Monitoring Environmental Changes in El-Ain El-Sokhna Area, Gulf of Suez, Egypt

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Abstract:

El-Ain El-Sokhna area lies on the northwestern part of the Gulf of Suez. This area is characterized by the presence of highly sensitive and fragile natural resources, habitats, wide coastal plain, extensive tidal flat, and its aquatic environment hosting an important coral reef. In recent decades this area has been subject to rapid and increasing changes in land use patterns, particularly with the growth of tourist activities, construction of El-Ain El-Sokhna port, resorts and the subsequent increase of population. Due to the rapid development projects, the area is presently suffering from environmental pollution and loss of some natural resources. This study aims at bringing out the environmental changes in the study area during the period of 1984 till 2002 and investigating their impacts on the ecology and environment of the coastal zone of the Gulf of Suez.

LANDSAT–TM images during the study period were used to conduct this study. They were used to detect analyses and assess the environmental changes due to the rapid development. Digital Elevation Model, slope and aspect maps were used to show topographic and geomorphologic setting of the area. Land-use/land cover maps and change detection map allocate different changes of the environmentally sensitive habitats and natural resources. The GIS tools were used to integrate the results of the applied digital images processing the adopted techniques and the field measurement data with the different digital maps such as, topography and geology maps to assess the environmental changes in the study area.

The study revealed that considerable land-use changes in the area as establishment of resorts, roads; port,

industrials and urban sites brought mainly by human activities and development programs. The revealed newer scope attracts attention towards the arising hazards concerning bio-system, stability of urban and resort buildings as well as pollution of petrochemical factories.

Introduction:

The study area lies on the northwestern part of the Gulf of Suez between latitude 29^0 $35^{\backslash}$ $57^{\backslash\backslash}$ N and 29^0 $46^{\backslash}$ $58^{\backslash\backslash}$ N, and longitude 32^0 $25^{\backslash}$ $45^{\backslash\backslash}$E and 32^0 $10^{\backslash}$ $42^{\backslash\backslash}$ E .The total surface area is 1087.88 Km2. The study area has a length of about 29.26 km and a width ranges between 37- 42 km. (Figure, 1). This paper is targeting to detect and evaluate environment changes in the study area brought out by human activities and development programs within the period 1984 till 2002. The results of such could be useful for future planning in similar areas and let decision makers to be aware about the adverse impact of unplanned development programs. The main objectives of this study are:

- Study the Geomorphologic setting in the study area by using remote sensing data and GIS technique.
- Produce land-use/land-cover maps of 1984 and 2002.
- Detect and evaluate changes in the study area brought out by human activities and its effect on natural resources.

Methodology:

The GIS technique was applied to achieve the overall aims of this study. This used data to detect the environmental changes in the study area are:

- Maps: The topographic map of scale 1: 50 000 produced in 1970 (Egyption Survey Authority,

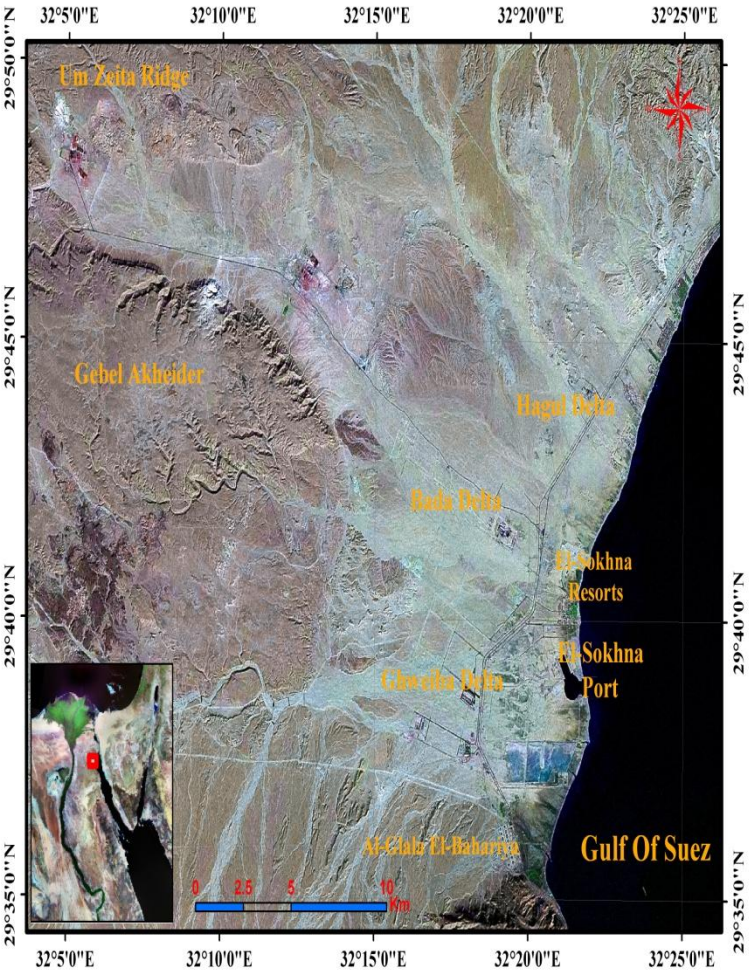

Figure (1): Location of El-Ain-El Sokhna

1970), also geological map of scale 1:500 000 of Conco (Conco, 1987) were used after conversion into digital format to study the topographic and geological setting and to produce a contour map.

- **Remotely sensed data**: The LANDSAT TM dated 1984 (30m resolution), and LANDSAT ETM dated 2002 (15m resolution) were used to study the geomorphologic features, and study

the change detection to produce land-use/land-cover maps.

- **Field study**: Verifying and documentation of colleted data about the geomorphologic features and environmental changes in the study area.

Data processing and techniques are used in this study are:

- Automation of topographic and geological maps through conversion into digital format using ARC GIS V.9.1 program.
- Digital image processing and techniques use ERDAS IMAGINE V.8.7 program in atmospheric correction, georeference with enhancement and ARCGIS V. 9.1 program to produce land-use/land-cover map and detect the environmental changes in the study area**.**

Results and Interpretation:

The topographic map and LANDSAT "TM" and "ETM" show that the main geomorphologic features in the study area are deltas e.g. Hagul, Bada and Ghuweibba delta, high lands, e.g. El-Galala El Bahariya, Gebel Kahaliya, Um Zeita ridge, and Gebel Akheider. The main man-made features are El-Ain El-Sokhna resorts and related infrastructure, roads, industrial area and El-Sokhna port .The considerable land-use in the study area impact on the ecology environment of the coastal zone of the Gulf of Suez.

1- Climate conditions:

The climatic averages were sourced from Suez climatic station (year 2000). The average minimum air temperature in January (15.2^{0}c) whiles the average maximum air temperature in July (30°C), the diurnal day range between (9.1°C) and ($13.9\ ^{0}$c). Rainfall rate is (17.2mm/year), the maximum value of rain in one day is 3.2mm. Evaporation ranges between (5.6 to12.5mm/day), (Figure, 2). Contemporaneously, the air temperature records its maximum value and rain fall reaches zero, this renders

the evaporation its effectiveness and believes responsible for the formation of sabkhas in low topographic troughs.

There are three principal directions of wind blown NW, N and W having, general ratios of 36.7%, 29.1% and 7.4%. The wind speed range between 11.5 and 19.2 km/hour (Egyptian Meteorological Authority, 1998-2004). The wind carries polluted air from industrial areas occupying lies in west resorts area.

Generally, high temperature, low rainfall, high evaporation and evapo-transpiration enhances capillary rise of water into surface sediments and consequent concentration of salt crystals in the upper parts of soil profile causes acceleration of salt weathering activity in the study area which has a bad effect on the roads and buildings. (Plate1).

2- Geological setting:

The study area belongs geologically to both Territory and Quaternary deposits. The Hagul formation is made of ca. 22m chalky limestone bed near the top followed by sandstone and shale beds. The formation is capped by a bed of large flint pebbles in a sandy shale matrix including fossil wood. The limestone carries an oyster bank of the genesis species, which indicates marine conditions of deposition. The occurrence of flint and fossil wood at the top of the section shows the prevalence of continental environment at the close of the Miocene in the Red Sea facies province (Issawi, et al., 1999).

The Ghweiba formation consist of marine and continental deposits from conglomerate, pebbles, limestone and sand, it contains of *Osteria Gryhoides*, it is spread on wadi Ghweiba and at the north part of wadi Bada (Said, 1962) (Plate2).Quaternary deposits consist of marine and fluvio-marien deposits, the first consist of sand, gravel, coral

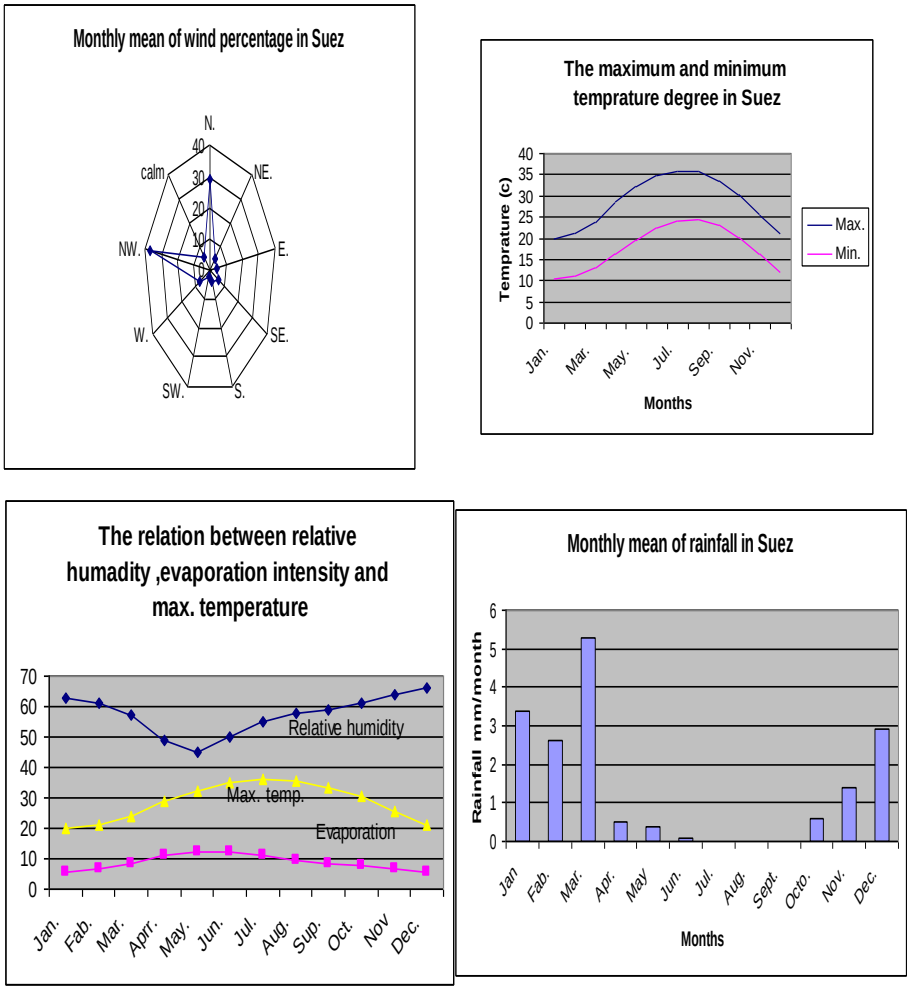

Figure (2): Climatic conditions from Suez station

reef and some fossils. While the second consist of gravel, sand and pebbles; it is spread in the flood plain of wadis Hagul, Bada and Ghweiba. Aeolian deposits and delta deposits spread in large area north El-Ain El Sokhna. (Plate3). Structurally, the study area is situated in the mobile shelf together with the Gulf of Suez graben outlined as a taphrogeocyncline.The fault dislocations trending mainly NW-SE and NE-SW, rejuvenation along these faults had affected the area (Mohamed, 2001).

3-Geomorphologic setting:

The major geomorphologic units of the study area are the high land, coastal plain, deltas, alluvial fan, beaches, sabkhas and braided channels.

High land; Gebel El-Galala El Bahariya is a great massive block extending as a high plateau bounded by scarps and is flanked in the north by the wide depression of wadi Ghweiba. Gebel Kahaliya is a conspicuous bold peak rising above the rest of Um Zeita ridge. It is restricted to the low plateau, the drainage from the northern side of this ridge reaches wadi Hagul through its tributaries, while the southern part is drained by wadi Bada tributaries. Gebel Akheider is a bold limestone plateau resting on the flat plain of wadi Bada. It is dissected by numerous deep wadi ended in wadi Bada and wadi Ghweiba. (Plate4)

The coastal plain; It consists of thick loose deposits and extends parallel to the shore line of the Gulf of Suez. Its elevation ranges from 10 to 24 meters above the sea level and is dissected by many drainage lines descending into the Gulf. There are many different geomorphic features that characterize this coastal plain such as deltas, sabkhas and beaches. The deltas were formed at the ends of the wadis debauching towards the Gulf of Suez. They are characterized by gradually sloping irregular surface dissected by braided shallow channels and covered by alluvial deposits. There are some local run channels spread near the apex of the deltas. The tidal channels are very shallow and have a straight pattern. The sabkhas lay in the

low land area near the Gulf of Suez. Their elevation mostly less than the sea level. They consist of silt, sand and clay mixed with evaporates formed due to high evaporation process. The beaches consists of sand and gravel, they have an irregular shape. The coral reefs found in front of these beaches due to the warm water. It is covered with friable sands mixed with calcareous remains (Mohamed, 2001).

4-Topographic setting:

The digital elevation model (DEM) analysis shows that the surface levels in the study area ranges between 0 to 500 m (Figures, 3 and 4). The surfaces levels range between 0 to 50 m, representing 16.2 % of the total surface area extends along the shore line of the Gulf of Sues. The surfaces levels range between 50-100m represents 14.2 % of the total surface area occur in the deltas surfaces. The surfaces levels range between 100-200m represent 39% of the total surface area, it occur at wadi channels and apex of deltas. The surfaces levels range between 200-300m represent 18.5 % of the total surface area, occur in Um Zeita ridge. The surfaces levels over 300m represent 12.1% of the total surface area; occur at Gebel Kahaliya, Gebel Akheider and El Galala El Bahariya. Generally, the low and moderate levels represent 30.4 % of the total surface area.

The slopes map shows that the slope degrees in the study area range between 0 to 47^0. The gentle slopes ranges between 0-3 ^{0} representing 79.29 % of the total surface area and the slopes range between 3-9 ^{0} representing 14.56 % of the total surface area, occur in deltas and wadis channels. The moderately slopes range between 9-24 ^{0} representing 5.53% of the total surface area, occur in low parts of high lands and in Um Zeita ridge. The highest slopes over 24^0 representing 0.62% of the total surface area; occur in upper parts in Gebel Akheider and El Galala El Bahariya (Figure, 5). Generally, the low slopes dominated in the study area, represents 93.85% of the total surface area.

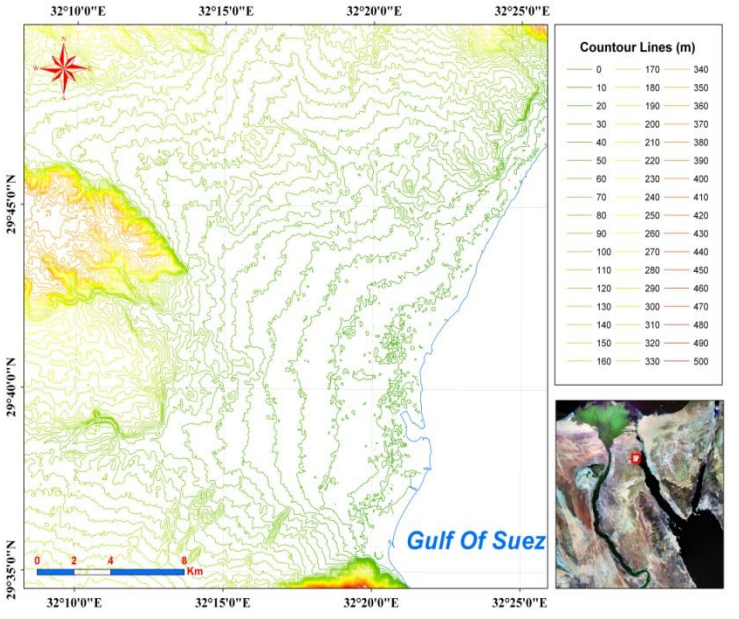

Figure (3): contour map of El -Ain El –Sokhna

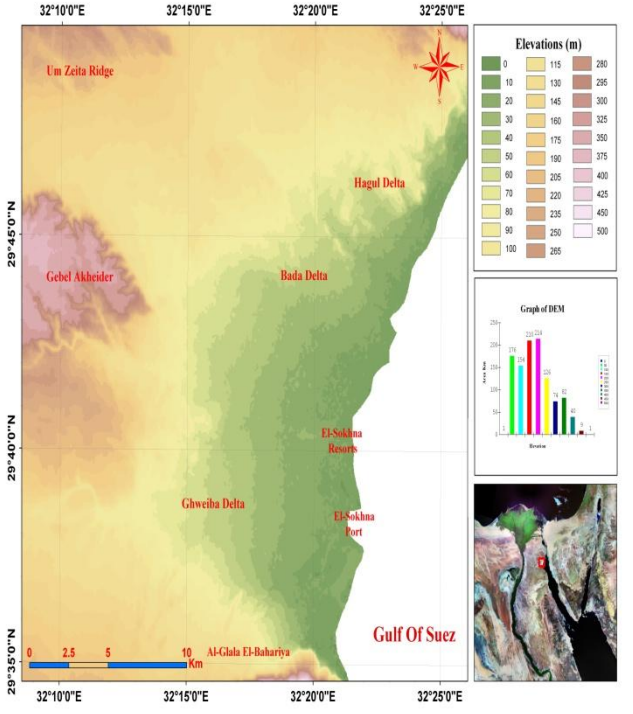

Figure (4): Digital Elevation Model of El- Ain El-Sokhna

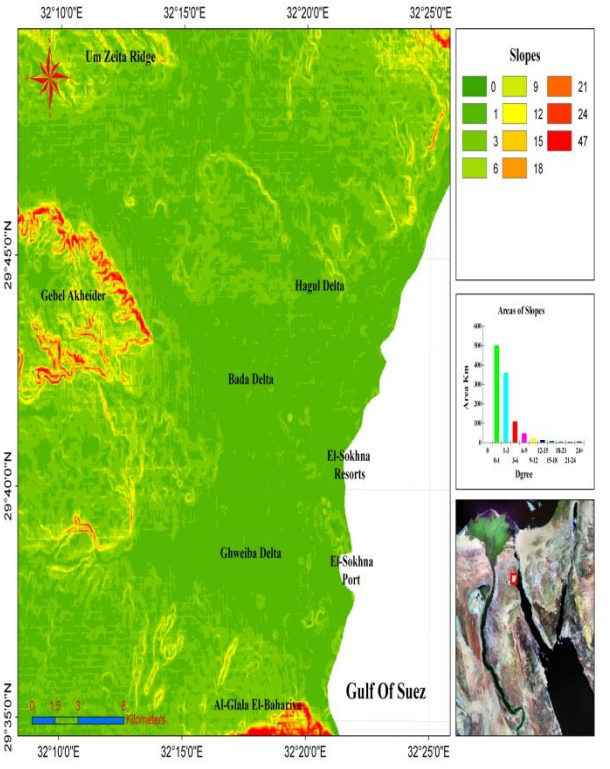

Figure (5): Slopes map of El -Ain El -Sokhna

The aspect map shows that the trend of surface slope to east, north east and south east representing 50.3 % of the total surface area, occur in deltas and wadi channels. The trend of surface slopes to north and North West representing 15.9% of the total surface area; occur in El Galala El Bahariya. The trend of surface slope to south, south west and west representing 34.1% of the total surface area; occur in some drainage lines of wadis (Figure, 6). The aspect map shows that the runoff of flash floods to the east is high probability and treats the resorts and manufactures.

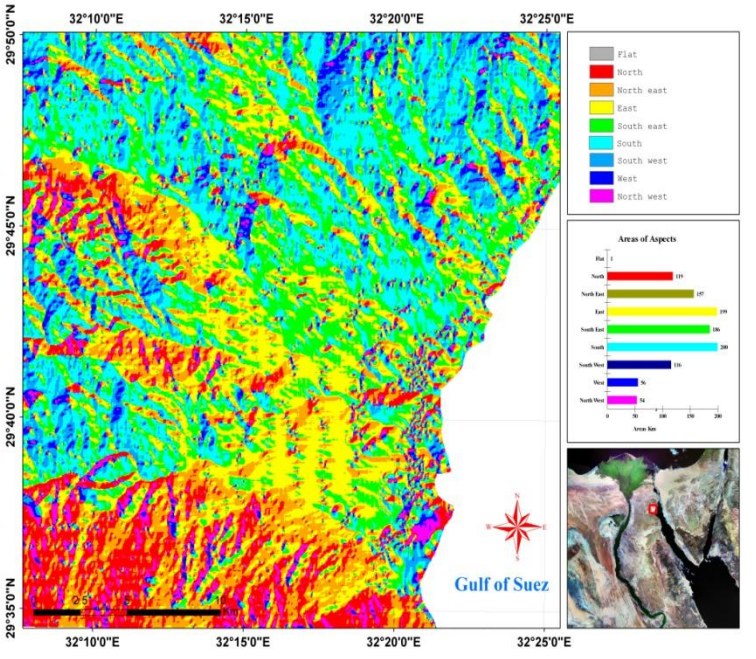

Figure (6): Aspect map of El -Ain El -Sokhna

5-Analysis of land-use/land-cover maps:

The land-use/land-cover maps produced by the supervised classification technique from LANDSAT 1984-2002 (Figure, 7), using ERDAS IMAGINE program v.8.7. (Figure, 8) shows land-use/land cover map of 1984. It consists of nine land-use/land-cover classes namely, sea water, alluvial fan, wet sabkhas, dry sabkha, wadi channels, industrial area, resorts and roads. (Figure, 9) shows land-use/land-cover map of 2002. The man-made features appear clearly in this figure. The figure consist of ten land-use/land-cover classes namely high lands, sea water, alluvial fan, wet sabkhas, dry sabkha, wadi channels, industrial area, resorts, roads and port. The difference between the land-use/land-

cover maps of the two dates shows the great increase in man-made features indicating the serious environmental changes in the study area.

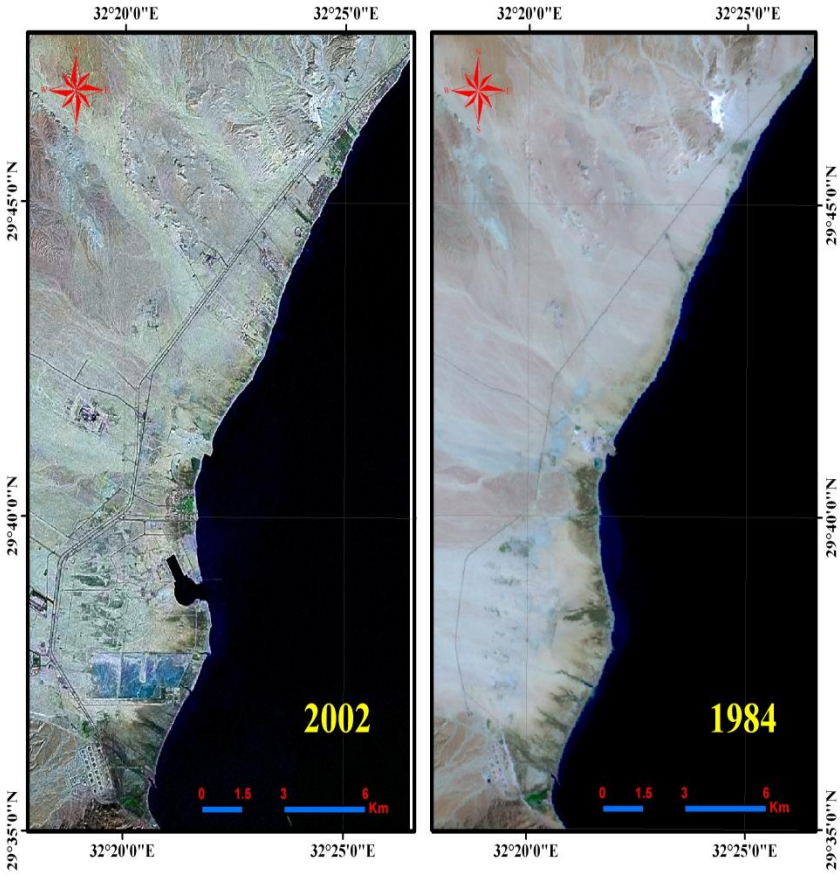

Figure (7): LANDSAT Images of El -Ain El -Sokhna

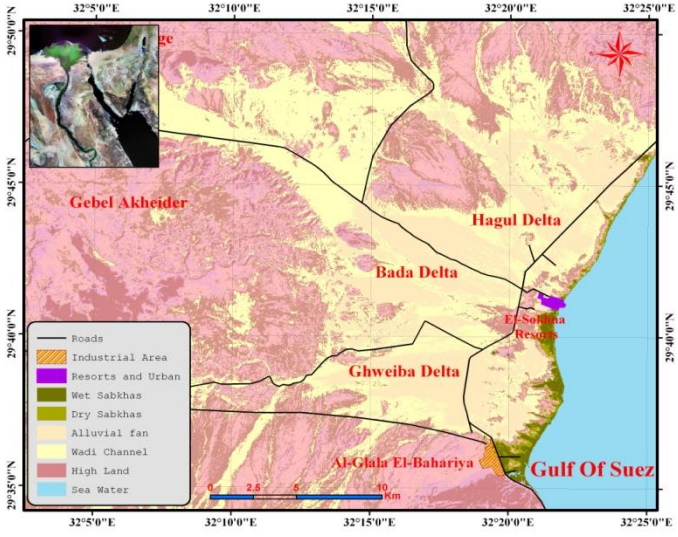

Figure (8): land-use/ land-cover (1984) of El -Ain El – Sokhna

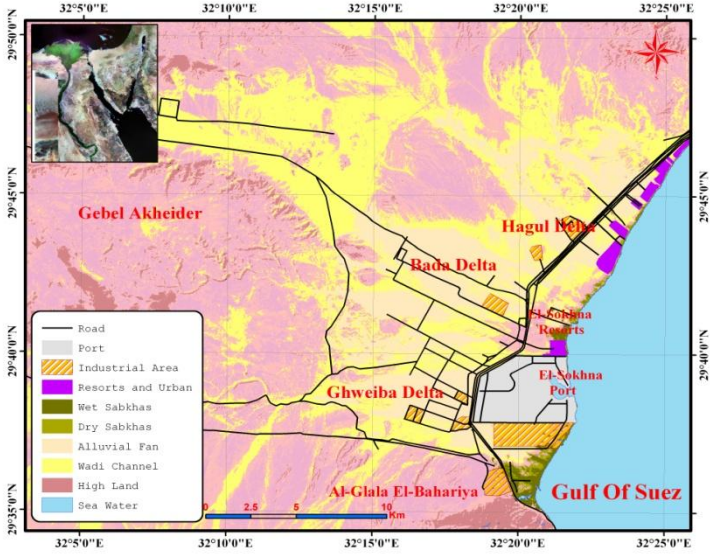

Figure (9): land-use/land-cover (2002) of El -Ain El - Sokhna

6-Change detection and its environmental impact:

The comparison between LANDSAT images of 1984 and 2002 and comparison between land-use/land-cover maps shows the detected changes in the study area during the period from 1984 to 2002 as follow:

- The total surface area of the changed land-use/land-cover is equal 71.14 km^2 representing 67.48% of the total surface area of coastal zone. The changed area concentrated around the shore line (Figure, 10).
- The total surface area of urban and resorts increased from 0.8 km^2 to 5.14 km^2 due to anthropogenic activities in the study area.
- Industrial area increased from 1.6 km^2 to 13.87 km^2
- Roads length increased from 143.41 km to 345.26 km.
- The total surface area of dry sabkhas decreased from 9.19 km^2 to 8.34 km^2 due to development of urban as well as constructed resorts over sabkha soils occurred mostly on the urban fringe of EL-Ain EL-Sokhna town. (Plate5).
- The total surface area of wet sabkhas increased from 4.86 km^2 to 9.12 km^2 due to the construction EL-Sokhna Port and rapid increased in industrial activity. (Plate6).
- The coral reef is negatively affected by the dredging activities.
- The bio-system covering the coastal zone is very poor due to continuous runoff sediment which supplies to the sea from the surrounding mountains, together with long shore current discharge of dredged inland material (Frihy, 2000)
- The intertidal reef flat is covered by a thin layer of fine grained sediments varying from sand to mud. These deposits are presently affected by the

addition of discharge material disposed from the disposal from the constructing of El-Sokhna port immediately adjacent to the northern limit of the power plant site. Sediments disposed into the sea have locally altered the coastline and the sedimentation pattern in this area. As a consequence, the coastline adjacent to the discharge site is progressively advancing seaward. The continuous accumulation of such sediments on the intertidal flat has also resulted in a serious of submerged sandbars. The formation of these bars suggests that the study area is a site of accumulation of sediments.(Frihy,2000)

- The hydrographic and water quality of the coastal water of El-Sokhna area lie within the expected normal levels characterizing the northern part of the Gulf of Suez, which is not affected by human interventions. Relatively high concentration of the suspended matter is attributed to sediments discharging from inland dredging activities at El-Sokhna port. The coastal water can be classified oligotrophic, i.e. poor in nutrient salts and productivity.
- The existing fauna and flora are very poor in the study area due to high sedimentation rate in the near shore zone. The sub tidal region is biologically deteriorated. Most of the observed molluscan and foraminifera shells are broken and very few living specimens were found.(Ahmed, 2000)
- The demolishing of sea grass mats would be affected negatively on the biodiversity of migrating birds (El-Gamily, 2003)
- The demolishing of sabkhas habitat is considered one of the most adverse impacts at El-Sokhna environment.

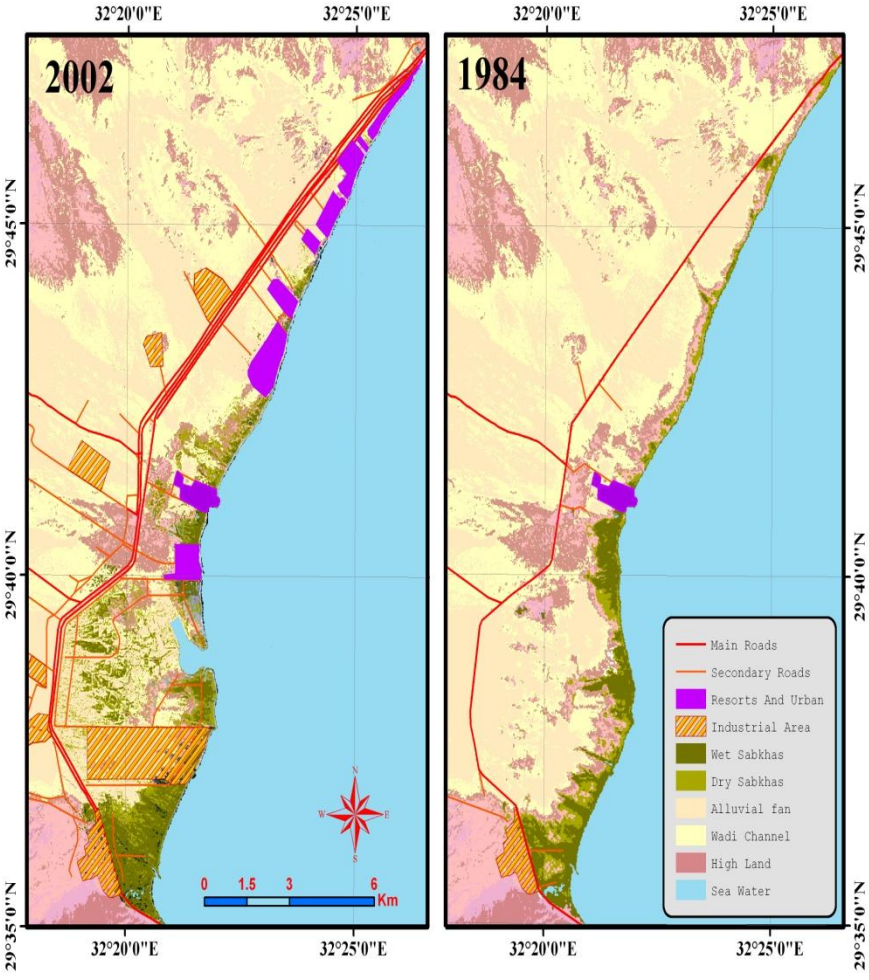

Figure (10): Environmental changes in the study area

7-Sources of hazards and its implications:

Gulf of Suez area is known geologically as unstable one since long time ago, consequently building, industrial areas, and also different man-made activities will cause different magnitude of hazardous.

Flash floods; among the hydrogeological conditions of the study area, the average annual

rainfall is 17.2 mm/year. Rainstorms usually occur at least once every year. The average annual value of perceptible water during storms is 12.2 mm (Salem, 1988).In the deltas of Bada and Ghweiba infiltration were found to be 0.2 mm/min. The previous studies about the morphometric analysis for the basins catchments area indicate that the bifurcation ratio values ranges between 4.7 to 4.04,drainage density values range between 3.2 km/km^2 to 4.9 km/km^2, while elongation ranges between 0.56 to 0.68.The drainage parameters in the study area are considered high and moderate flash flood risky basins. The flash floods attack resorts and industrial areas (Figure, 11).

Earthquakes; frequent and large events might affect the coastal plain of the Red Sea and the Gulf of Suez "mainly" between latitude 26^0 $45^{\backslash}$ N and 28^0 $15^{\backslash}$ N pose little seismic risk (Sultan, 1993), whereas its effect is a large destructive one.

Salt weathering; according to high temperature and evaporation, low rainfall enhance capillary rise of water into surface sediments and consequent concentration of salt crystals in the upper parts of soil profile causing acceleration of salt activity.

Surfaced roads in the study area show signs of damage as falling downs in terms of cracking, potholing, scabbing, stripping, crumbling and disintegration. The deterioration rate(s) in the roads is due mainly to lack of quality control. Some of buildings in the study area were affected by salt weathering affecting mainly the outer and inner paints (stone decay features) such as efflorescence, flowstone, granular disintegration, grey and black crust.

Pollution; there are many sources of pollutant agents (gas, noise, fluids) in the study area, the industrial areas west El- Sokhna adds significant

suspended particles to the pollution of the marine environment and air. The power generations are currently the primary sources of heated effluents released into the coastal marine water. Shipping in the Gulf of Suez causes real risks of oil spills. Tourism and the planned infrastructure for tourism has already caused some hazardous to the coastal ecosystem.

In the absence of regulation and education, tourists have a proclivity for breaking off pieces of living coral, spear fishing, and killing corals by stepping on them or anchoring in the reef area.

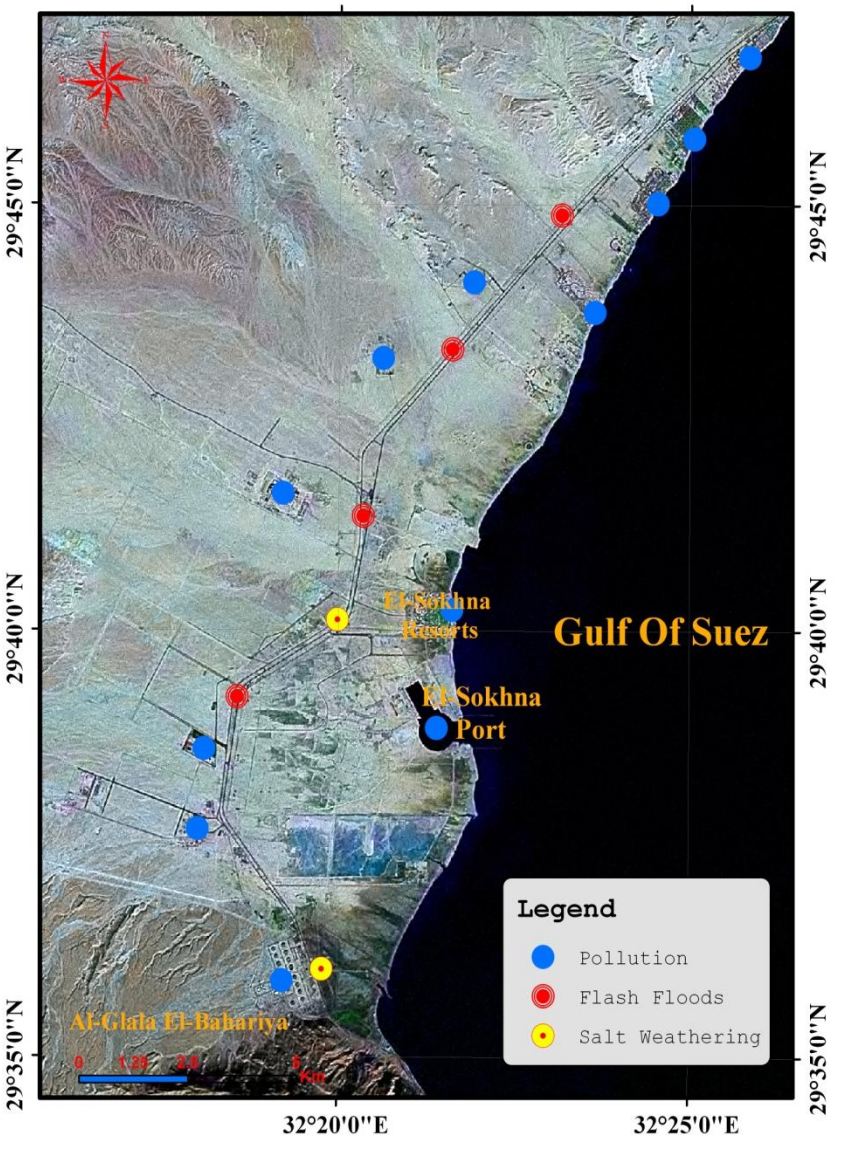

Figure (11): The hazard map of El -Ain El -Sokhna area

Conclusion and Recommendations:

El-Ain El-Sokhna area has valuable natural resources and habitats, almost during the last five decades rendering the site as an attractive one for tourism, industry, export and import activities. Consequently more care to the hazardous should be monitored tightly in order to keep the area flourished and off course to maximizes the national income. The study shows that the area is characterized by low and moderate levels dominated, as well as gentle slopes. The field investigations, analysis of LANDSAT images and land-use/land-cover maps revealed that the total changed area is 15.05% of the total surface area of the coastal zone. The major distinct changes occurring in the study area are due to the extension of urban, tourism activities, transportation, and construction of industrial areas and El-Sokhna Port during the period from 1984 to 2002 which is relatively short. The great increasing of man-made features has more effects seriously on natural resources in the study area. The bio-system covering the coastal zone is poor now and the hydrographic and water quality lie within the expected normal levels. The study area has been threatened by some hazards such as flash floods, earthquakes, salt weathering and pollution.

The following recommendations are introduced to protect and maintain the natural resources and habitats at the study area:

- The importance of producing Environmental Sensitivity Index maps for the entire Egyption coastal zones.
- The necessity of utilizing the multi dates remotely sensed data, in the monitoring of the environmental changes through out the Egyptian coastal zone

- The importance of preparing geomorphologic searches before the construction of urban and industrial areas.
- Introducing the culture and importance of natural protectorates in this area as to serve both monitoring and de-limiting the implications caused by the active hazardous in the area recently.
- Proper planning of soil choice and different fields of investment should be controlled and preceded by extensive studies showing the best way for investment.

Acknowledgment:

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Plate (1): Salt crust in the upper part of soil surfaces

Plate (2): Ghweiba formation in the lower part of Wadi Ghweiba

Plate(3): Delta deposits in the coastal zone

Plate (4):Geological formation in Gabel Akheider

Plate (5): Dry Sabkha in the coastal zone

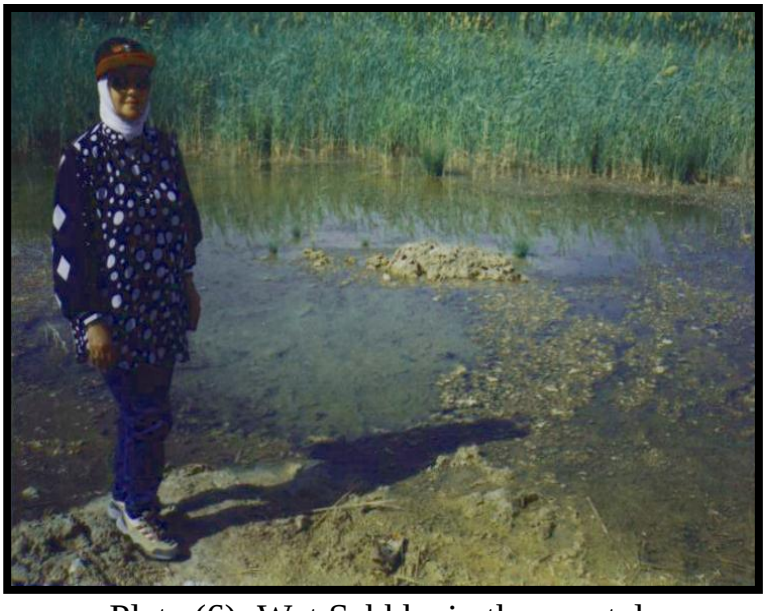

Plate (6): Wet Sabkha in the coastal zone