Applying Remote Sensing and GIS to detect changes along northern coast of Egypt

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Abstract

Information technology has developed rapidly. In recent years, the application of Remote Sensing and Geographical Information Systems (GIS) has become an essential demand in all fields, in which including the study of Environment and Natural Hazard. The northern coast of Egypt has changed clearly in many areas along the Mediterranean Sea for many different reasons such as influence of human activities and by the action of waves and current.

Keywords: Remote Sensing, GIS, Accretion, Erosion.

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1. Introduction

The position of the Egyptian Northern Coast is very important in socio-economy system of Egypt, and is the place where there is also a lot of urgent problem such as shore corrosion and conserving the environment. Economic activities didn't obtain high result by limited knowledge about characteristic of geological environment, which have negative effect on geological and ecological environment. Remote Sensing and Geographical Information System (RS & GIS) has applied in many fields throughout, in there including the study of geological environment. This application has made great advances in management for coastal environment and developed activities in order to achieve high economic effect. Therefore, application RS & GIS in researching geological environment and natural hazard at Northern Coast of Egypt is right and necessary.

2. Basic Features

The Northwest Coast of Egypt forms a belt about 20 Km deep, which extends for about 500 Km between Amria (20 Km west of Alexandria) and El Salum near the borders with Libya.

Physiography

The region can be subdivided into five physiographic areas, each with its own particular topographical features (FAO/UNDP 1970; Ayyad *et al.* 1990):

Alexandria to Alamein : The coastal plain is wide and includes three main ridges running parallel to the coast – a recent coastal ridge covered by sand dunes, and two old consolidated ridges – with flat depressions in between .The coastal plain rise to the Maruot Plateau at an elevation of 5-40 m asl.

El Alamein to Ras El Hekma: This is an irregular succession of alternating low hills and closed depressions, sloping from south (60 m asl) to north (the coastline). There is an almost continuous range of dunes along the coast.

Ras El Hekma to Ras Abu-Laho: The cliffs of the Libyan Plateau run parallel to the coast. A discontinuous series of dunes develops at a distance varying from 200 m to 3 Km from the coast. There are some saline depressions in the lower part of the plain, some with outlets to the sea. The escarpment of the plateau is deeply cut by wadis.

Ras Abu-Laho to Sidi Barrani: This region is characterized by a uniform topography. The coastal belt of alluvial soils is narrow and intermittent. South of the coastal belt, a large area of gentle uniform slopes extends up to the Libyan Plateau.

Sidi Barrani to Salum: A flat coastal band 2-4 Km wide, is found South of the dunes, starting some 10 Km east of El Salum. A few large depressions occur along the edge of the Libyan Plateau at 200 m asl. Some important wadis dissect the escarpment, especially southwest of Sidi Barrani.

Main Climatic Features

The North West coast (NWC) is characterized by dry Mediterranean climate, with average high and low temp of 18.1 _C and 8.1 _C in the winter and 29.2 _C and 20_C in the summer, respectively. Rainfall in the Northwest Coast ranges between 105.0 mm / yr at El Salum and 199.6 mm / yr at Alexandria. Data from eight stations situated near the coastline show that most of the rainfall (70% or more) occurs within the winter months (November to February), mostly during December and January.

There is significant variation in rainfall from one location to another, which is attributed mainly to the orientation of the coast at these locations. The prevailing rainfall gradient from north shows that the average mean decreases sharply from 150 mm near the coast to 50 mm at 20-70 Km inland. The NWC area has the highest average wind speed in Egypt in the winter where wind speed could reach 18.5 Km/hr. Wind speed drops gradually inland.

Soil and Water Resources

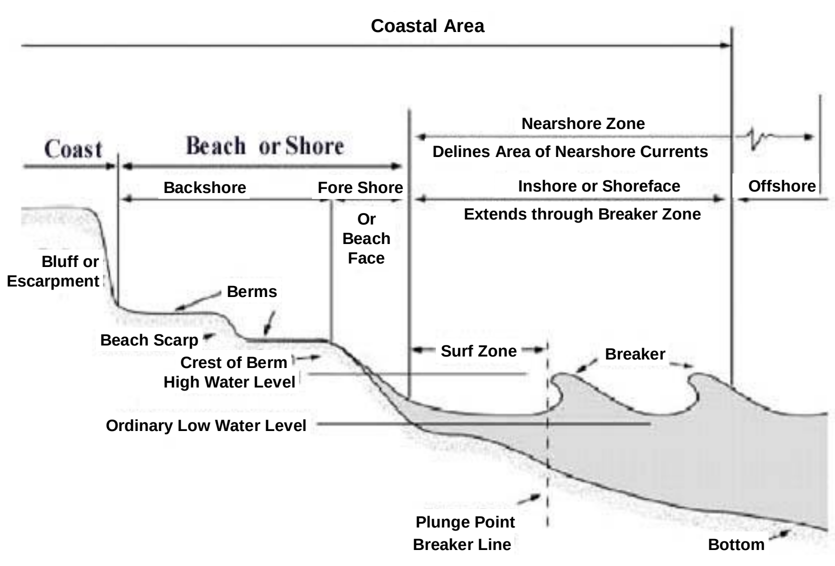
Soil types and properties are highly influenced by geomorphic and pedogenic factors. The main soil units could be summarized as follows:

- Coastal oolitic sand dune
- Soils of the lagoonal depressions.
- Consolidated dunes.
- Deep sand and clay loam soils.
- Moderate to limited depths of sandy to clay loam.
- Windblown formations.
- Soils of the alluvial fans and outwash plains over the plateau.

Water resources are mainly that of rainfall, groundwater resources are limited and usually of low quality especially with respect to varied salinity content.

Human Resources

Human Resources are diversified in distribution, background, level of education and occupations. Agro pastoralists with tribal traditions are the main dwellers of rangelands. Lately wide-spread construction of touristic villages and summer resorts spread all along the Mediterranean Sea Coast bringing human resources affiliated to these villages and summer resorts. Urban dwellers occupy several cities and small towns along the main International Road to the Libyan borders.



Beach profile terminology adapted from the Shore Protection Management 1984

Some Terminology of the Coasts

It is a remarkable fact that beaches around the world are quite similar in composition and shape. The beach profile, which is a cross section of the beach taken perpendicular to the shoreline, is generally composed of four sections: the offshore, the nearshore, the beach, and the coast, The sand making up this profile, is shaped by waves coming from the offshore and breaking in the nearshore zone, where sandbars may exist. The foreshore, or swash zone, is the region of the profile that is alternately wet or dry as the waves rush up this steep portion of the profile. The dry beach may have one or more berms, which are horizontal sections of the profile, and scarps ,which are near-vertical cuts caused by wave action during higher water levels perhaps associated with a storm. The landward portion of the beach may have sand dunes created by winds blowing sand off the beach into these features (aided by the sand-trapping capability of beach grass and other vegetation) or a bluff or a cliff (particularly on elevated eroding shorelines).

The beach profile and planform shapes are a result of the action of waves and currents at the shoreline. The waves not only suspend the sediments but give rise to nearshore currents that carry the suspended sediment alongshore or cross-shore. a long-shore current is driven by waves breaking obliquely to the shoreline and flows in a direction corresponding to the wave direction. Often, this current turns seaward and becomes a rip current, taking sediment (and hapless swimmers) offshore. The sediment carried by the waves and currents is referred to as the littoral drift ,and the amount of sediment moved along the coast is the littoral transport ,or long-shore sediment transport, which is usually measured in units such as cubic meters per year or cubic yards per year (see the appendix to this chapter for conversion among different units). As the wave environment changes during the year, the transport can change directions; however, a most coastlines there is a dominant direction of sediment transport. *Down drift* refers to a direction coincident with this dominant transport direction, whereas up-drift is the opposite direction. The cross-shore transport, which is caused by wave-or wind-induced mean cross-shore flows, is largely responsible for the existence of sandbars and other beach profile changes. These changes can be slow, on the order of years in duration, or they can occur rapidly during storms with time scales on the order of hours.

3. Original Data and software.

A- Archived TM Satellite Images Data

Archived TM Landsat Satellite Images for the following path and rows respectively 177/38, 178/38, 179/38, 180/38, 181/38, that cover the Egyptian Mediterranean coast, these archived data acquired in 1984.

B- Recent TM Satellite Images Data

More recent TM Landsat Satellite Images cover the same path and rows. These data were acquired in 2003 were also used.

C- Topographic maps

The following sheets of scale 1:250000

Al Salum, Sidi Barrani, Matruh, Al Iskandryia, Al Alameen, Al Mansoura, Al Qahiera.

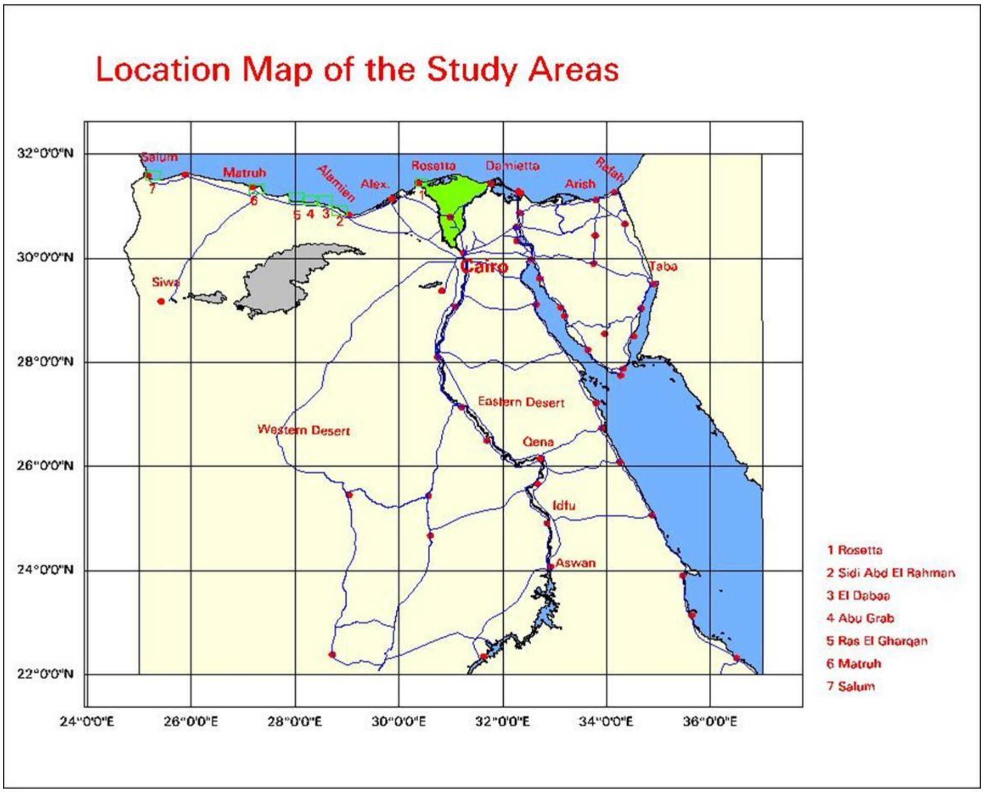


Fig.1 Location Map of the Areas

D- Software

ERDAS Imagine 8.3 software, WinWord, PowerPoint

3. Preliminary Processing.

To clear up the remote sensing images (RS images interpretation) is defined as a process of separating the quality information and quality information from each image. The main processes were carried out, manipulation and interpretation.

Manipulation processes includes pre-processing, i.e., Geometric correction, Image enhancement, and radiometric correction are the main processes for image processing. Unsupervised classification techniques were used to emphasize changes between eroded and accreted areas as well as changes along the Northern coast of Egypt.

- Seven main areas has been chosen for monitoring the shoreline during the two dates (1987, and 2003).
- The seven areas from east to west are (Rosetta, El Alamien El Dabaa, Abu Grab, Ras El Gharqan, Matruh and El Salum). Fig. (1) shows the location of each area.
- The techniques used described briefly as
    1- subset image from the two dates data
    2- unsupervised classification into only two classes (land and water)
    3- recode the classified images to become **zero** for water and **one** for the land
    4- apply subtract between each two recoded classified images
    5- the result well be three main classes [zero for that pixels not changed, positive values for that pixels changed from water to land ACCRETION and finally negative values for the pixels changed from land to water EROSION].

4. Observations.

1- In Rosetta area at the end of the Nile branch while there is a very high rate of erosion resulting disappear of many features such as El Ghalion lagoon, El Shaqaqy lagoon , El Hemeir lagoon and Rasheed light house, there is a low rate of accretion along the eastern beach in front of Ezbet El Waqf. Fig. (2)

The measurement of the erosion rate recorded 171 m/yr in the period 1984-1987, 130 m/yr in the period 1987-1993, 40 m/yr in the period 1993-1997 and finally 25 m/yr in the last period 1997-2003.

The total erosion in the full period 1984-2003 is 1608 meter by rate 80 m/yr

- The rate of erosion decreased as a result of the protection process but it is not enough.

2- In Sidi Abd El Rahman area the observation shows erosion with rate of 30 m/yr in the period 1987-2003 in the western side in the area around Sidi Abd El Rahman and the accretion happened in El Derazia area and the inshore lagoons tend to dried the area of land increased. Fig. (3)

3- In El Dabaa area the observation shows erosion with rate of 52 m/yr in the period 1987-2003 in the western side in the area between Elwet El Dabaa and Tanoum El Kabeir and the accretion recorded south Ras Abu Grouf area and the inshore lagoons tend to be dried and the area of land increased. Fig. (4)

4- In Abu Grab area the observation shows erosion with rate of 50 m/yr in the period 1987-2003 in the eastern side in the area between Abu Sandouk and Ras El Dabaa and an accretion recorded in around the area of Abu Grab with a rate 28 m/yr. Fig. (5)

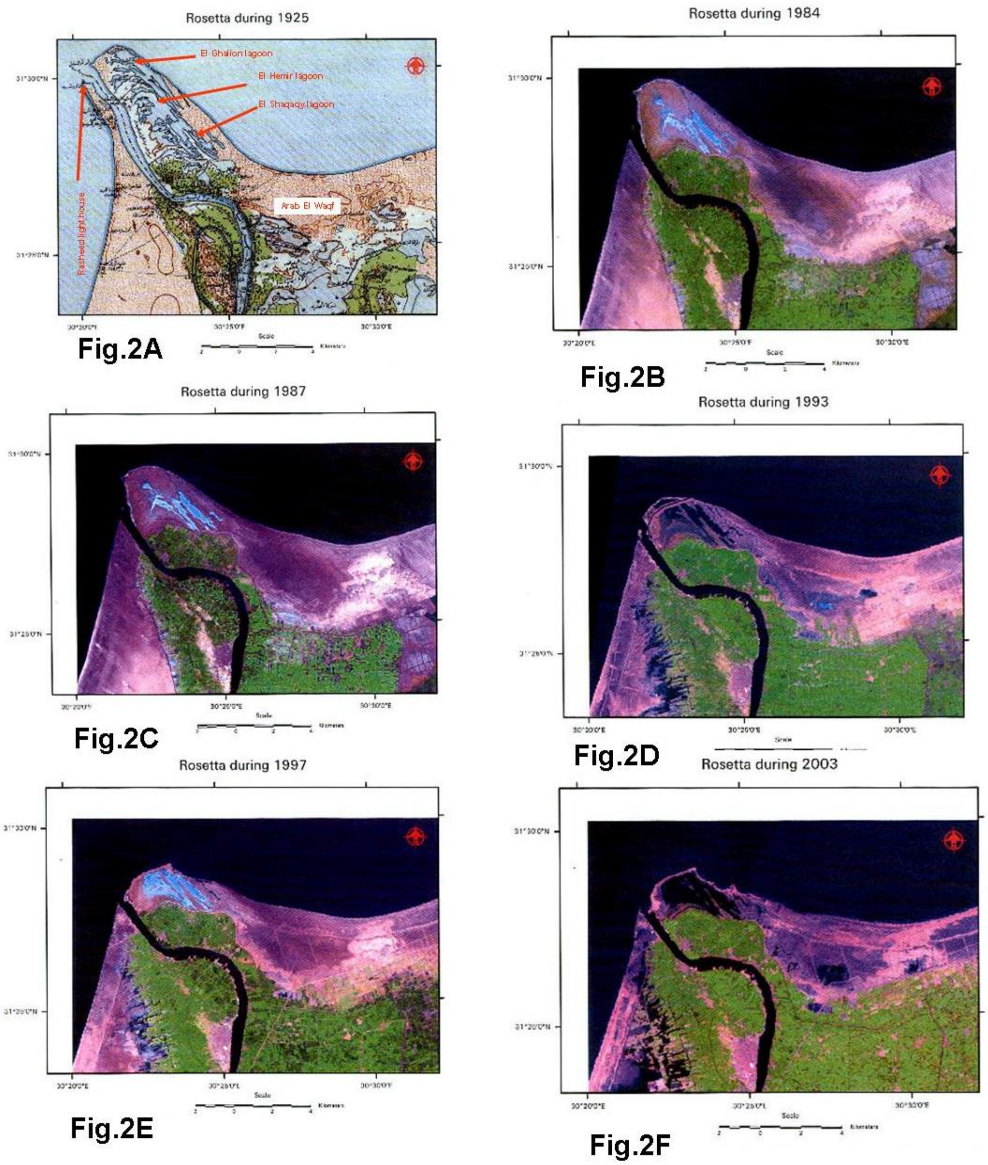


Fig. 2 Rosetta area

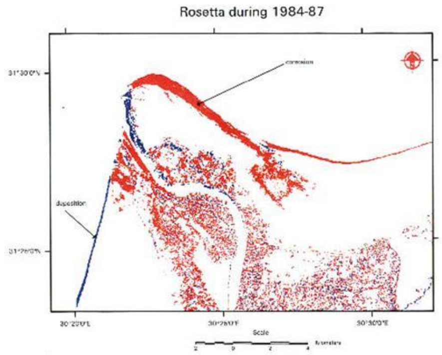


Fig.2G

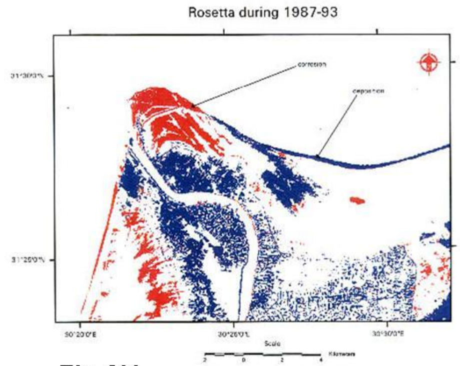


Fig.2H

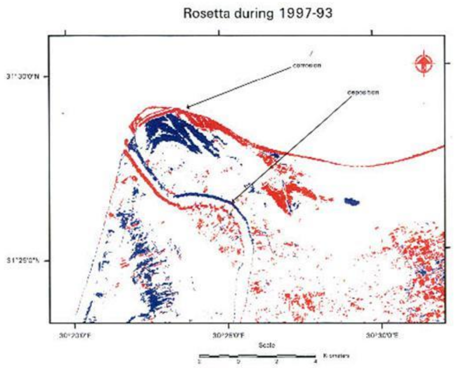


Fig.2J

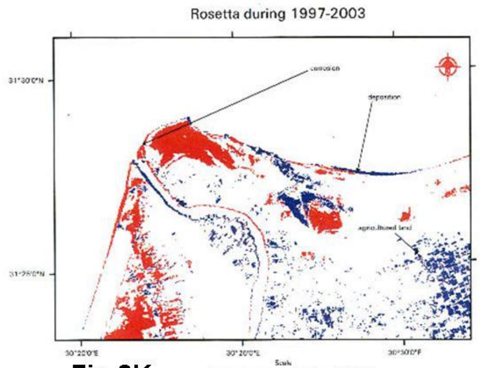


Fig.2K

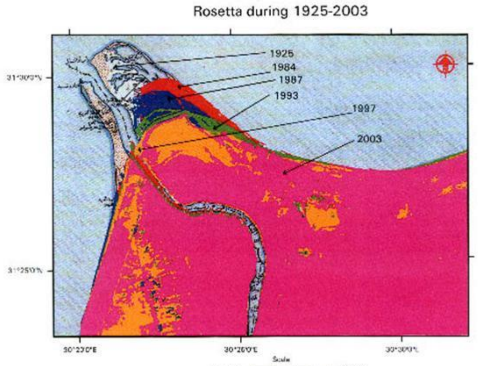


Fig.2L

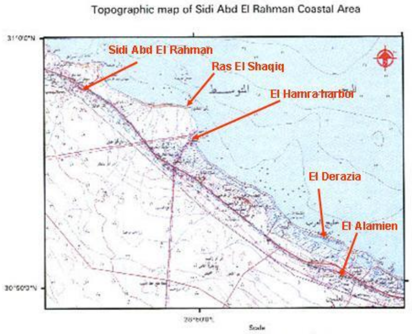


Fig.3A

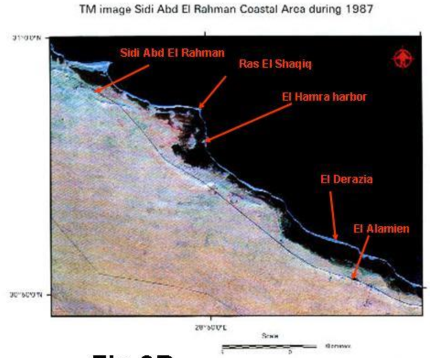


Fig.3B

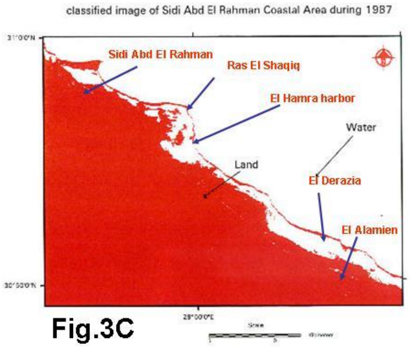


Fig.3C

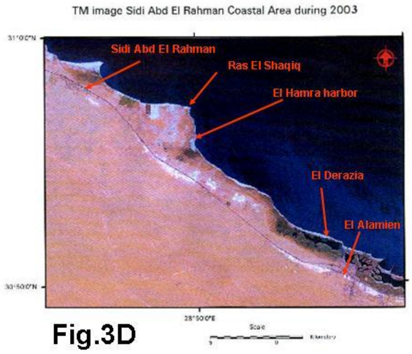


Fig.3D

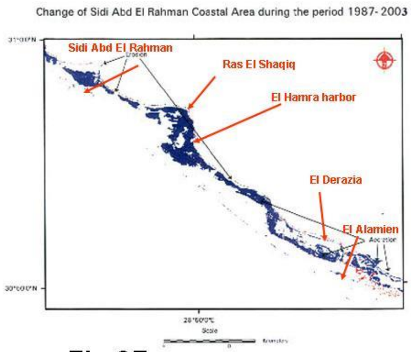


Fig.3F

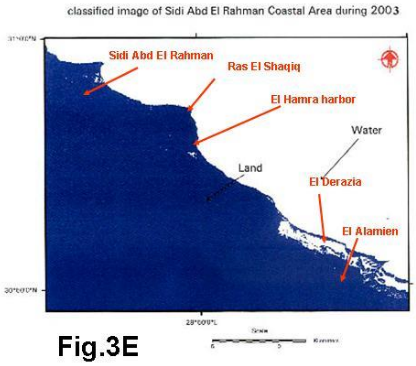


Fig.3E

Fig.3 Sidi Abd El Rahman Area

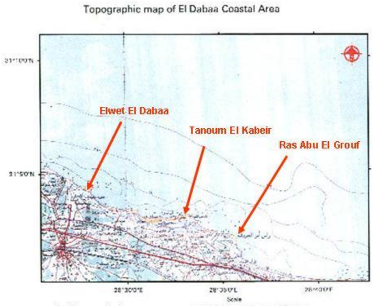


Fig.4A

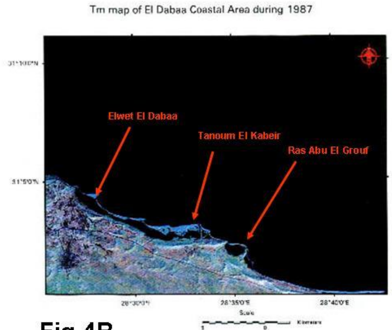


Fig.4B

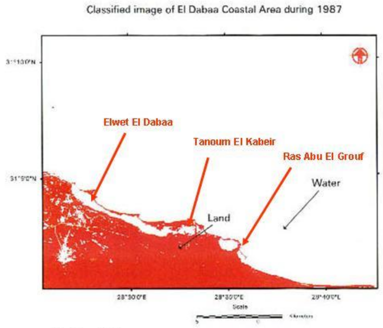


Fig.4C

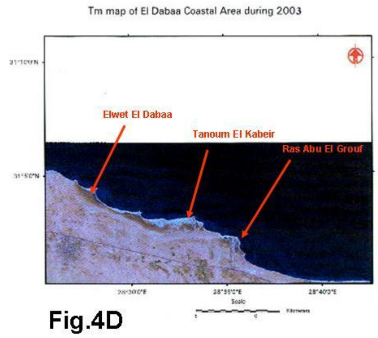


Fig.4D

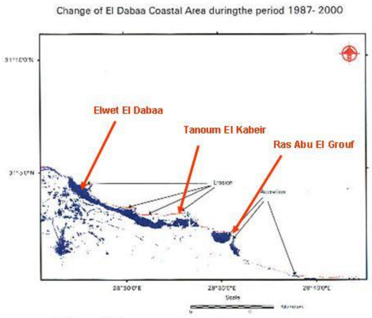


Fig.4F

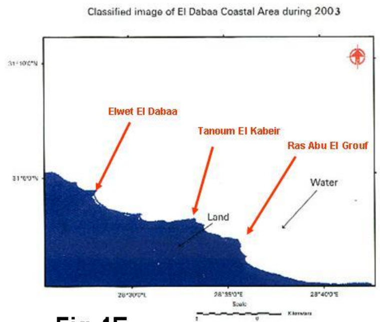


Fig.4E

Fig. 4 El Dabaa area

5- In the Ras El Gharqan area the area of accretion found in front of El Hekma Gulf till Ras El Ghgarqan with a rate up to 75 m for the whole period between (1987-2003) Fig. (6).

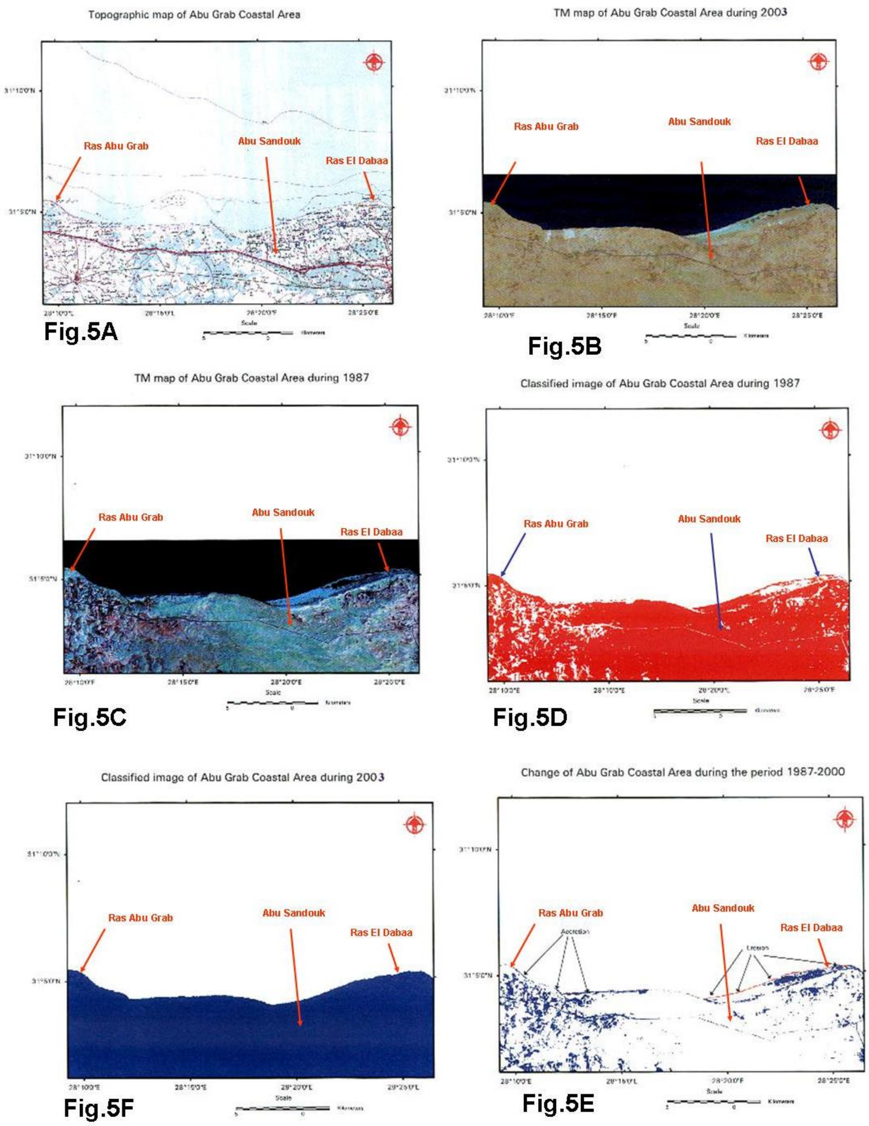


Fig.5 Abu Grab Area

6- In Matruh area the erosion observed in the western area of Matruh till Fukah while the inshore lagoons in Alam El Room area dried increasing its land for the whole period between (1987-2003) Fig. (7).

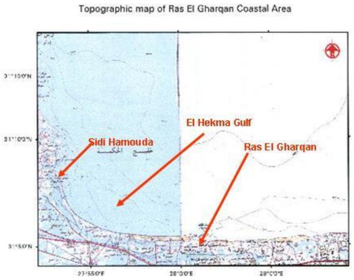


Fig.6A

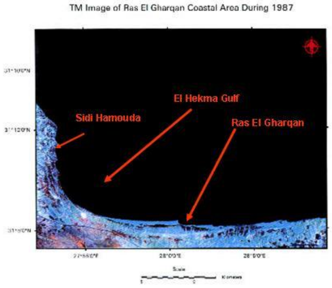
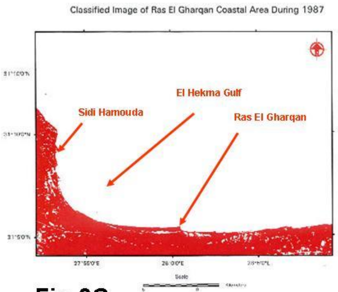


Fig.6B



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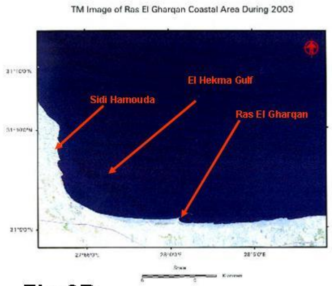


Fig.6D

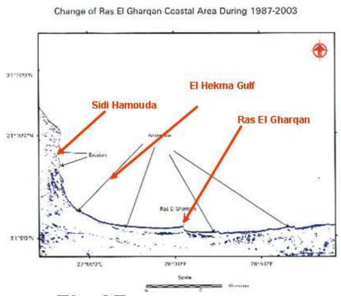


Fig.6F

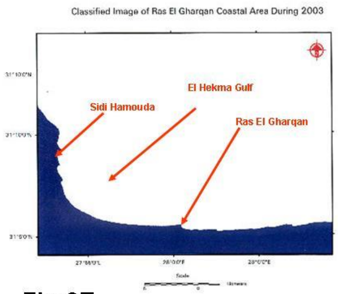


Fig.6E

Fig. 6 Ras El Gharqan area

7- In El Salum area the area erosion recorded at Alam El Karar with a rate up to 29 m for the whole period between (1987-2003) Fig. (8).

Topographic map of Matruh Coastal Area

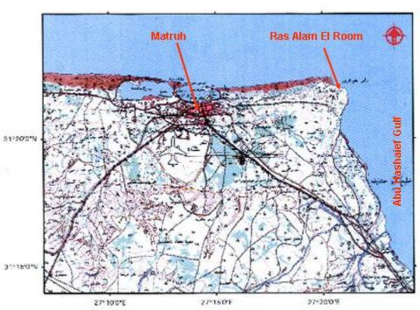


Fig. 7A

TM Image of Matruh Coastal Area during 1987

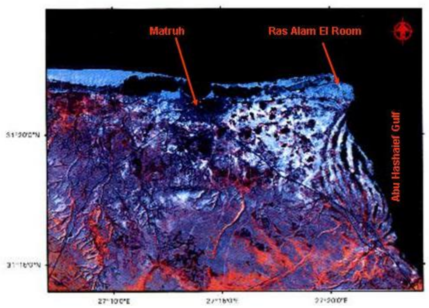


Fig. 7B

TM Image of Matruh Coastal Area during 2003

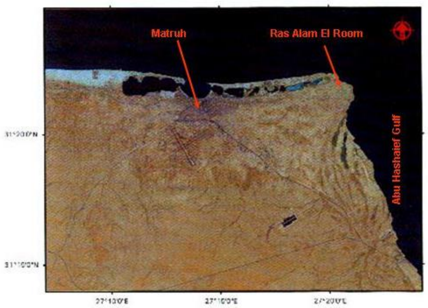


Fig. 7C

Classified Image of Matruh Coastal Area during 1987

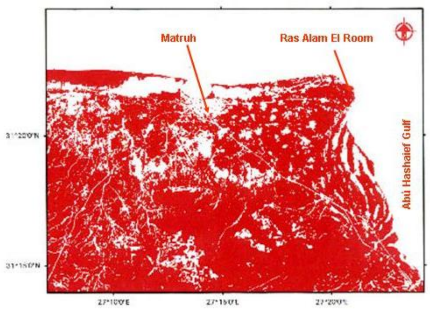


Fig. 7D

Classified Image of Matruh Coastal Area during 2003

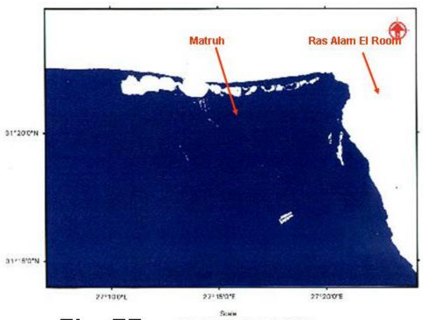


Fig. 7F

change along Matruh coastal area during 1987-2003

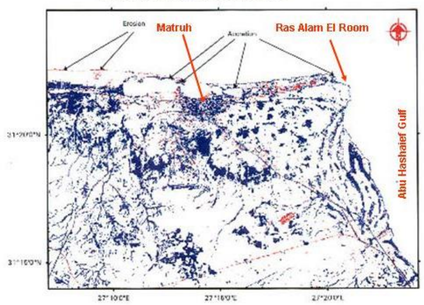


Fig. 7E

Fig. 7 Matruh Area

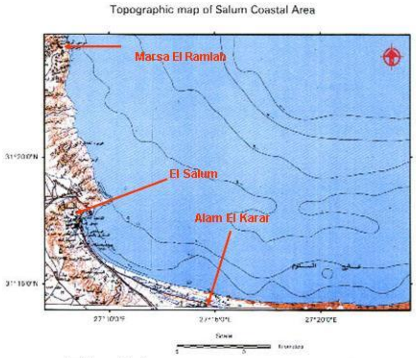


Fig.8A

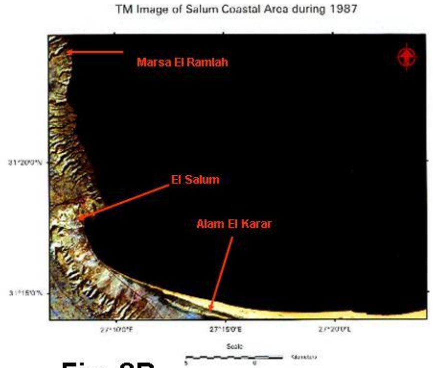


Fig. 8B

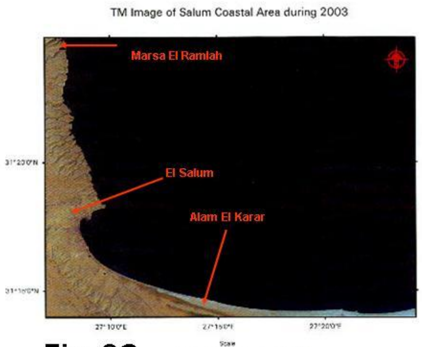


Fig. 8C

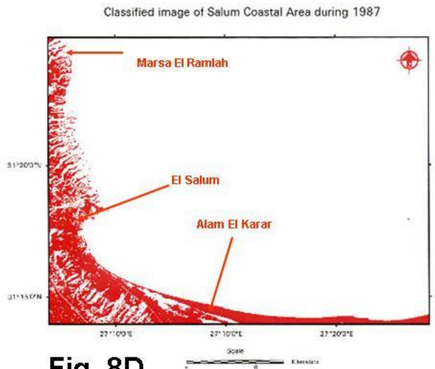
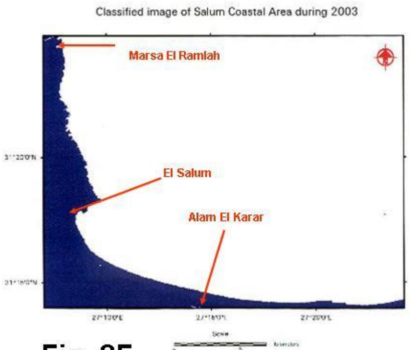


Fig. 8D



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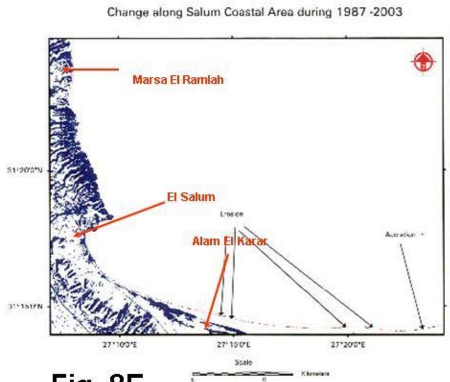


Fig. 8E

Fig. 8 Salum area

5-Discussion

The Mediterranean is a semi-enclosed sea covering an area of approximately 2.5 million km2, with a width of around 3800 km from west to east and with a maximum north to south distance of about 900 km. The total coastline measures 45 000 km (or more than once around the earth), including 19 000 km of island coastline. The shores of the Mediterranean link 22 countries and territories across the three continents of Africa, Asia (the Middle East) and Europe.

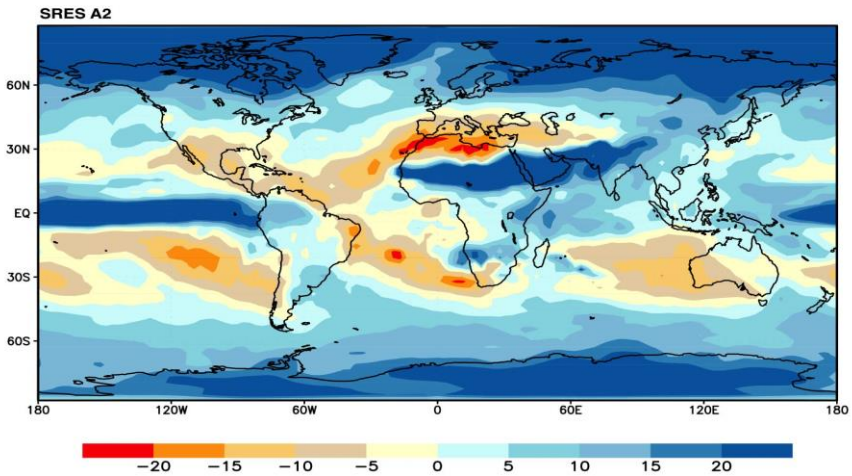
In fact, coastal erosion is one of the most serious challenges for many Mediterranean countries today. The situation has of late become truly alarming for numerous stretches along the Mediterranean coastline that are now subject to unprecedented erosion and excessive tidal flooding. The problem of coastal erosion often extends hundreds of kilometres inland, for example in the case of large deltaic areas, and sometimes across country borders. On the other hand, as in the case of pocket beaches, it may also be a very local phenomenon affecting only nearby neighbourhoods. In any case, coastal erosion, whether due to natural or anthropogenic reasons, causes significant ecological damages, economic losses and social problems.

The loss of wetlands as a result of coastal erosion, flooding or human activities also constitutes a major problem. It is estimated that the Mediterranean has lost around one million hectares of wetlands in the last 50 years.

With regard to the causes of coastal erosion, there is, as with many environmental problems, no single, straightforward explanation. It is rather a combination of inter-linked natural and human-induced factors that lies behind the erosion of the Mediterranean coastline.

One natural explanation, although it is to some extent also human-induced, is climate change. Although estimates regarding the future vary, both global and regional temperatures are rising, partly – some experts maintain mostly – due to an increase in atmospheric concentrations of carbon dioxide and other greenhouse gases. The warming over the last century has been more rapid than during any other period for which data exist.

Some areas are projected to become wetter, others drier with an overall increase projected

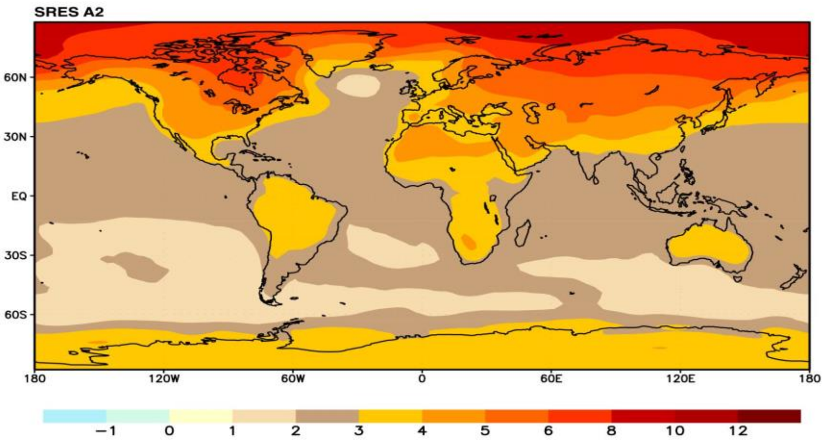


Annual mean precipitation change: 2071 to 2100 Relative to 1990

After Kabat, 2004

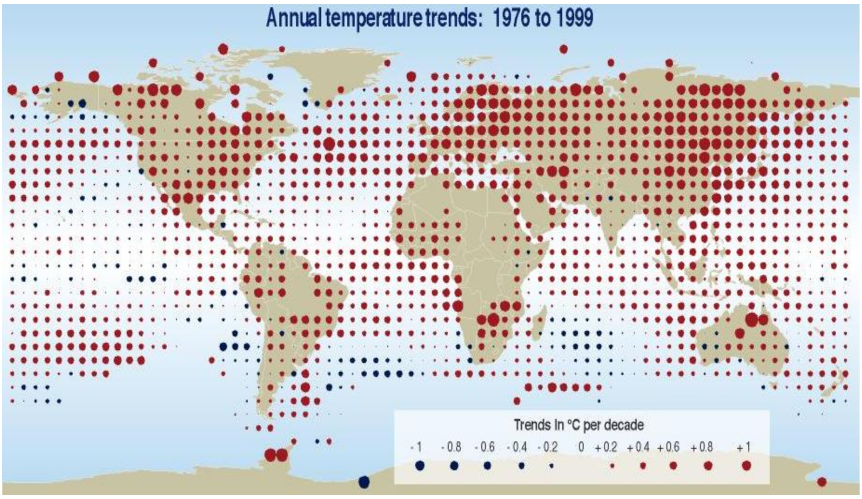
One direct effect of this trend in global warming and climatic change is a rise in sea level. While there is still no scientific consensus on the likely rate of sea level rise in the future, the Intergovernmental Panel on Climate Change (IPCC) concludes that the "average sea level is expected to rise as a result of thermal expansion of the oceans and melting of glaciers and ice sheets". Hence, whatever the extent of the rise in sea level, many coastal areas will inexorably be more exposed to sea water intrusions.

Land areas are projected to warm more than the oceans with the greatest warming at high latitudes



Annual mean temperature change, 2071 to 2100 relative to 1990: Global Average in 2085 = 3.1ºC

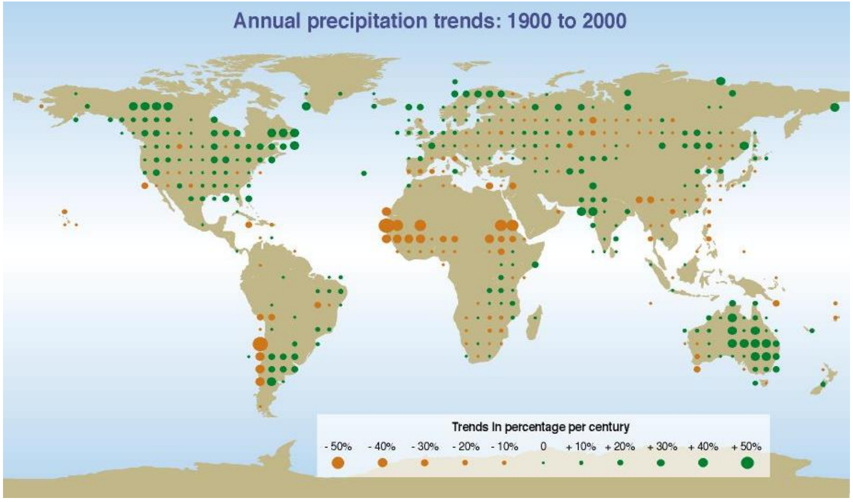
The Land and Oceans have warmed



After Kabat 2004.

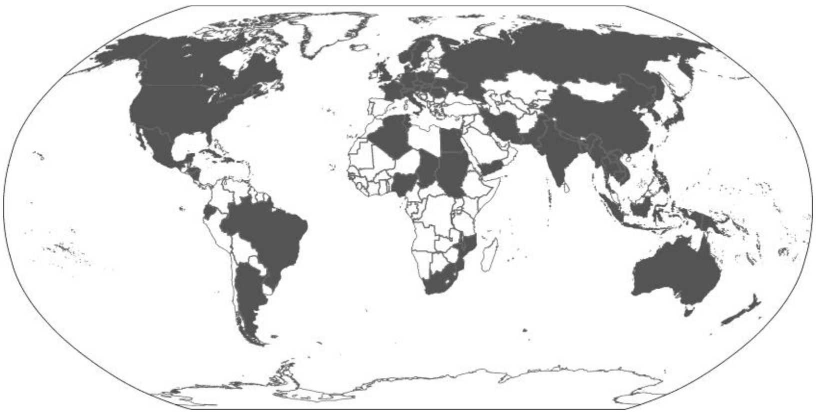
Another concept of climatic change and affecting the coastal erosion is the changes of annual rate of precipitation where it affects the amount of rain and its load reached to the sea consequently.

Precipitation patterns have changed



After Kabat 2004.

Coastal erosion might also be exacerbated by the upstream construction of dams and the development of other forms of river or coastal infrastructure as such constructions hinder the natural flow of sediments that rivers bring to the sea and the coasts. One conspicuous example is the coastal erosion in Egypt in the wake of the construction of the High Dam at Aswan.



Countries affected by destructive flooding since 1990

After Kabat 2004.

6-Solution

Coastal protection barriers and defences that follow conventional hard engineering solutions in order to prevent coastal erosion and flooding in fact often aggravate the problem further (and farther geographically).

Hard protection barriers (such as breakwaters) are not only expensive to put in place and costly to maintain but also cause collateral damages provoking erosion in nearby areas and harming the aesthetical aspect of the beaches or coastlines they seek to protect, hence decreasing their economic value for tourism purposes.

The protection of the Mediterranean coastline requires a proactive and interdisciplinary framework for the management of coastal areas. **Integrated coastal zone management (ICZM)**, is a multidisciplinary approach towards promoting sustainable management of coastal zones. It covers the full cycle of information collection, planning, decision-making, management and monitoring of implementation measures. **ICZM** includes all stakeholders to assess the community goals in a given coastal area and to take actions towards meeting these objectives. It seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives. The term 'integrated' refers to the harmonisation of objectives and of the instruments required to meet these objectives. It entails close co-ordination of all relevant policy areas, sectors and administrative levels as well as integration of the land and marine components of the target territory.

All aspects of coastal protection measures have to be carefully considered, and costs and benefits of different options have to be assessed in order to avoid causing one problem by solving another. Indeed, selective protection of shorelines or no artificial protection in some coastal areas may be part of a protection strategy, marking a departure from earlier defence philosophies which imposed a systematic intervention on any stretch of coast threatened by erosion, thereby obstructing natural regulation through the redistribution of sandy sediment along the coast.

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تطبيق الاستشعار عن بعد ونظام المعلومات الجغرافية لاكتشاف التغيرات على طول الساحل الشمالي لمصر

ملخص

تطورت تكنولوجيا المعلومات بسرعة في السنوات الأخيرة، أصبح تطبيق أنظمة الاستشعار عن بعد والمعلومات الجغرافية (GIS) مطلبًا أساسيًا في جميع المجالات، بما في ذلك دراسة البيئة والأخطار الطبيعية. لقد تغير الساحل الشمالي لمصر بشكل واضح في العديد من المناطق على طول ساحل البحر الأبيض المتوسط لأسباب عديدة مختلفة مثل تأثير الأنشطة البشرية وفعل الأمواج والتيار.

الكلمات الدالة: الاستشعار عن بعد، نظم المعلومات الجغرافية، التراكم، التآكل.