression with alluvial deposits. The Nile Delta's agricultural products support the entire country. An extensive network of canals now crisscrosses the delta region and assists the flow of the waters into the agricultural fields. A number of lakes and marshes dot the Nile Delta. In the eastern part of the Nile Delta area (west of the Suez Canal) land degradation threatens the ongoing agricultural activities and prohibits further reclamation expansion (Fig. 6.3).

The Nile Delta, Egypt's bread basket since antiquity, is being turned into a salty wasteland by rising seawaters, forcing some farmers off their lands and others to import sand in a desperate bid to turn back the tide. The fertile Nile Delta provides around a third of the crops for Egypt's population of 80 million and a large part of these crops are exported providing the country with an important source of revenue.

Climatic changes (see below) have forced some Delta farmers to abandon their land, while others are trying to adapt by covering their land with beds of sand to isolate it against seawater infiltrations, and grow crops.

Land reclamation has been going on for some years but salinization, alkalization, soil compaction and water logging are the main barriers to irrigated agriculture in the area. The main causative factors of human induced land degradation types on the already established areas are; over irrigation, human intervention in natural drainage, improper time use of heavy machinery and the absence of conservation measurements. Low and moderately clay flats, gypsiferous flats, have high to very high risk in both salinization, sodification (becoming strongly alkaline) and physical degradation. The assessment of the different degradation degrees has been carried out through integrating remote sensing, GIS and GLASOD approaches (Mohamed et al. 2012). A spatial land degradation model was developed based on integration between remote sensing data, geographic information system, soil characteristics and DEM. This will be of great help and be the basis for the planners and decision makers in developing more sustainable land use plans (Ali and Shalaby 2012).

3.2 El Fayoum Depression

The El Fayoum oasis is a depression or basin in the desert immediately to the west of the Nile and south of Cairo. The extent of the basin is estimated to be between 1,270 and 1,700 km^2. The floor of the basin is irrigated by a canal from the Nile. The depression comprises lacustrine plain, alluvial–lacustrine plain, and alluvial plain representing 12.2, 53.6, and 34.2 % of the total area, respectively. Over 1,000 km^2 of the El Fayoum is irrigated. Drainage water goes to Lake Moeris – a once freshwater lake.

Land degradation puts cultivated land in El Fayoum depression at risk. Most of lacustrine and alluvial–lacustrine soils are actually degraded by salinization, sodification and waterlogging. The results from research by Ali and Abdel Kawy (2012) indicate that severe risk to chemical and physical degradation affect 54.2 and 29.2 % of the depression, respectively. Negative human impact affects 26.3 % of the area mostly in the alluvial plain. Great efforts related to the land management are required to achieve agricultural sustainability (Ali and Abdel Kawy 2012).

4 Egypt's Coastal Zones

4.1 The Setting

The dominant feature of Egypt's Northern Coastal Zone is the low lying delta of the River Nile, with its large cities, industry, agriculture and tourism. The Delta and the narrow valley of the Nile comprise 5.5 % of the area of Egypt but over 95 % of

its people of which 25 % live in the Low Elevation Coastal Zone (LECZ) areas. In this context, the Nile Delta and Mediterranean Coast include 30–40 % of Egypt's agricultural production, half of Egypt's industrial production, mainly Alexandria, Damietta and Port Said. The three main Delta lagoons are Idku, Burullus and Manzala produce over 60 % Egypt's fish catch. In addition, Alexandria is known as the main summer resort in Egypt and the returns from the inbound tourism forms one of the main sources of income to the city. Approximately 15 % of Egypt's GDP is generated in these LECZ.

Due to the concentration of much of Egypt's infrastructure and development along the low coastal lands and the reliance on the Nile delta for prime agricultural land, coastal inundation or saline intrusion caused by anthropogenic climate change induced sea-level rise will have a direct and critical impact on Egypt's entire economy. Observations confirm that sea-levels are already rising in the Nile delta due to a combination of factors including coastal subduction and reduced sediment loads due to the construction of the High Aswan Dam upstream. Land subsidence is currently estimated at 1–5 mm/year. The present coastal erosion and retreat of the Delta, which are aggravated by human interventions such as reduced sediment input, groundwater extraction, and hard engineering work in coastal strip. Protecting coastal zone areas at risk from the affects of climate changes (see below) has been internationally recognized, particularly in *Agenda 21, Chapter 17*. The United Nations Convention on Climate Change (UNCCC), has urged developed and developing countries to work together to mitigate and adapt to the impacts of climate change. *Agenda 21, Chapter 40*, has also stressed the need for information for decision making concerning environmental problems and sustainable development.

4.2 Problems Faced

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 salinization, land use interference, ecosystem pollution and degradation, and lack of appropriate institutional management systems. Egypt's coastal zones constitute particularly important regions from economic, industrial, social and cultural points of view. In addition to increased tourism activities, a tremendous move towards building new industrial complexes is in progress at this time. Realizing the importance of this zone, the Egyptian government has already taken steps towards reducing the impact of these problems.

The coastal zones of Egypt extend for over 3,000 km in length along the 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 constitutes about 25 % of the total area of wetlands in the Mediterranean region, and produce over 60 % of the fish catch of Egypt. The coastal zone of Egypt is therefore particularly vulnerable to the impact of sea level rise in addition to impacts on water resources, agricultural productivity and human settlements.

4.3 Sea Level Rise

Egypt's Mediterranean Coast is very vulnerable to the impacts of sea level rise (SLR). A 0.3 m SLR would be sufficient to increase flood frequency from the present estimate of one in ten year flood to ten times a year. Several studies on the vulnerability of Alexandria, the second largest city in Egypt, indicated that a 0.3 m SLR in Alexandria would inundate large parts of the city. This would result in land and property losses worth tens of billions of dollars, including damage to infrastructure, over half a million inhabitants to be relocated and approximately 70,000 lost jobs (El-Raey et al. 1999). Furthermore, with SLR exceeding 0.5 m over this century, that is predicted to result in devastating impact on Alexandria with an economic loss estimated of over US$ 35 billion including loss of 30 % of the total area and 195,000 jobs, and relocation of more than 2 million people.

Several general analyses of the potential impact of sea level rise on the Nile Delta coast have been carried out (e.g. Sestini 1989; El-Raey 1993; CRI and Delft Hydraulics 1992; Stanley and Warne 1993). 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 Behaira governorates, Port Said and Damietta governorates, and Suez governorate. In addition, several other smaller areas, such as those near Matruh and north of Lake Bardaweel, have also been identified.

Accurate, up to date information on elevation, land use and socio-economic characteristics is still needed for an integrated assessment of possible impacts. As a result, a complete quantitative, high resolution analysis and assessment has not yet been finalized. However, a pilot quantitative analysis, using a geographic information system and land use classification obtained by remote sensing over the governorate of Alexandria, has been carried out, (El-Raey et al. 1995).

Satellite images of the governorate were used by the present authors to obtain information on land use in the coastal area and were supplemented by available ground survey data. A geographic information system (GIS) was built and checked with information based on available ground data. The GIS includes data layers on land use/land cover, topography, and population density distribution over Alexandria. A scenario of sea level rise (SLR) of 0.5, 1.0, and 2.0 m, 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 6.1 presents gross percentage loss for each scenario of SLR.

Table 6.1 illustrates that, if no protection action is taken, the agricultural sector will be the most severely impacted (a loss of over 90 %), followed by the industrial sector (loss of 65 %), and the tourism sector (loss of 55 %) due to a SLR of 0.5 m. 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 6.2. It is estimated that a SLR of 0.5 m in the governorate of Alexandria alone would cause a displacement of almost 1.5 million people and the

Table 6.1 Potential loss of area, population and land use due to Sea Level Rise (*SLR*) over Alexandria Governorate, in the Nile Delta of Egypt

Attribute	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

Table 6.2 Population expected to be displaced and loss of employment due to SLR in Alexandria Governorate

Year	2000 (SLR = 5 cm)	2010 (SLR = 18 cm)	2030 (SLR = 30 cm)	2050 (SLR = 50 cm)
Area at risk (km^2)	32	144	190	317
Population to be displaced	57	252	545	1,512
(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

Table 6.3 Areas (km^2) population displaced and employment losses due to a SLR of 0.50 m in various districts of Port Said Governorate, Egypt

Losses	El Shark	El Arab	El Monakh	El Dawahy	Port Fouad	Total
Beach area	0.426	0.377	7.419	–	13.039	21.26
Urban area	0.034	0.044	0.339	–	0.046	0.46
Industry area	0.015	0.002	0.018	–	0.016	0.05
Agriculture area	0.000	0.000	0.000	–	0.000	0.000
Aquaculture area	0.000	0.000	0.000	–	0.024	0.024
Transport network (km)	10.0	7.0	3.0	–	3.0	23.0
Population (persons)	3,968	16,699	6,503	–	1,021	28,191
Employment (jobs)	953	4,000	1,558	–	248	6,759

After El-Raey et al. (1999)

loss of about 200,000 jobs by 2050, if no action were taken. Work is in progress to identify and assess vulnerable sectors in each district of the governorate.

Tables 6.3 and 6.4 show the results of the impact of SLR on the other two most important cities in the coastal zone of Egypt, Rosetta and Port Said, respectively (El-Raey et al. 1999). Again, results indicate serious impact and calls for advanced planning and adaptation measures.

The most important limitation on these results is the availability of recent land-use data and reliable topographic and socio-economic data. However, upgrading

Table 6.4 Economic evaluation of beach, urban, industry, agriculture, aqua-culture areas (km^2) municipal services and transportation network (km) losses of Port Said Governorate in case of Sea Level Rise of 50 cm

	Losses	Percentage (%)	value loss (million $)
Beach area (km^2)	21.26	1.60	2.126
Urban area (km^2)	0.46	7.80	48.0
Industry area (km^2)	0.05	12.50	5.0
Agriculture area (km^2)	0.00	0.00	0.00
Aqua-culture area (km^2)	0.024	0.12	2.40
Transport network (km)	23	11.73	4.60
Population (persons)	28,191	5.30	–
Employment (jobs)	6,759	5.30	–

the quality of topographic data using GPS (Geo-Positioning Satellites) and high resolution laser profilers, and building accurate geographic information systems (GIS) in an ARC/INFO environment, are now in progress (Mohamed et al. 2012).

5 Climate Change Impacts

Global warming is expected to affect Egypt in many ways. In particular, water resources, agricultural resources and coastal zones (see above) are expected to be adversely affected:

5.1 Impacts on Water Availability

A detailed quantitative assessment of the impacts of climate change on water resources in Egypt has yet to be produced. The demand for water in Egypt is dominated by three major user groups: agricultural irrigation, domestic use and industry. Even if no climate change takes place at all, the population is expected to double before the year 2050, if the present growth rate is maintained. A correspondingly rapid growth in agricultural and industrial output will be required to sustain this population. 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.

Due to the importance of predicting environmental impacts which could result from climate changes affecting the Nile basin several models have been advanced. Results of their predictions are summarized in Table 6.5 (after Strzepek et al. 1996).

It can be seen that these models are still incapable of predicting, with some certainty, what would happen if climate change occurs. However, the indictors call for serious action. In summary, the following impacts on water resources in the Nile river basin are expected:

Table 6.5 Model predictions of the impact of climate change on the Nile water budget

Model[a]	Temperature rise (K)	Water budget (bcm)	Percent
Base	0	86	100
GFDL	3.15	20	23
UKMO	4.73	76	88
GISS	3.45	112	130

[a]Current climate models

1. Increase of temperature increases losses by evaporation and demands for water for agricultural domestic and industrial applications increase.
2. Change of precipitation patterns will lead to a loss of water in coastal areas if proper storages are not available to collect runoff from upstream.
3. Increases in airborne dust levels, soil salinity and domestic use decreases water quality.
4. Sea level rise will increase occurrence of saline intrusion with contamination of groundwater resources in the coastal zone.

5.1.1 Water Resources

Both water supply and demand are expected to be affected by climate change. Impacts on the supply side are likely to arise from possible changes of precipitation patterns over the Ethiopian hills (which accounts for around 85 % of water flow into the River Nile), and equatorial lakes such as Lake Victoria (15 %). The effects of predicted climate change on both components are uncertain. The first is dependent on two factors, namely variation of the general cycle of the wind, and the El-Nino and ENSO phenomena. The second component is also uncertain due to increased frequencies of droughts and their intensities over the last two centuries. Rainfall on the upper White Nile catchment, the upper Blue Nile catchment, and the Middle Nile basin (which includes the confluence of the two major Nile tributaries), are all showing a decline in total rainfall and some change in rainfall intensity.

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 and this will impact both sown crops and other vegetation as well as those people who rely on groundwater for their business or for daily living.

5.2 Impact on Agricultural and Food Resources

Intensive, multiple cropping and high occupation rates are normal agricultural practices in Egypt. More than 6 million ha of crops are cultivated annually on 3 million ha of land, giving an intensity index of 2. (based number of crops per

year etc.) Soil depletion is expected under such heavy land use unless sustainability measures are provided. Egypt is already a major cereal importer, and demand is expected to increase. As a result, the country is vulnerable to deficits in food production resulting from climate change. Expected higher prices for food imported from developed countries would aggravate the situation considerably.

Marginal agriculture and marginal farming are the most vulnerable, both to short term variations in local weather conditions and long term variation of climate. Adjusting to climate change will be made difficult by several factors: ownership of cultivated land is widespread but limited – 98 % of owners have a holding size of less than 5 ha each. Also, many types of farming are practiced near the edge of their appropriate climate zone. These marginal factors, along with under capitalization or low levels of financing, render farming particularly vulnerable to the effects of climate change (EEAA 1995). Livestock and fisheries are also vulnerable to the impacts of climate change, though changes in climatic conditions and sea level rise are expected to affect populations and various species differently.

In summary, the following climate changes impacts on agriculture are expected:

1. Increase of temperature and frequency of extreme events will reduce crop yield (some crops are more tolerant than others).
2. Change of average temperature will induce changes of the agricultural distribution of crops.
3. Increase of temperature will negatively affect marginal land and force farmers to abandon marginal land.
4. Shortage of water resources will also force farmers to abandon marginal land, and this will accelerate land degradation.
5. Socio-economic impacts associated with loss of jobs, such as increase of unemployment, loss of income, and political unrest.

An assessment of the impacts of climate change on some crops has been advanced (e.g. Eid et al. 1993). However, a detailed quantitative assessment of the impact of climate change on the agricultural sector, has not been carried out yet.

5.3 Change of Precipitation, Wind Velocity and Heat Waves

No assessment of the vulnerability of the coastal zones or inland areas to this impact is available for Egypt, nor is there any reliable model for prediction. However, the following impacts are to be expected to a greater or lesser degree:

1. Increased vulnerability of slum areas to wind and flood damage, and increased frequency of floods and fires in rural, as well as in some urban, areas. Settlements built in the path of old stream torrents will be particularly vulnerable.
2. Increased vulnerability of livestock due to shortage of water resources, increased salinity, and loss of grazing sites.
3. Changes in the frequency, timing and duration of heat waves will affect agricultural yields, and increase number and variety of insect pests.

5.4 Socio-economic Impact on Coastal Settlements

This will include the following:

1. Inundation and salt water intrusion will compel a significant proportion of the coastal zone population to abandon their land and homes.
2. Changes in the ecological system of lakes will reduce fish catches and drive away a large portion of fishermen and their dependents.
3. 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.
4. Increased saltwater intrusion will affect the management and access to archaeological sites; reduce tourism, and result in socio-economic impacts on the inhabitants of these areas.
5. Increased unemployment induces political and civil unrest.
6. Increased water-logging and salinity give rise to insect and pest problems which in turn causes health problems.
7. Increases in temperature lead to increased soil erosion and dust. Increased dust has direct adverse impacts on health, installations and equipment. Increased wind speed encourages sand dune movements and threatens coastal infrastructure.
8. Increased humidity and temperature decrease the human comfort zone, and reduce human productivity.

5.5 Regional Impacts of Accelerated Climate Change

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. Its only source of water, the River Nile, provides more than 95 % of all water available to the country. The source of this water lies far to the south, from rainfall on Ethiopian hills (86 %) and equatorial lakes (14 %). Most of the population of Egypt (over 60 million people in total) is associated with the agricultural sector which constitutes 20 % of gross national product (GNP) and consumes about 80 % of the water budget.

The coastal zone of Egypt extends for more than 3,000 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.

Alexandria city is one of the oldest cities on the Mediterranean coast, and is an important tourist, industrial and economic center. The city has a waterfront that extends for 60 km, from Abu-Qir Bay in the east to Sidi Krier in the west and includes a number of beaches and harbors. Alexandria's beaches are the main summer resort of the country, and its harbors are the most important import/export link between Egypt and Europe. About 40 % of all Egyptian industry is located within the governorate of Alexandria. As a result of its high population density

and industrial pollution, environmental problems have affected a large sector of the community in the area.

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.

In addition to its local impacts, climate change over Egypt has secondary regional impacts which also affect the international community. These include:

1. Increasing temperature increases soil erosion and wind speed, which in turn increases amount of Saharan dust carried across the Mediterranean to European countries causing health and economic problems.
2. Increased unemployment increases immigration pressure on European countries.
3. Decrease of water resources increases friction among countries sharing the same water resources (e.g. Nile and Euphrates), and leads to political unrest.
4. Increases in temperature and humidity increase rates of deterioration of Egyptian archaeological treasures which are considered among the most important in the world.

5.6 Government Response to the Climate Change Challenge

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. 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. The coastal zones as a whole are also particularly vulnerable to changes in precipitation, excessive frequency of storm surges and changes in the heat pattern through the impacts of floods. 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. 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. 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. A program based on a strategic policy for coastal protection and adaptation must be advanced and implemented.

5.7 Adaptation to Climate Change in the Nile Delta Through Integrated Coastal Zone Management

UNDP in partnership with Ministry of Water Resources and Irrigation, Coastal Research Institute, The Egyptian Shore Protection Authority initiating a project aimed at strengthening Egypt's capacity to mitigate the impending problems of SLR, sea water incursion and other factors (see above) and adapt to the changing situation.

6 Egypt's National Environmental Action Plan (NEAP)

The NEAP addressed many environmental issues which included the three thematic areas: *climate change,* and *desertification*. The National Environmental Action Plan (NEAP) represents Egypt's agenda for environmental actions between years 2002 until 2017. It complements and integrates with sectoral plans for economic growth and social development and is the basis for the development of local environmental initiatives, actions, and activities. It is designed to be the framework that coordinates for future environmental activities in support of the sustainable development in Egypt. The NEAP includes programs and projects that address the environmental issues. Each program consists of three major components: information and monitoring, preventive and/or corrective measures, and supportive measures. Most of the information and monitoring activities are conducted by the EEAA. Most of the corrective and preventive measures are the responsibility of the central and local agencies in order to integrate environment protection into their plans.

6.1 Climate Change

Egypt is taking the issue of climate change seriously. The Nile Delta and coastal zones are prone to flooding due, in part, to rising sea levels. Agricultural productivity is another subject that climate change will potentially negatively affect as a result of increased average temperature. Human health is also at risk due to climate change. The increased temperatures might lead to the outspread of vector-borne diseases. Coral reefs are one of Egypt's natural resources that climate change adversely affects. Egypt seeks the help and support of the international community to mitigate the impact of climate change.

Egypt implemented two major projects in the field of climate change during the period 1995–1999. These projects were "Support for National Action Plan" and "Building Capacity for Egypt to Respond to UNFCCC". These projects ended in December 1999 by submitting Egypt's National Communication and establishing a

Climate Change Unit at EEAA as the institutional focal point for climate change. In addition, a support program to build the capacity to institutionalize Clean Development Mechanism (CDM) was completed successfully during November 2001 as a step towards implementing Egypt's strategy on CDM. The strategy includes, but not limited to, improving energy efficiency, promoting use of renewable energy, and expanding current activities for afforestation using treated wastewater to plant timber trees. The climate change targets are mainly improving energy efficiency, promoting use of renewable energy, (Box 6.1) and expanding current activities for afforestation using treated wastewater to plant wood trees.

Box 6.1: Renewable Energy Wind Power

Egypt had its wind potential assessed in 2003. With wind speeds of 7–10 m/s, almost the entire country is ideal for wind power, with the best areas in the Gulf of Suez coast. Then in 2008, the Egyptian government passed an ambitious plan to produce 20 % of its energy from renewables, with 12 % to come from wind. The Egyptian cabinet has approved inducements to wind power development, including exemption from customs duties and 20–25 year power purchase agreements with government guarantees. Now a 7,600 km^2 region has been earmarked by the New and Renewable Energy Authority (NREA) for wind development. NREA has obtained permits for land allocation and leases to wind farm developers. If successful, Egypt will get 12 % of its energy from wind power.

6.2 Desertification

Egypt, with land extending over one million square kilometers under arid and hyperarid climatic conditions, is endowed with varied agro-ecological zones (Fig. 6.1) with varied and specific attributes of resource base, climatic features, terrain and geomorphic characteristics, land use patterns and socio-economic implications. A meaningful national action plan for Egypt would be comprised of sub-components, each of which is geared to address the specific attributes of each agro-ecological zone distinguished in Egypt. The zones could be identified as follows:

1. North Coastal Belts: Including North West coastal areas and Northern areas of Sinai.
2. The Nile Valley: Encompassing the fertile alluvial land of Upper Egypt, the Delta and the reclaimed desert areas in the fringes of the old Nile valley.
3. The Oases and Southern Remote Desert Areas: Including Uwienate, Toshki and Darb El-Arbien Areas and Oases of the Western Desert.
4. The Desert Inland: Including the plateau and dry valleys of Sinai and elevated areas in the Southern Eastern Desert.

The general priorities in desertification in Egypt as presented in the NEAP tackled several issues, these are:

- Degradation of irrigated farmland as a result of using low quality water in irrigation.
- Degradation of rain-fed farmland (northern coastal belt and northern Sinai rainfall 100–250 mm), for insufficient water harvesting and water spreading processes.
- Degradation of rangeland (northern coastal belt) through overgrazing, degradation of plant cover.
- Encroachment of sand formations, especially from the Western desert, on the Nile Valley land (southern Egypt) and on the High Aswan Dam reservoir (in Egypt and Sudan).
- To formulate meaningful options that ensure that the introduction of irrigation into the area does not threaten the sustainable use of the marginal land or the livelihoods of the present local population.
- To conserve the ecosystem from invading pests and pollutants.
- To provide and enhance green areas for better and healthier microclimatic conditions.
- To formulate rational and innovative policies for waste management treatment and reuse of solids and effluents.
- To promote public awareness campaigns dealing with environmental issues using all available media means.
- To develop environmental institutional aspects with appropriate capacity building and training in issues specific to characteristics of the surrounding ecosystems.
- To combat damaging flash floods through appropriate water spreading and water conservation techniques; and to prevent and alleviate damages of flash floods to the infrastructures and available resources including adverse socio-economic impacts.
- To conserve, manage and utilize the highly valued and diversified natural flora and fauna resources.

The Desert Research Center works towards solving these problems (Box 6.2).

Box 6.2: Role of the Desert Research Center Arab Republic of Egypt Ministry of Agriculture and Land Reclamation

Desert Research Center is the Oldest Organization for Research and Development in the Desert and Newly Reclaimed Regions of Egypt.

Objectives

- Investigating desert potential for agricultural development.
- Carrying out studies on behalf of government institutions, societies and small landholders.

(continued)

Box 6.2 (continued)

- Preparing postgraduate research assistants and scholars for higher degree study in the field of scientific research.
- Conducting applied research and projects related to the development of desert and new reclaimed areas.
- Transfer of technologies to local farmers, Bedouins, investors, stakeholders, etc. through training and extension programs.

The work of the Ecology and Dry Lands Agriculture Division

Desertification control

Studies on sand dune fixation.

Establishment of wind screens for protection of newly settled area, towns, factories and desert roads.

Studies on the desert Ecosystem.

Mapping of vegetation and rangelands.

Evaluation of natural plant cover.

Studies on medicinal and aromatic plants of the Egyptian deserts.

Propagation of selected seedling adaptable to desert environments.

Co-operation with national and the international organizations in the field of agricultural research and biotechnology.

Run-off managements and its utilization for developing rainfed agriculture in the desert area. Conservation of plant collection. Seed banks

Production of cultivars and tolerance genotypes for biotic and a biotic stresses.

Increasing horticultural and field crop productivity by introducing new varieties.

Biological and ecological studies on plant diseases and pests

6.3 *Egypt's National Action Plans in the Three Thematic Areas*

The first commitment of the countries that ratified the UNFCCC, UNCCD and CBD is the preparation of National Action Plans (NAP) to mitigate and adapt climate change, combat desertification and to preserve biodiversity. According to the UN Conventions, the NAP should identify the factors contributing to climate change, desertification and biodiversity loss, and set up practical measures to reduce it.

The priorities considered in the NAPs are from the identified cross-cutting capacity in the prioritization phase of the NCSA project. The focus is only related to the prioritized cross-cutting issues: public participation; technology transfer and cooperation; financial mechanisms; legislation formulation and enforcement; and monitoring, evaluation, and reporting.

6.3.1 Climate Change

The climate change action plan was produced in 1999 and identified the following cross-cutting issues as priorities in its agenda to be considered in the policy of all involved entities: The improvement of national plans, programs and institutional capabilities; increasing scientific research capabilities, enhancement of technology transfer and cooperation; improvement of monitoring and evaluation systems; increase of public involvement and awareness of the issue; and the provision of training for people in the sector. In the climate change NAP, it addresses international cooperation in the field of climate change as an important issue that is essential for implementing most of the actions introduced in the climate change plan.

6.3.2 Desertification

In the desertification sector, the main priorities identified in the action plan that were cross-cutting with the other thematic areas are: development of national plans, programs and Institutional capabilities; improvement of legislation (both formulation and enforcement); enhancement of technology transfer and cooperation; improvement of monitoring and evaluation systems; increase of public involvement and awareness of the issue; the provision of training for people in the sector and the development of new funding strategies and financial mechanisms for combating desertification. In addition to increase of integration and cooperation with the biodiversity and climate change sectors.

Key issues:

- Enhance technical capabilities of some institutions to carry out comprehensive studies and follow-up of land degradation issues.
- The allocated funds for desertification control in eastern and western deserts including Sinai are relatively low.
- Division of labor between institutions needs to be more clearly specified. Improve coordination and institutional support.
- Need to incorporate combating desertification aspects into policies and planning
- Measurers taken for implementation of the convention are to be complemented and continued (according to the review of the previous activities that were completed in the NAP).

In the desertification NAP, it is stated that there should be measurements for the types and degrees of desertification and the rate of its extension in the four agro-ecological zones (Fig. 6.1) in Egypt should be monitored. In order to provide the decision makers with relevant analyses of the desertification processes. It is also stressed that it is important for Egypt to obtain technical assistance from concerned regional and international institutions as well as from other developed countries and donors and to adopt innovative technologies for halting the desertification processes. It is further stated that additional legislation and regulations at the national,

governorates and local levels will be needed as well as enforcement of existing and newly issued legislations and regulations are also needed to support efforts and activities of combating desertification in the different agro-ecological zones.

There should be participation of local communities, targeted groups, stakeholders, and NGOs in planning, implementation, evaluation and monitoring. Up-grading the capacity of the local community, NGOs, institutions and all partners in the various aspects of desertification control is an essential prerequisite for NAP success. The promotion of public awareness campaigns dealing with environmental issues, particularly combating desertification, should be done using all available media. Awareness raising in the field of desertification control in general and rangeland management and sand dunes fixation in particular should be the focus.

6.3.3 Biodiversity

The issues tackled in the biodiversity action plan related to the requirements of the CBD are: Development of national plans, programs and institutional capabilities; improvement of legislation (formulation and enforcement); enhancement and increasing scientific research capabilities; enhancement of technology transfer and cooperation; improvement of monitoring and evaluation systems; increase of public participation and the incorporation of biodiversity into public education. Also, the provision of training for people in the sector and the development of new funding strategies and financial mechanisms are within these Priorities.

In the NEAP, one of the goals of biodiversity conservations is developing Egyptian scientific and technological capabilities in fields of conservation. In the biodiversity NAP, it is stated that the Nature Conservation Authority should use internationally recognized best practices to achieve the standards of excellence expected by the Convention on biodiversity.

Allocating adequate permanent financing resources required for combating desertification. Financial assistance to Egypt should be obtained from concerned regional and international institutions as well as from other developed countries and donors, additional funds through GEF, the Global Mechanism, World Bank, the International Fund for Agricultural Development, etc. An important point that was declared in the national consultation workshop is that Egypt is in the process of establishing a national fund for implementation of UNCCD obligations as part of the NAP projects.

Additional legislation and regulations at the national, governorates and local levels will be needed. Enforcement of existing and newly issued legislations and regulations are also needed to support efforts and activities of combating desertification in the different Agro-ecological zones.

The NAP states that there should be measurements for the types and degrees of desertification and its extension in the four agro-ecological zones in Egypt should be monitored. In order to provide the decision makers with relevant analyses of the desertification processes. A system to monitor the impact of desertification should be set up to quantify the extent, intensity of land degradation on special scale

and some indications on temporal scale. Thematic maps and creation of relevant indicators should be generated to inform stakeholders and decision makers regularly with the scope of the desertification phenomena and provide them with an objective basis for making related plans.

7 Recommended Lines of Action to Implement the National Conservation Strategy and Meet the Objectives of the NAPs

Usually in Egypt, the same as in most developing countries, there is a gap between most written action plans and their implementation on the ground. In order to ensure that the National Conservation Strategy and Action Plan is implemented; several practical, simple, and clear measures need to proposed and agreed upon.

7.1 Cross Cutting Issues Relevant to Desertification and the Other Two Rio Conventions

Several actions were recommended in the in-depth phase of the NCSA project to address the main prioritized constraints specifically and all the gaps that were noted in the stocktaking and gap identification phase generally. These actions should be applied to achieve the goals of the three Rio conventions (Biodiversity, Desertification, Climate change). These actions are in the area of ***Public Participation; Technology Transfer and Cooperation; Financial Mechanisms; Legislation Formulation and Enforcement; and Monitoring, Evaluation, and Reporting***.

7.2 Development Framework

The requirements of the three Rio Conventions, as well as the principles emerging from the cross-cutting/synergy analysis of the NCSA process. For accomplishment of the capacity development objectives, the responsible entities should be governed by the following strategic principles:

7.2.1 National Ownership and Leadership

The efforts should be nationally owned, led and driven, including strategic planning, self-monitoring, and self-evaluation. A high degree of national political commitment is essential, but in the same time there should be decentralization in responsibilities.

7.2.2 Stakeholders' Participation and Partnership

Multiple stakeholders should be involved in national decision making and have shared responsibility in implementation to maximize impact and create synergies.

7.2.3 Holistic and Integrated Approach

Capacity-building efforts should be realistic, recognize and build on existing strengths, knowledge and experience. Capacity development must be integrated with ongoing initiatives to enhance capacities for broader environmental managements and for sustainable development in general without duplication of efforts or resources. Parallel to this, the outcomes of the action plan should be taken in consideration in national planning and decision-making.

7.2.4 Flexibility

Capacity-building efforts should be supported by a variety of tools and methodologies. These could range from the more traditional methods to capacity building (such as workshops, training, awareness raising, etc.) to those that offer greater scope both methodologically and institutionally, such as networking, horizontal exchanges and cooperation. Capacity building is a dynamic process therefore adequate monitoring and evaluation techniques are essential for adaptive management and improvement.

7.2.5 Improving Inter-agency Coordination

A number of different entities are concerned with the thematic areas of the three Rio Conventions. Currently coordination between these different agencies and entities is random, particularly with regards to monitoring, evaluation and reporting. This leads to significant hindrances to effective monitoring evaluation and reporting, with adverse effects on the inclusion of global environmental issues in national policies and plans.

8 Summary and Conclusions

The government has addressed many environmental issues which included the three thematic areas: *climate change, desertification and biodiversity*. The National Environmental Action Plan (NEAP) represents Egypt's agenda for environmental actions between years 2002 till 2017. It complements and integrates with sectoral plans for economic growth and social development and is the basis for the development of local environmental initiatives, actions, and activities. It is designed

to be the framework that coordinates for future environmental activities in support of the sustainable development in Egypt. Agricultural productivity is another aspect that climate change will potentially negatively affect as a result of increased average temperature. Human health is also at risk due to climate change.

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