جامعة المنوفية
مركز البحوث الجغرافية
والكارتوجرافية
بمدينة السادات

مجلة مركز البحوث الجغرافية
والكارتوجرافية

العدد الحادي عشر

Change Detection of the North Sinai Coast

Using Remote Sensing and Geographic Information System

Doctor

Mohamed A. Azab

Faculty of Arts – Zagazig University

INTRODUCTION:

Coastal Zones are important issues in the international debate on the environment and sustainable development. The coastal zone generally consists from the interface between land and sea in such an equation where marine space and resources are as important as terrestrial ones.

The coastal zone has become the major site for extensive and diverse economic activities. Many of the coastal developing countries depend heavily on the scarce coastal resources for their economic growth. Rapid urbanization and economic development spawn complex resource use conflicts and environmental degradation problems in the coastal zones. Increasing population and market forces normally exert a heavier influence on the resources exploitation and use pattern.

Unexpected environmental hazards have been observed on the water bodies of North Sinai caused by sand movements, sand precipitation and salinitization .

Traditionally, natural hazards have been viewed in an ecological framework; this distinguishes between natural events and their interpretation as natural hazards .

Since the northern coastal zone of Egypt is a highly dynamic system, most of natural events show a wide range of variation, through time, in the use of energy and materials of environmental processes. The main goal of this study is to assess the coastal hazards that may occur due to shoreline changes (erosion or/and deposition), sand movements on the coastal zone. This will lead to determine the degree of hazard magnitude of the unstable coastal areas, which will reduce the environmental risk for the national development and natural resources of North Sinai coastal areas. This study will provide the end users and decision-makers with the necessary information on long term shoreline behaviors. This approach could be applicable to other coastal areas of Egypt (i.e. South Sinai , North of Eastern Desert and Red Sea coastal zones).

The identification of large-scale pattern of shoreline changes along Sinai coast implies that the coastal areas can be divided into a series of discrete sedimentation compartments called "littoral cells". Each cell contains a complete cycle of littoral transportation and sedimentation, including sources and sinks of sediments and transport paths. These sub-cells are part of the regional Nile littoral cells extending from Alexandria to Akko on the northern part of Haifa Bay, Israel (Inman and Jenkins 1984).

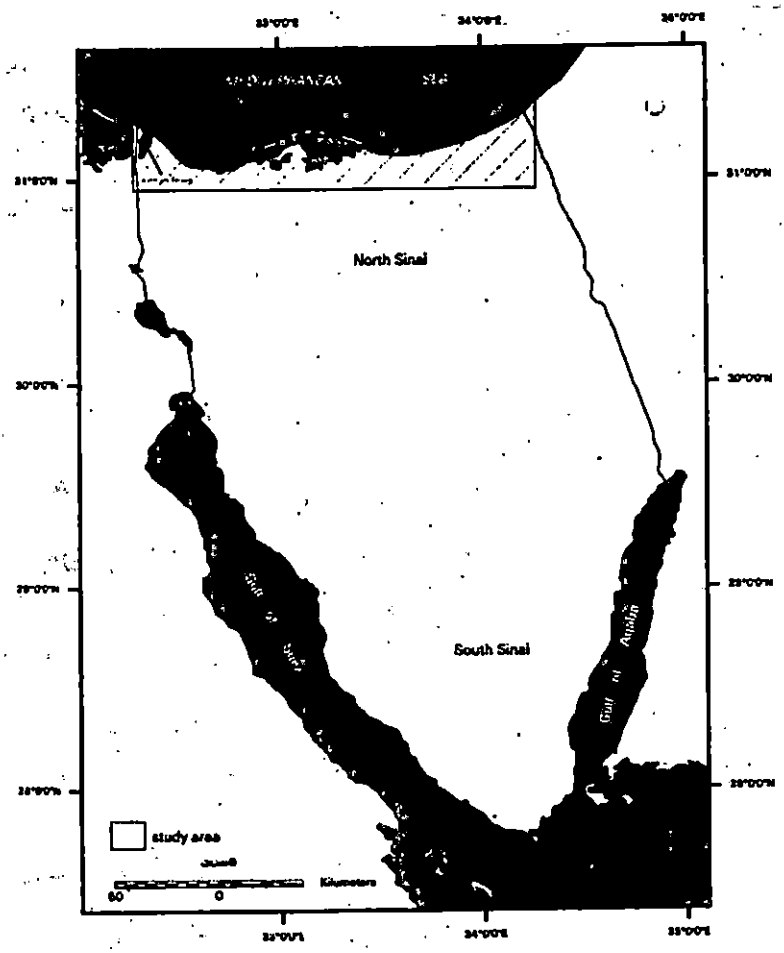
Seasonal variability of wave approach produces converging and diverging current pattern along the Sinai coast, the principal sources of sediments for each littoral sub-cell are the eroded headlands that supply large quantities of sand to the coast. Of particular importance to this study are the north Sinai littoral cells. Each sub-cell begins with a source area and ends by a sink. These cells have been previously identified based on shoreline changes by Frihy and Lotfy (1997). These are the Port Said sub-cell and Bardawil sub-cell. Each sub-cell contains a zone of erosion (sediment source) followed by a zone of deposition wherein sand eroded from a headland is transported to the east and is mostly deposited in the next embayment, resulting in shoreline accretion.

The Port Said sub-cell includes the eastward transport of sand along the down coast east of Port Said, about 67km, and deposition along the shoreline within At-Tinah Bay. The latter acts as sediment sink for the erosional products coming from the Port Said headland. For the most part, this sand is wave-driven by eastward littoral currents and currents generated by the east Mediterranean gyre which sweep across the inner shelf (Inman and Jenkins 1984).

The Bardawil sub-cell represents the general erosion along the central bulge of Bardawil lagoon barrier and the longshore transport of sand to the east, where it is deposited to produce shoreline accretion along the embayment of El Arish-Rafah beach. El Arish-Rafah embayment acts as a sediment sink for sand eroded from the arcuate bulge-barrier of Bardawil lagoon.

The geographic location of the study area :

The study area extends at the Northern Sinai Coastal zone between 32^0 20\' - 34^0 00\' East and 30^0 55\' - 31^0 20\' north, which extends about 175 km. long from Port Fouad in the west to Rafah in the east. This coastal area of Sinai is considered as an integral part of the Mediterranean Coast of Egypt (Fig. 1). The landforms are predominantly sand dunes, sand sheets, and coastal depressions (Swedan , A. et. al., 2001)



(Fig. 1) Location map of the study area

OBJECTIVES :

- Determine the pattern of shoreline changes along North Sinai coastal area.
- Determine the hazard areas due to coastal changes, as well as natural hazards affecting use and development of resources.
- Provide maps showing the hazard areas over the coastal zones of North Sinai.

METHODOLOGY:

All changes have been determined along Northern Sinai Coastal and Bardawil Lake using vectors obtained from satellite images of Thematic Mapper (TM) acquired in 1984, 1996 (scenes No.175/38, 175/39, 176/38, 176/39) and the topographic maps 1973 of scale 1: 100,000. The topographic maps (5 sheets: Port Said, Rommanah, Bohairat Al Bardwel, Al Aresh and Rafah) are geometrically corrected using the control points and the digital image data, first of all enhanced by removing weather effects filtered by used software ERDAS IMAGINE.

The pattern of erosion versus deposition is interpreted from the relative movement of shoreline in the seaward or landward directions along the study area.

The horizontal movements of the shoreline position shifts were measured at several points in the shoreline Fig.(7).

PATTERN OF EROSION AND DEPOSITION IN NORTH SINAI:

Changes in shoreline positions along the Sinai coast are attributed to natural and anthropogenic factors. This could be represented as follows:

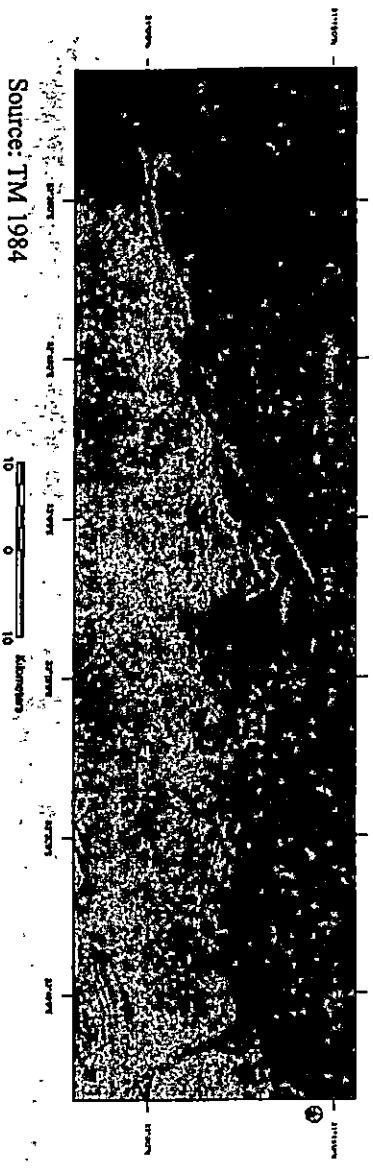


Fig. (2) Shoreline of the North Sinai from TM 1984

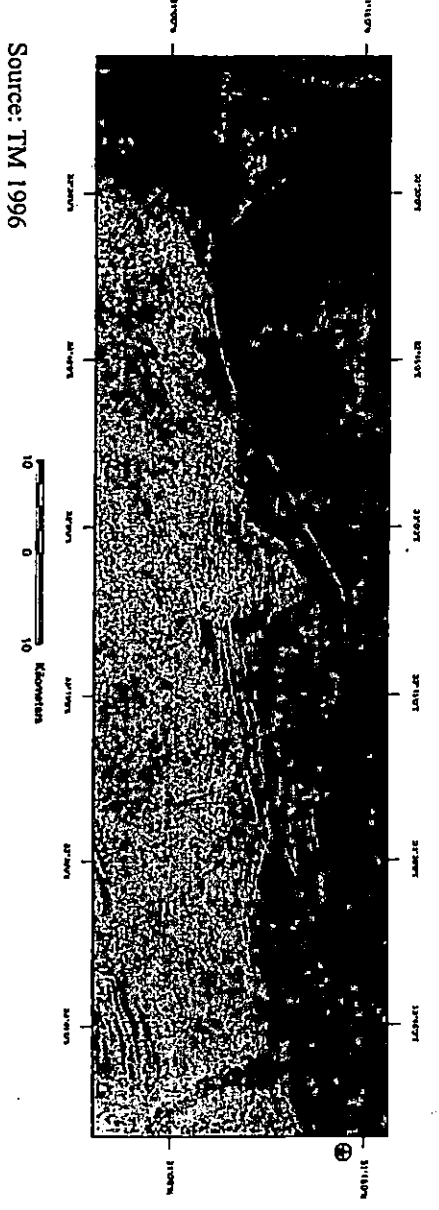


Fig. (3) Shoreline of the North Sinai from TM 1996

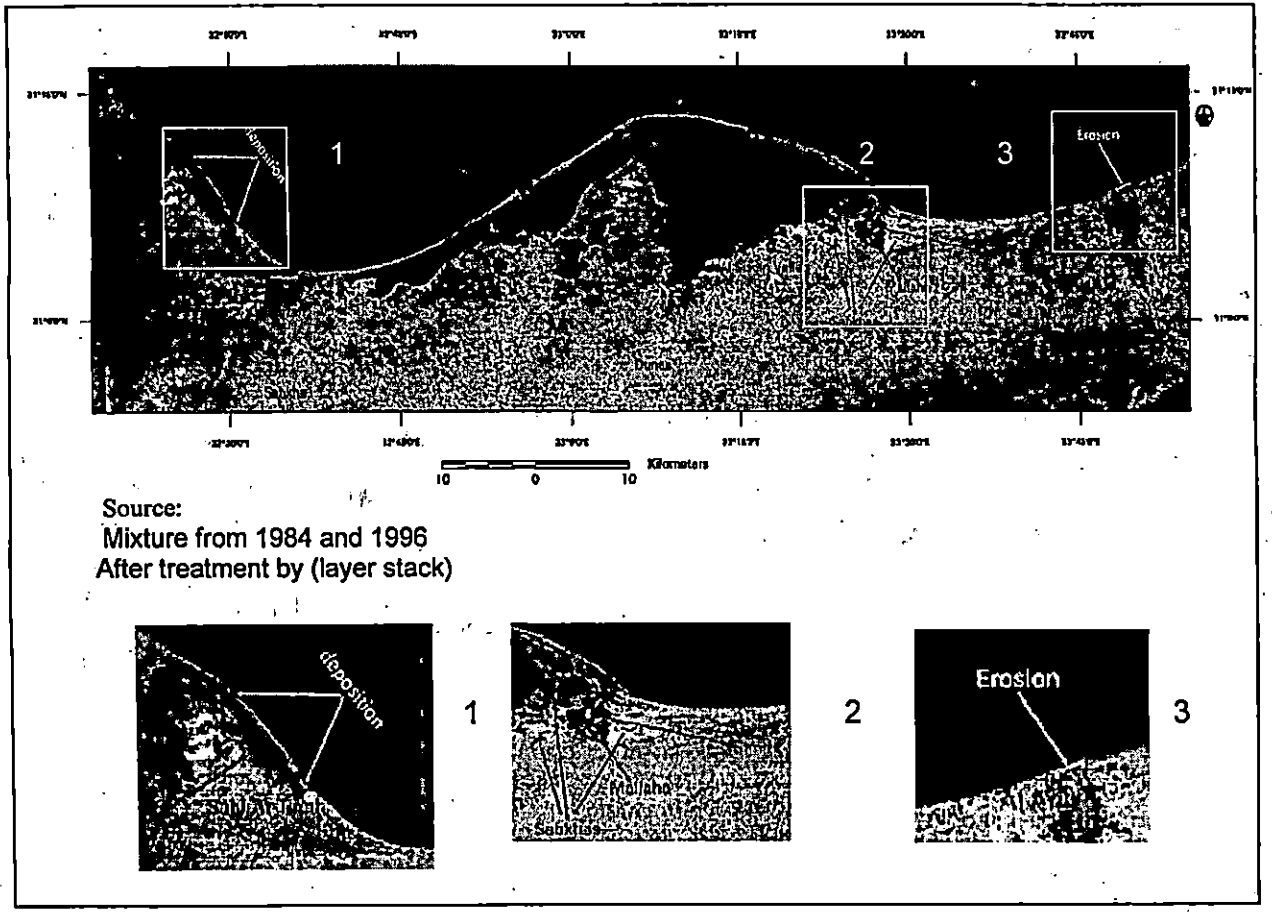


Fig. (4) Change Detection of the North Sinai Coast from 1984 and 1996

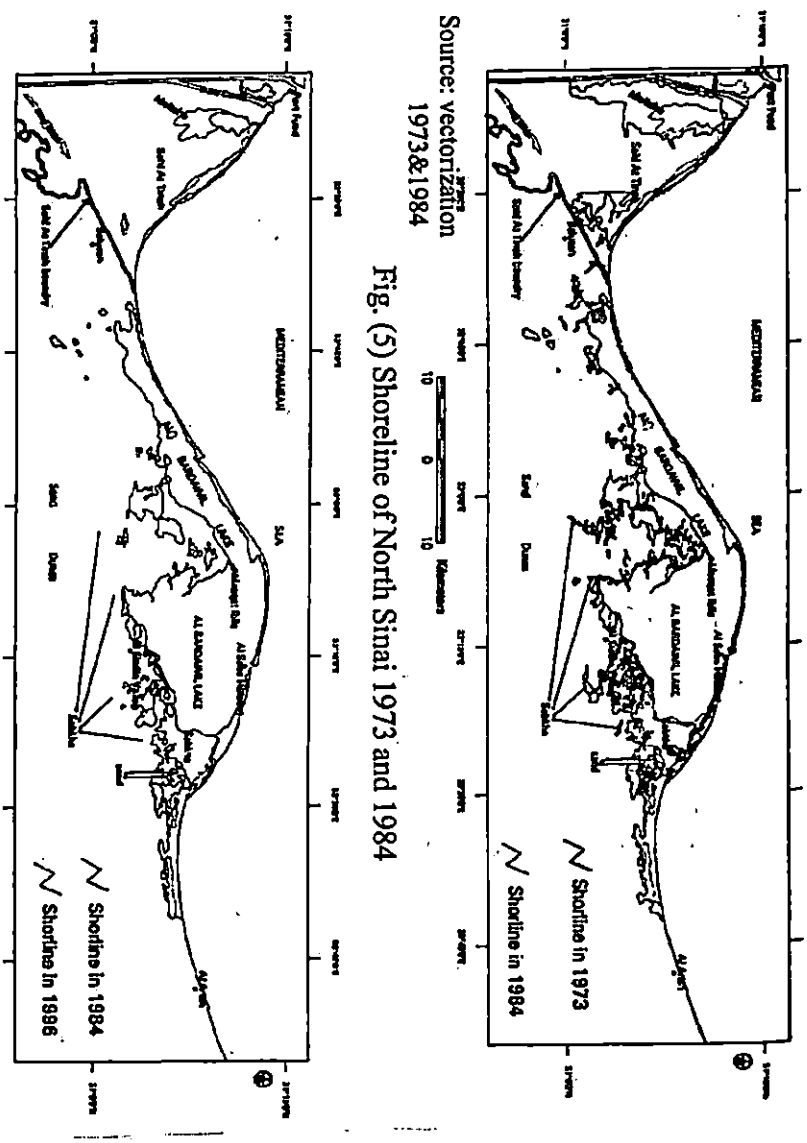
A- Natural Changes:

Previous works revealed that the shoreline of the North Sinai is accreted over the last 72 years at an average rate of 11.7 m/ year. Relatively smaller rates were calculated on the historical basis from-dated, accretion ridges (1925 years) and from Tel El Pharma historical site (2000 years). These rates are 1.6m/year and 1.8m/ year, respectively (Frihy, 1994). This difference could be attribute to the difference in time span, thousands of years versus tens used in case of the satellite images. According to wave directions, the shoreline pattern is a response to an southeastward transporting of sand, resulting from the prevailing wave arrive from the NW, generating southeastward flowing long shore currents. Sand is eroded from the east Port Said shore and adjacent shelf area and subsequently transported down coast to the east and southeast, resulting in shoreline and bottom accretion.

The resulted coast-wide patterns of shoreline changes reveal that significant erosion is occurred along down coast east of Port Said followed by accretion along the embayment of At Tinah Bay, the later is interpreted as a "sediment sink". This pattern represents a simple pattern of erosion from the eastern tip of Port Said headland, with the eroded sand moving by waves coming from the NW, generating eastward-flowing long shore currents to the east wherein deposition occurs along the embayment of At Tinah Bay. The erosion processes of the winds accumulating great volumes of sand, which probably is transported to the east by littoral currents. Some of these sediments are transported into the basin causing sedimentation on the seabed.

The horizontal movements of shoreline position shifts are measured computerized. The examined pattern is inferred from the comparison of the following shoreline positions in these figures

- **Shorelines of 1973 and 1984 (Fig. 5).**
- **Shorelines of 1984 and 1996 (Fig. 6).**
- **Shorelines of 1973 and 1996 (Fig. 7).**



Source: vectorization
1973&1984

Fig. (5) Shoreline of North Sinai 1973 and 1984

Source: vectorization
TM1984&1996

Fig. (6) Shoreline of North Sinai 1984 and 1996

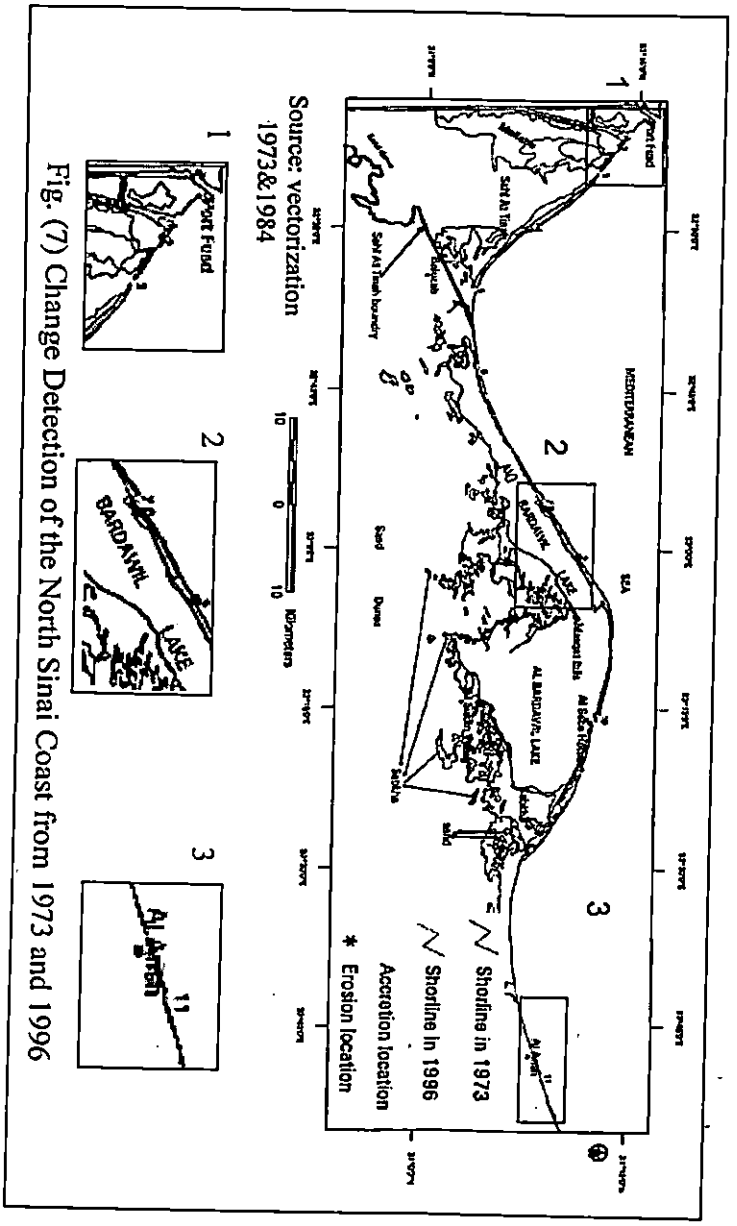


Fig. (7) Change Detection of the North Sinai Coast from 1973 and 1996

According to the results derived from image processing and comparing the shoreline in 1973 from topographic sheets and in 1996 from satellite image, the coast shows wide patterns of changes (erosion and accretion). In eleven observation points on the shoreline presented in fig.(7). The shoreline changes estimated in table No. (1).

These measurements reveal that significant accretion occurred along down coast east of Port Said at the net accretion rate of 32 m/year in observation point No. 1. This is followed by erosion along the embayment of At Tinah Bay and the eastern part of El Bardawil lagoon barrier.

Observation points	1	2	3	4	5	6	7	8	9	10	11
Shoreline Change from 73 to 96	+730	-297	+83	+420	+154	+61	+113	-164	-240	+254	+185
Average m/year	+32	-13	+4	+18	+7	+3	+5	-7	-10	+11	+8

Table No.(1) North Sinai shoreline changes in different places

Moving eastward from part of Port Said shows mild net erosion rate of 13 m / year in observation point No.2. Erosion is reverted to accretion along the coastline of El Tineh plain and the eastern part of Bardawil lagoon barrier up to Inlet. The accretion pattern induced from this study is evidenced from the chronic accretion features documented in this region since about 2000 years ago (Sneh and Weissbrod, 1973). This was indicated from a series of accretion coastal sand ridges parallel to the present coastline of El Tineh Bay and in observation points No. 3, 4, 5, 6 and 7. The eroded sand moving by waves coming from the NW, generating eastward-flowing alongshore currents to the east wherein deposition occurs along the embayment of Tineh Bay. Further to the east, erosion also occurs in the observation points No. 8 & 9. Along the arcuate bulge of the central Bardawil coast-barrier with a maximum net rate of 18 m/ year over 23 years is reached.

Changes of Bardawil Lake :

Sedimentation unbalance is more pronounced at many sites on the lagoon sandy barrier. This imbalance has impacted the ecosystem in the lagoon by causing serious shoaling problems and thus changing the ecosystem of the lagoon and the fish productivity in particular (Swedan, A. et. al., 2001) Several attempts have been carried out since 1972 to combat this problem. Significant changes which occur in down coast orientation at the two inlets produce movable sand bars leading to changes in the shape and the width of the Bardawil Lake inlets.

Large quantities of sand are being blockade on the western side of the jetties, which were built to prevent shoaling the artificial inlets of the lagoon. As a consequence, the eastern coast of each inlet has been subjected to erosion.

Rate of sediment transport at these inlets is considerably high according to Aerial Photographs, the sediment transportation have been estimated, the net to be from 0.3 to 0.5 million m^3 /yr. in the eastward direction (Swedan , A. et. al., 2001).

Change Detection of the water bodies, represent in table No. (2) and fig (8), we can see that the area of Bardawil Lake changed rapidly from year 1973 to year 1984 and the average loss is 128 Km^2 /y and changes slowly from year 1984 to year 1996 and the average loss is 5 Km^2 /y

year Location	1973	1984	1996
At Tinah Bay	1238.8	336	317
Bardawil Lake	6864.7	5447.5	5389.2

Table No. (2) Change Detection of the water bodies from 1973-1996 (in Km^2)

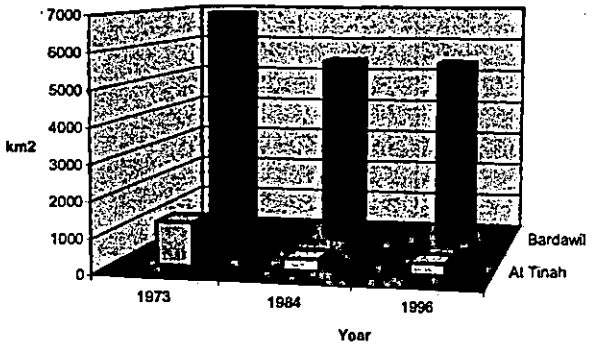


Fig. (8) Change water areas between 1973 to 1996 of the Bardawil Lake and Sahl At Tinah Bay.

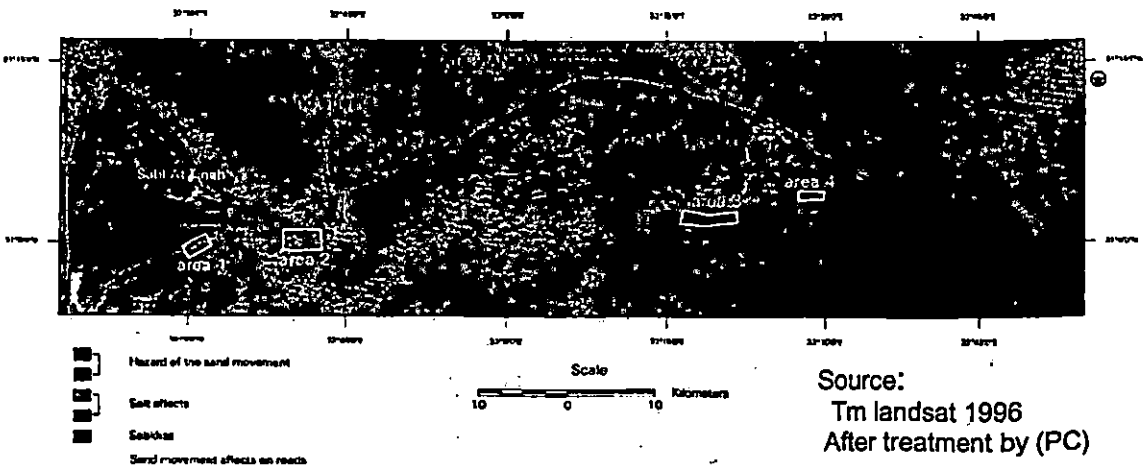


Fig. (9) Different hazard affects on the study area

Changes of At-Tinah Bay :

The resulted coast-wide patterns of shoreline changes revealed that significant erosion occurred along down coast east of Port Said followed by accretion along the embayment of At-Tineh Bay, the later is interpreted as a "sediment sink". This pattern represents a simple pattern of erosion from the eastern tip of Port Said headland, with the eroded sand moving by waves coming from the NW, generating eastward-flowing alongshore currents to the east wherein deposition occurs along the embayment of At-Tineh Bay. Sedimentation unbalance is more obvious at many sites on Sahl-At-Tinah and At-Tinah Bay, Fig.(9).This Sedimentation has impacted the ecosystem in these sites by causing serious shoaling problems and thus changing the ecosystem of them and the fish productivity in particular. The large quantitative of the deposited sand, vaporization, saline and the human activities in these sites cause of these changes.

Table No.(2) and fig.(8) which show the areas of North Sinai water bodies in different years (in Km^2) we can see that the area of At-Tinah Bay changes rapidly from year 1973 to year 1984 with average loss is 83 Km^2, and changes slowly from year 1984 to year 1996 and the average loss is 1.6 Km^2.

sand movement HAZARDS:

Using remote sensing techniques we can determine the location of the most threat areas, which can be represent in this area by 4 sites in which sands affect on the asphalt roads figures (9 & 10).

Generally, it is expected that the following impacts will happen

1- Direct inundation and loss of beaches and archaeological sites with associated loss of tourism and damage of the international coastal road .

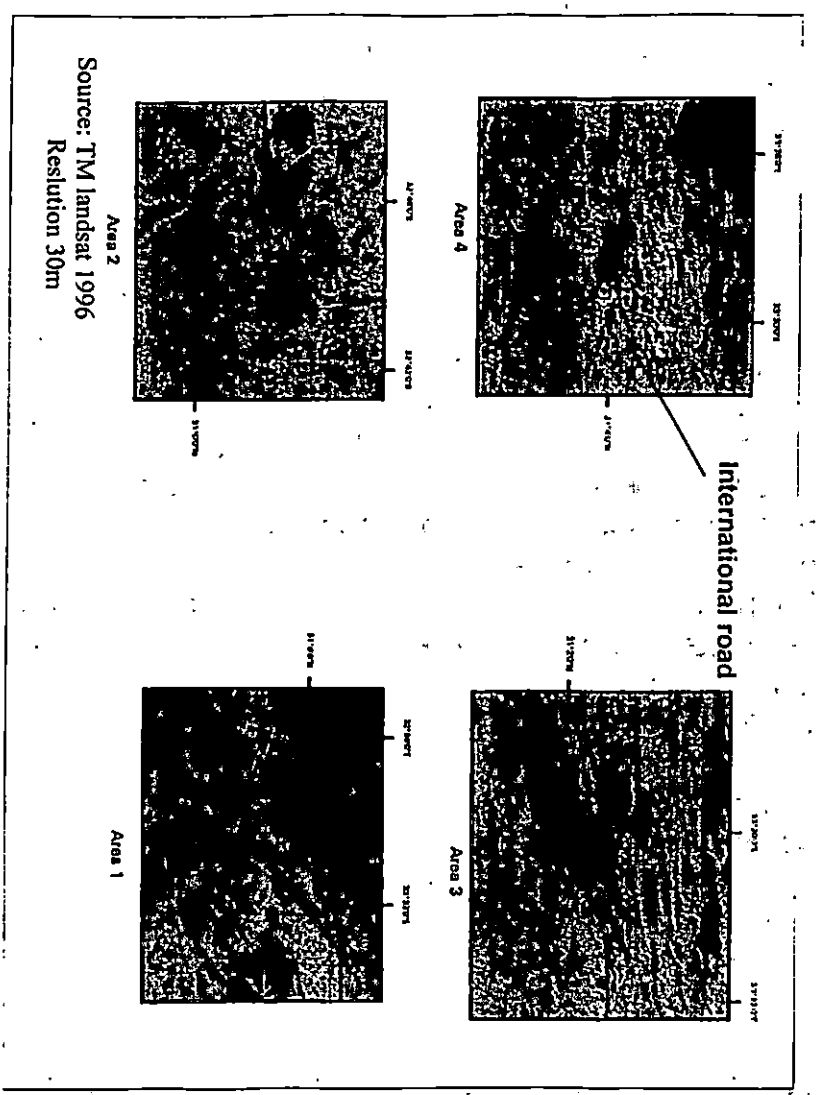


Fig. (10) Sand and sabkha affects on roads

2- Loss of arable and agricultural land and fishing grounds and a decrease of fish catch in some areas and an increase in other areas.
3- Increase in the rate of salt water intrusion, soil salinity, water logging, desertification and a loss of land productivity.
4- A change of the coastal water circulation pattern, with associated changes in fish catch and navigation.
5- A decrease of life spans of coastal buildings and archaeological sites due to increase of saltwater intrusion.
6- Contamination of fresh water aquifer, with associated agricultural losses.
7- Impacts on the harbor designs due to changes in sea level and frequencies of storm surges. This may cause severe economic losses.

Real policy implications are as follows

1- Beach nourishment and groins:

a- Beach nourishment strategies.
b- Depositing sand onto the open beach.
c- Beach scraping.
d-Building artificial dunes as storm beach sand reservoirs buffers.
e-Laying pipes underneath the beach to suck in the water.
f- Groins trap sand, which cover the beach.

2- Breakwaters:

a-Break-waters are hard structures used in beach protection.
b-The wave energy reaching the shoreline.
c-It is the best available tool for the lowland areas protection.

3- Legal Development Regulation:

It means taking legal or regulatory actions to restrict development or prohibit development in a hazard-prone area.In Egypt, this strategy has no effect on fishermen, farmers and industrial workers, but may affect only businessmen

References:

El Fishawi, N. M. and Badr, A.A. (1995): Erosion and Flooding as related to Recent Sea Level Rise, Nile Delta coast, Egypt. MEDCOAST '95. Institute of Marine Biology of Crete.Cited :http//ww. irnbc. gr/biblio_ serv/medcst/ X0120 097. Html

Embabi, N. S., (1998): Sand seas of the Western Desert of Egypt: In A. S. Al-Sharhan and (Eds.). Proc. Inter. Conf. Quaternary Deserts and Climatic Change, Al-Ain, U. A. E., Rotterdam. Balkema, p.495-509.

ERDAS (1997): ERDAS Field Guide, Atlanta Georgia, and USA ERDAS, Inc. 5th ED.,665p.

Frihy, O. E.; Lotfy, M. F.,(1997): Shoreline changes and beach sand sorting along the Northern Sinai Coast of Egypt, Geo. Marine Letters, 1997, V.17, no.2, P. 146.

Frihy, O. E., (1994): Discrimination accreted and eroded Coasts using heavy minerals compositions of the Nile Delta beach Sanob., Sedimentology, 1994, V.41, no.5, P.905–912.

Inman, D.L. and Jenkins,S. A.,(1985): The Nile littoral cell and man's impact on the coastal Zone of the southeastern Mediterranean, Am. Soc. Civ. Eng., New York, United States, P.1600–1617.

Sneh, A.and Weissbrod, T.,(1973): Nile Delta; the defunct pelusiac branch identified; Sci., Repr. No. 45, 1973, V.180, P 59 –61.

Swedan, A.,et. al.,(2001): Shoreline changes along Sinai Coastal Zones and Lake Nasser Western Boundary; Sedimentary geology of Egypt, Applications and Economics, Part 2, Environmental GeoEgyptology, 2001.

رصد التغيرات لمنطقة الساحل الشمالي لسيناء باستخدام الاستشعار عن بعد ونظم المعلومات الجغرافية

د/ محمد عبد العزيز عزب
zizoazab@hotmail.come-mail:
قسم الجغرافيا - كلية الآداب - جامعة الزقازيق

منطقة الدر اسه تمتد على طول الساحل الشمالي لشبة جزيرة سيناء والتي تعتبر جزء من ساحل البحر المتوسط. منطقة الدراسة هذه هى منطقة ساحلية تتكون من تداخلات بين الأرض والمياه وتعتبر تلك هذه المناطق الساحلية ذات أهمية خاصة من الناحية الجغرافية والاقتصادية والبيئية وخصوصا منطقة ساحل شمال سيناء لما يتميز به من موقع جغرافي وموارد طبيعية نستطيع من خلالها عمل التنمية المستديمة.

أن الهدف الرئيسي من هذه الدر اسه هو رصد وتوضيح المخاطر الطبيعية الناتجة من عملية التآكل والترسيب للساحل وكذلك المخاطر البيئية للمنطقة وذلك لاختيار انسب الأماكن الصالحة لعمل التنمية المستديمة وإقامة المشروعات عليها وكذلك رصد أماكن الخطورة والبعد عنها في إقامة المشروعات او عمل المعالجات اللازمة لها.

وقد تم في هذه الدراسة الاستعانة بالعديد من مصادر المعلومات منها الخرائط الطوبوغرافية مقياس رسم ١ : ١٠٠٠٠٠ لسنة ١٩٧٣ وكذلك لقطات من القمر الصناعي الأمريكي (TM) لسنة ١٩٨٤ و ١٩٩٦ والمعلومات التي تم رفعها من الدر اسه الميدانية .

تم عمل تصحيح هندسي لهذه الخرائط والصور ثم عمل طبقات معلوماتية لمنطقة الدراسة وعمل المعالجات اللازمة لها من خلال البرنامج المتخصص في معالجة صور الأقمار الصناعية ERDAS IMAGEN وذلك لتوضيح التغيرات الطبيعية والبيئية التي طرأت على المنطقة خلال الفترة من ١٩٧٣ - ١٩٩٦ وعمل التوصيات بها.

Change Detection of the North Sinai Coast
Using Remote Sensing and Geographic Information System

In the last few decades, Geo-Environmental and pollution were common phenomena in North Sinai coast; as a result to natural and human impact. The changes affected on the sustainable development and planning processes, as well as they threaten people activities and quality of life. In order to determine, assess, evaluate and manage these changes, Topographic maps, Remote Sensing data and GIS were used added to fieldwork. This study identified those changes in :

1- North Sinai shoreline changes, as result to erosion and deposition due to waves, tides, sea level rising. The measurements showed that the average of erosion ranged between -7 to – 13 m/year for the period from 1973 to 1996, and the average of deposition was + 3 to + 32 m/year for the same period.

2- The shrinkage of Bardawil lake water body area, where the area was 6864.7 km2 in 1973, reduced to 5389.2 km2 in 1996. The continuous reduction due to unplanned human activities, and the excessive of evaporation process.

3- According to the sea level rising, and inspecting of the level will rise one meter in 2100 (EL Fishawy and Badr 1995), the sea water will cover big areas of the northern part of the North Sinai lands. In order to manage those problems, the study present number of suggestions that may help in the area planning and useful in sustainable development.