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Coastal Erosion Along the Egyptian Delta

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ABSTRACT

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Since construction of the Aswan High Dam in 1964, there has been concern that the Egyptian coastline along the Mediterranean Sea would suffer from increased erosion. The dam effectively stopped the supply of sediment carried by the River Nile to the Mediterranean and so left the coastline without a shore building capability.

Through analysis of satellite images, the morphometry of the coastline along the Egyptian Mediterranean has been studied. Landsat images acquired in 1973, 1978 and 1984 were compared with topographic maps from the 1930's and other historical references to the shoreline.

Although coastal erosion is a serious problem along the Egyptian Mediterranean Coast, it is localized at specific areas. These areas have undergone slow to moderate erosion since the turn of this century as a result of natural decrease of the River Nile flow and as a result of increased number of structures across the Nile. In a post High Dam phase, these areas eroded at accelerated rates (3-5 times the rates before the Dam).

However, a major part of the coastline seems to have survived and has not changed radically since construction of the High Dam.

ADDITIONAL INDEX WORDS: *Control structures, Egyptian delta, hydrology, Mediterranean Sea, satellite mapping, sea-level change, subsidence.*

INTRODUCTION

Since construction of the Aswan High Dam in 1964, the problem of coastal erosion along the Egyptian Mediterranean has attracted extensive interest. Closure of the River Nile at Aswan shifted the balance of forces along the delta shore and resulted in a massive imbalance of the shoreline. Coastal erosion, however, existed along the Egyptian Mediterranean long before the Aswan High Dam. In fact, the process of building the Nile Delta by deposition of the annual sediment load carried by the Nile began to weaken during the late nineteenth and early twentieth centuries as a result of a natural decrease of the Nile's discharge and river controls, including the delta barrages and the first Aswan Dam.

The erosion threatens coastal cities and summer resorts along the delta coast, including Ras El-Bar, Rosetta, Baltim and Alexandria. The problem area also includes the most important ports in Egypt, such as Alexandria, Port Said and Damietta. The sea's advance similarly threatens arable lands, contaminates fresh water aquifers in the northern delta and eliminates sandy barriers separating the northern coastal lakes from the Mediterranean.

It is the objective of this paper to assess the current status of erosion along the Egyptian Mediterranean Coast and ascertain the relative contribution of the Aswan High Dam to the problem. Remote sensing techniques have been employed in this study in order to capitalize on the synoptic perspective provided by satellite imagery. Our use of remote sensing has also circum-vented the restrictions imposed for security reasons by the Egyptian government on access to coastal areas. Without such access no study would have been possible at all.

Physical Description and Geomorphology of the Nile Delta

Occupying an area of about 22,000 Km^2, the Nile delta is one of the world's largest coastal expanses. It is the product of sedimentary processes that began during the Upper Miocene about 10 million years ago (SAID, 1981). Five thousand years ago, the Nile delta had seven tributaries to the sea. These tributaries, except for the present-day active branches of Damietta

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and Rosetta, degenerated and were abandoned. These defunct branches played an important role in the early development of the morphology of the Nile Delta and the continental shelf (ABDEL-KADER, 1982).

At the time when there were seven tributaries, the delta was a wave-dominated, smooth, and arcuate type delta (SUMMERHAYES and MARKS, 1977). The Nile sediment load at that time was discharged over a much wider geographic area than is the case in recent times. When the Nile discharge was finally confined to the Rosetta and Damietta branches, the delta changed to a pattern of river-dominated sedimentation, or Mississippi-type delta.

Major geographic features of the Egyptian Delta are shown in Figure 1. The Delta contains 90% of the country's population and virtually all the cultivated land. There are two types of coastal morphology in the northern portion of the delta (SESTINI, 1976):

(1) sand barriers created by wind and waves; the main components of the sand barriers include shoreline features (cusps, spits and small shoreline dunes); old accretion ridges (at Rosetta, Damietta and East of Port Said); backshore plains (flat beach-sand areas at the back of Abu Qir Bay, east of Rosetta, from Kitchener Drain to Gamasa and Ras El-Bar, and from Port Said to Tineh); and coast dunes (uninterrupted belts of complex dunes and deformed barchans at Idku and from Baltim to Gamasa, fields of small dunes and sheet sand from Baltim to the Kitchener Drain, isolated groups of barchans and seif dunes, a complex of low dunes at Rosetta, Kom Mastra, El-Burg, Baltim, and Gamasa).

(2) Lake and deltaic morphology consisting of three major types: (a) small deltas and deltaic areas, (b) lake margins, and (c) flooded basins and islands of silt and fine sand marking former Nile channels.

HYDROLOGY OF THE RIVER NILE

The River Nile is a dominant feature of the African continent which has remained a land area since the Precambrian Era, except for limited marine incursions along its coastal plains (SAID, 1981). The structural pattern of the continent consists of broad basins separated by irregular swells. The Nile derives its waters from the lake plateau region, the southern region of east and central Africa; this area includes the southern swell bordering the Sudan basin and the Ethiopian Highlands which form part of the East African coalescing series of plateaus traversed by the great African rift system. The equatorial plateau contributes 15% to the Nile's water, and the Ethiopian Highland region produces 84%.

Three major tributaries (the Blue Nile, the White Nile, and the Atbara River) comprise the Nile system. The annual Nile discharge at Aswan averages 86 billion m^3/year derived from a watershed of about 3 million km^2 (SAID,1981). The annual discharge varies dramatically from one year to another and seasonal variations are even more dramatic. More than 80% of the river's total discharge occurs during the flood period which lasts between August and September (SMITH, 1983).

DYNAMIC FACTORS RESPONSIBLE FOR EROSION ALONG THE NILE DELTA COAST

Wave Action

The major agents affecting coastal processes along the Nile delta are winds and waves. The two major wave conditions that affect the shoreline are the stormy winter season and the summer swell season. The winter season starts in late October and extends to the end of March with an average of 16 major storm events each year (MANOHAR, 1976).

The most common southern Mediterranean winter storms derive from low pressure areas which move from west to east over southern Europe and the Mediterranean. The storms occur every 6 to 7 days and their centers move with migration velocities of 900 to 1000 km/day (INMAN and JENKINS, 1984). On average, the storm waves vary from 1.20 to 2.10 m in height, with periods 9-10 seconds. The predominant storm directions are NNW or NW.

Summer swells occur between June and August with heights varying from 40 to 75 cm with periods of 8-10 seconds. The summer swell predominant directions are also NNW or NW. The swells shift sediments shoreward in the form of bars which gradually merge with the shore. However, the constant swells reaching the coast continue uninterrupted during July and August causing the mean water level to

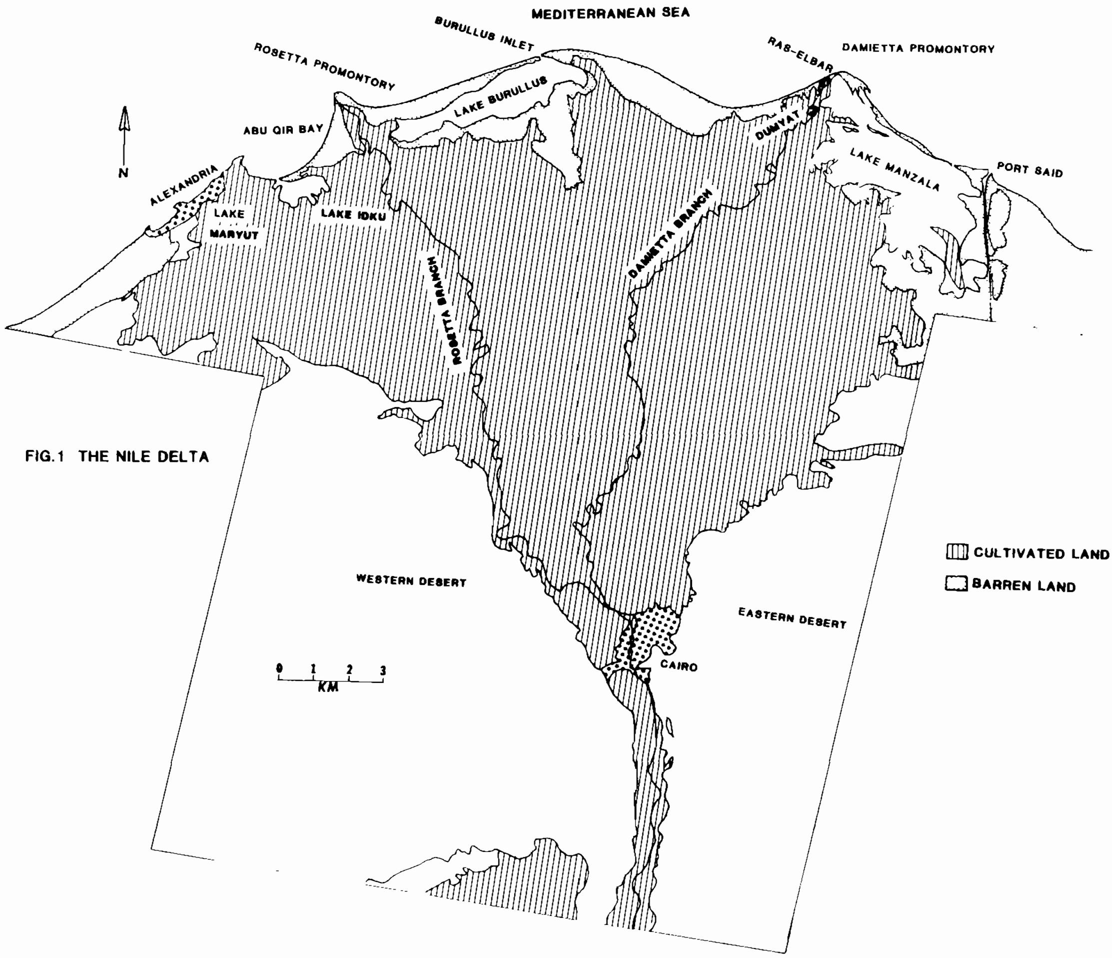

Figure 1. The Nile Delta.

rise more than twice the mean sea level (MANOHAR *et al.*,1977). This rise, together with the shift of wave action landward, proves to have a destructive action on eroding dunes and berms. Hydrographic surveys indicate that summer accretion is localized and small, and erosion takes place in several spots (MANOHAR, 1976).

Storm waves in the winter season cause further erosion. The action of waves and currents progressively erodes offshore deposits as well as shoreline material. The erosion of the bottom is most intensive during stormy periods when the flux of wave energy is at its maximum, resuspending large amounts of sediment (SUMMERHAYES and MARKS, 1976). At the same time, the build-up of large water masses against the shore forces the water to escape laterally along the shore or to move seaward as an undertow. Large quantities of sediment are transported by this mechanism.

The regular flow of the east Mediterranean is driven by hydraulic west to east gradients that originate from the geostrophic effect and thermo-haline processes. The counterclockwise gyre of the east Mediterranean moves water from the straits of Sicily past the Nile delta. The effects of winds on the shelf flows are so dominating that the regular circulation pattern is completely masked (NIELSEN, 1977b).

Two effective current systems are produced by the waves approaching the Nile delta at an angle; the cell circulation system of rip currents and long-shore or littoral currents. It is estimated that the energy dissipation due to current action over the sediment bottom of the Nile delta to be about 2.5 million Kw, whereas that associated with wave action nearshore to be about 0.5 million Kw. The energy flux at Nile delta coast structures cause longshores and transport rate of about 1 million m^3/year (INMAN and JENKINS, 1984).

Tides play an insignificant role in coastal erosion along the Nile delta because the Egyptian Mediterranean coast is almost tideless. Tides are semidiurnal and ranges do not exceed 25-30 cm.

Sea Level Change and Land Subsidence

Sea level of the Mediterranean along the Egyptian coast has remained essentially unchanged during the last 5,000 to 6,000 years (NIELSEN, 1977b). However, in the past century, the level appears to have risen by 10 to 15 cm. It has been hypothesized that this rise is a global phenomenon caused by the dual effects of thermal expansion of ocean surface water and possibly by net melting of glaciers (MILLIMAN, 1986). The change is associated with an increase in global temperatures which can be attributed to the greenhouse effect produced by higher concentrations of carbon dioxide in the atmosphere as the result of fossil fuel combustion (BARTH and TITUS, 1984).

It is reasonable to assume that all low lying deltas, including the Nile's, will be affected by global sea level rise. The impact on Egypt will be particularly acute given the high population density located within a few meters of sea level.

The Mediterranean Sea's rise over the past 100 years accounts for a shoreline retreat of 10 to 15 m along Egypt (INMAN and JENKINS, 1984). A 1 to 3 meter rise of the Mediterranean's level along the Egyptian coast due to combined eustatic sea level change and land subsidence will possibly occur in the next century if current trends are maintained (BARTH and TITUS, 1984). If the rise is limited to 1 m, it has been estimated that 15% of the total Egyptian delta area will be inundated with water (BROADUS *et al.*, 1986). These estimates must be interpreted with caution because the details of the interactions of sea level rise mechanisms are not well understood and timing and magnitude of sea-level changes are not precisely known (ROSS and ROSS,1986).

Much of the Egyptian delta is simultaneously in the process of subsidence. Subsidence is a natural process for deltas as the alluvial material becomes compacted under its own weight. This process has been encouraged in the Nile delta by increased water well pumping (SMITH, 1986). The central African drought of 1978 to 1985 provided incentive for Egypt to seek sources of water other than the Nile. The government has subsequently promoted groundwater exploration both within the delta and the desert. It may be expected that the same sort of subsidence problems now affecting areas such as the Mississippi Delta.

Nile Discharge Variation

The River Nile has exhibited enormous variation in its annual discharge. Records of flow have been maintained at Roda Island in Cairo since 622 A.D. The river's average annual discharge at Cairo is 86 billion m^3 with an associated standard deviation of 45 billion m^3 (SAID, 1981). Extreme values of the Nile's flow historically marked the ends of civilizations along the ancient river valley and dictated virtually every aspect of life in Egypt. Both the flood of 158 billion m^3 which occurred in 1879 and droughts producing less than 36 billion m^3 (1914) made the difference between famine and prosperity (HURST, 1952).

Since 1900 the Nile has exhibited significantly lower than average annual flows as compared to the previous century. The average annual discharge measured at Roda Island for the period 1900 to 1986 was 83 billion m^3 compared with 109 billion m^3 for the period 1800-1899 (RIEHL and MEITIN, 1979).

Lower flows carry proportionally less suspended sediment and so result in smaller amounts of deposition. The net result of the loss of this sediment is increased coastal erosion. A direct connection, however, between lower flow and higher coastal erosion is difficult to verify in the case of the Nile because of the series of structures on the river which fundamentally control the flow of the Nile.

EFFECT OF CONTROL STRUCTURES ON THE NILE

The Aswan High Dam is the latest, but probably not the last, major control structure on the River Nile. Built under a storm cloud of political and environmental controversary between 1964 and 1970, it is one of the largest dams of its type in the world.

The River Nile is totally controlled by 3 dams and 7 barrages. Each structure has altered the flow regime of the river causing an inbalance of the equilibrium between sediment deposition and erosion. Until the Aswan High Dam, however, none of the previous control structures exerted an influence large enough to significantly alter sediment delivery to the coastal Mediterranean (ABDEL-KADER, 1982). Unlike the other dams and barrages, the High Dam was designed without sluice gates. The trap efficiency of the dam is approximately 98%, meaning that virtually all of the sediment entering the reservoir remains in its dead storage. The only sediment that traverses the entire 500 km length of the reservoir are fine silts and clays which are passed through the turbines and spillway (SHALASH, 1982).

The loss of this sediment to the Egyptian Mediterranean coastline has resulted in a number of downstream environmental impacts (QUELENNEC and KURK,1976). Prior to the High Dam, basin irrigation was widely practiced throughout the Nile Valley and Egyptian Delta. Farmers diverted sediment-laden flood water from the Nile onto their fields and allowed the alluvium to replenish nutrients of the soil. The huge capacity of the High Dam was the main factor that effectively eliminated the annual flood in Egypt. This has resulted in lower soil fertility and land subsidence throughout the delta (WATERBURY, 1978).

Approximately half the total sediment load of 125 million tons carried by the Nile into Egypt was deposited onto agricultural fields along the Nile Valley and throughout the Delta; the remainder was discharged to the sea (SHALASH, 1984). This sediment loss to the Mediterranean caused a shift in the forces along the coast and a net loss of shore-building material. Previously, the major portion of this material that had added to the Egyptian Mediterranean coastline emanated from the Nile (INMAN and JENKINS, 1984). After 1964, the only source of shore-building material was sand transported from the Libyan shores west of Egypt and it represented a minimal contribution to the sediment load (INMAN and JENKINS, 1984).

STUDY METHOD

In order to precisely assess the process of coastal erosion, the Egyptian shoreline was mapped using several satellite images including Landsat Multispectral Scanner (MSS) imagery taken in November 1973 and September 1978, Landsat Return Beam Vidicon (RBV) imagery taken in September 1978 and Landsat Thematic Mapper (TM) imagery taken in 1984. Using a process camera, the images were matched to the same scale, overlaid and remapped using control points, to produce a single map. The MSS, RBV and TM images were digitized using the Wild Aviotab TA2 plotting table. These data were used to produce maps at a scale of 1:1,000,000.

The shoreline was divided into five physiographic regions: Abu Qir Bay, the Rosetta Promontory, Burullus Headland, the Damietta Promontory and the stretch between Damietta and Port Said as shown in Figure 2. A radial line template was used to assess advance or retreat of the shoreline. Corresponding points located along specific radial lines were defined each time the diagram was overlaid on a specific map. All points were measured by referencing them to a central control point on the radial line diagram. All points were referenced along a common base line connecting two control points, one of which coincided with the center of the radial line diagram. Measurements were made perpendicular to the shoreline. In situations where the radial lines were not perpendicular to the shoreline, lines were mathematically or physically retreated in order to obtain perpendicular distances.

Each of the four remote sensing images used in the analysis originated from different sensors and so mention should be made of their relative interpretation. The topographic maps prepared by the British Ordinance Survey in 1934 served as base maps for the study. The accuracy of these maps is not known and so measurements made from them must be treated accordingly.

Landsat MSS collects reflected light in four spectral bands from an area 79 x 56 m on the

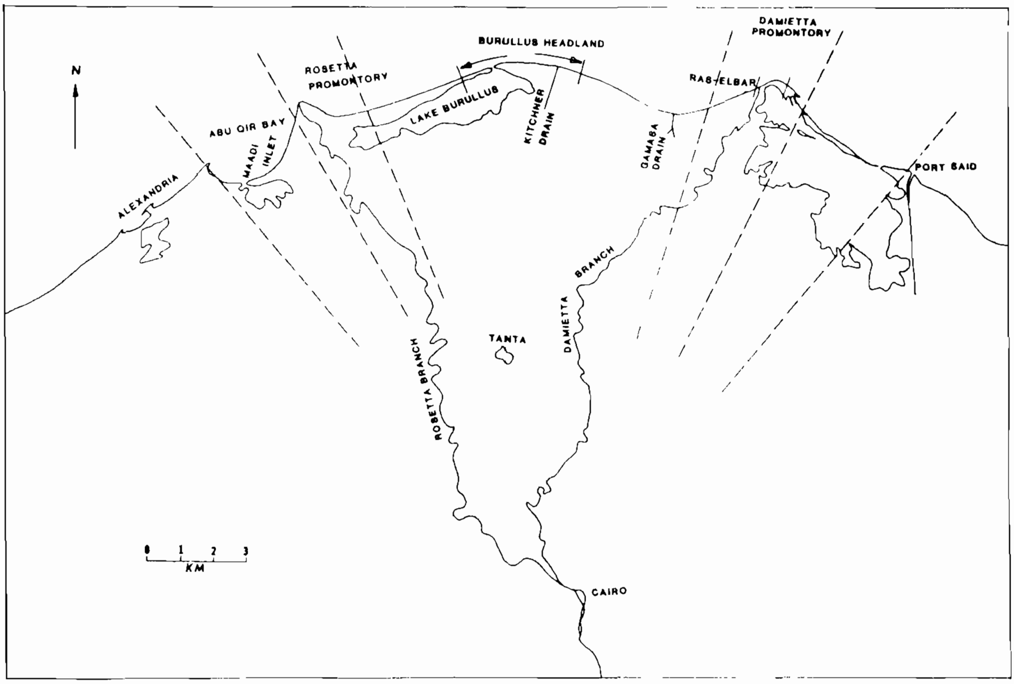

Figure 2. Physiographic Regions Used in the Study.

ground. Thus, 79 m roughly approximates the linear precision of a measurement in one dimension. The RBV on Landsat had a pixel size of 40 m x 40 m and the TM has one of 30 m x 30 m.

Comparisons of shoreline morphological change were made with respect to the system with the lowest spatial resolution. In many cases, although an area may be known to be in the process of retreat as determined by on site observations made regularly by the Egyptian Coastal Protection Agency, it will be reported as unchanged if the erosion has been less than the largest pixel cell.

RESULTS

Coastal processes for each of the five physiographic regions will be discussed separately. The discussion will begin at the western part of the delta (Abu Qir Bay) and move eastwards to Port Said. Alexandria, built upon sea materials and so largely independent of the coastal erosion problem with respect to the Nile, was not included in the study. Alexandria has had a major sea wall protecting all frontage of the city for the past 200 years. Except for local scour, Alexandria is not considered to be threatened by coastal erosion (INMAN and JENKINS, 1984).

Abu Qir Bay

The Abu Qir Bay, shown in Figure 3, generally accreted between 1934 and 1973. Portions of the eastern half of the Bay, however, eroded at an average annual rate of 1.5 m during this time.

The remainder of the Bay accreted between 1934 and 1984. For example, a section west of the Rosetta outlet advanced about 226 m. However, accretion rates reduced between 1973 and 1978 and erosion took place between 1978 and 1984. This shift probably occurred because of the former abundance of sediments brought to the Bay from the Rosetta's mouth prior to construction of the Aswan High Dam. After the High Dam, the advance could no longer be supported and erosion began.

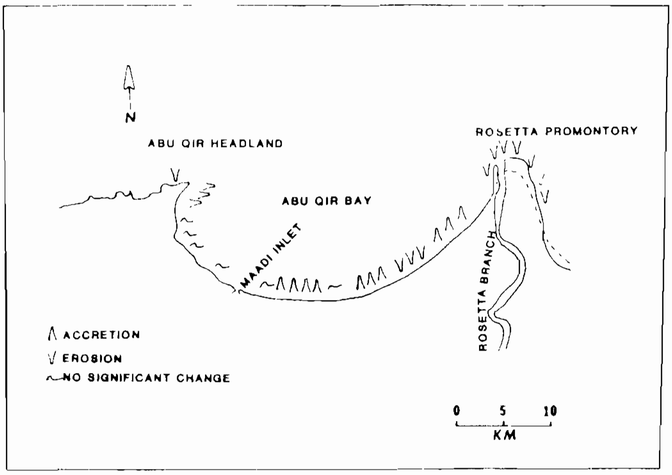

Figure 3. Abu Qir Bay.

The Rosetta Promontory

Historical records indicate that the Rosetta promontory has under gone several periods of advance and retreat over time (ABDEL-KADER, 1982). The promontory advanced about 9 km between 1600 and 1800, extended 3.6 km between 1800 and 1898, and remained stationary between 1898 and 1909 (MISDORP, 1977; SESTINI, 1976; INMAN and JENKINS, 1984). The promontory started to retreat in this century culminating in greatly accelerated erosion after construction of the Aswan Dam in 1964 (ABDEL-KADER, 1982). The Rosetta promontory retreated 550 m between 1934 and 1973. Erosion was greater between 1973 and 1984, averaging 50 m/year. The rate of erosion increased to an average of 90 m/year between 1978 and 1984.

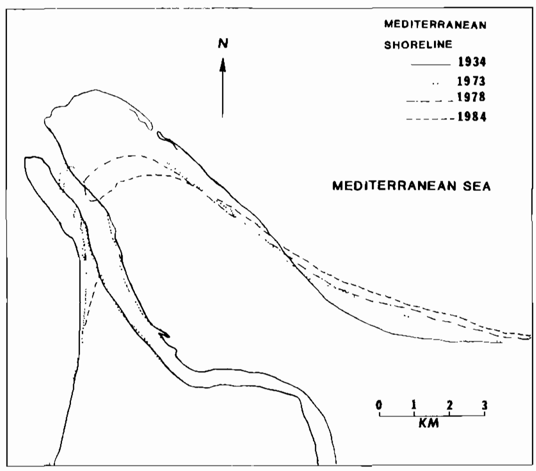

Figure 4. The Rosetta Promontory.

The area of greatest erosion occurred at a point immediately to the eastside of Rosetta's mouth. This area retreated at a rate of 30 m/year between 1934 and 1973, 150 m/year between 1973 and 1978, and 275 m/year between 1978 and 1984. The total retreat between 1934 and 1984 was 3700 m representing the largest amount of erosion for any location along the Egyptian coast. Figure 4 illustrates the process of erosion of the Rosetta promontory between 1934 and 1984.

Some areas of the Rosetta accreted rather than eroded. At the base, east of the river mouth, for example, advances occurred at a rate of 9 m/year between 1934 and 1973, 25 m/year between 1973 and 1978, and 1.5 m/year between 1978 and 1984. West of this area, an area eroded an average of 8 m/year between 1934 and 1978, advanced at an average of 1 m/year between 1973 and 1978, and 4 m/year between 1978 and 1984.

The Rosetta promontory seems to be the most sensitive area of the Egyptian Mediterranean coast with respect to response of the Nile's discharge variation and control. The erosion rate increased five-fold between 1973 and 1978 and eight-fold between 1978 and 1984.

Rosetta to Damietta Stretch

In general, the stretch between the promontaries was stable with negligible change between 1934 and 1984. An exception is the Burullus Headland,where retreat of 13 m/year occurred between 1934 and 1973 and 44 m/year between 1973 and 1978. An erosion rate of 29 m/year occurred between 1978 and 1984 at Burullus. Its pattern of retreat correlates with the general pattern of post-High Dam accelerated rates of erosion.

Damietta Promontory

Similar to the situation at the Rosetta promontory, there is historical evidence that the Damietta promonotory has undergone periods of advance and retreat (ABDEL-KADER, 1982). At the city of Ras El Bar, for example, the shoreline in 1895 was 1250 m seaward from the present day jetty at the Damietta's mouth (NIELSEN, 1977a). This point has been steadily eroding since 1895.

About 3 km west of Ras El Bar, at the new port of Damietta, the coastline advanced at a rate of 8 m/year between 1934 and 1973, but had no appreciable change between 1973 and 1984. Erosion at a rate of 35-50 m/year was found to occur between 1978 to 1984 just east of the mouth of the Damietta. Between 1934 and 1973 about 2,000 m of shoreline were lost at this point. Erosion continued at a rate of 50-60 m/year between 1973 and 1984.

The coastline east of the Damietta generally acts as a drain site for sediments eroding from the Damietta promontory. This area is characterized by a growing spit which first formed in 1955 and it has been migrating southeast since then. This area advanced at a rate of 33 m/year between 1934 and 1973, 58 m/year between 1973 and 1978, 34 m/year between 1978 and 1984.

Unlike the Rosetta promontory, the Damietta promontory does not show regular patterns of change, but instead it shows alternating pockets of erosion and accretion. Many of the accretion pockets eventually erode away within a few years. However, the mouth of the Damietta promontory continuously eroded at a moderate

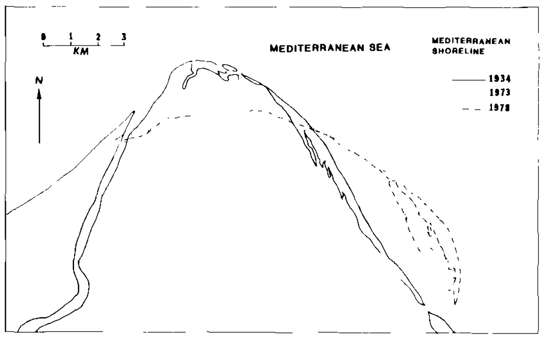

Figure 5. The Damietta Promontory.

rate between 1934 and 1973 to higher rates between 1973 and 1984 as shown in Figure 5. This is similar to the general trend of the eroded areas affected by cessation of River Nile sediment after the Aswan High Dam.

Damietta to Port Said

The coastline between Damietta and Port Said is characterized by appreciable erosion and accretion. Indeed, erosion rates along this stretch average 16 m/year between 1934 and 1984. The shoreline undulation had shifted markedly to the southeast. It was noted by satellite imagery that areas of advance occur southeast (downstream) from areas of retreat.

At Port Said, the shore had advanced west of the west breakwater prior to 1984, but since 1984, this pattern is no longer dominant and slight erosion is now occurring. The pattern of shoreline change along this stretch indicates that at least part of the sediment eroded from the Damietta mouth before the High Dam had been transported eastward.

DISCUSSION

Coastal erosion along the Egyptian Mediterranean is a serious problem. It is, however, a localized phenomenon affecting specific regions of the shoreline as shown in Figure 6. The most significant areas affected are the Rosetta and Damietta promontories, the Burullus Headland, some areas along the Damietta-Port Said stretch and some locations in Abu Qir Bay.

Sea level rise along the Nile Delta, as related to the combined affect of eustatic change and

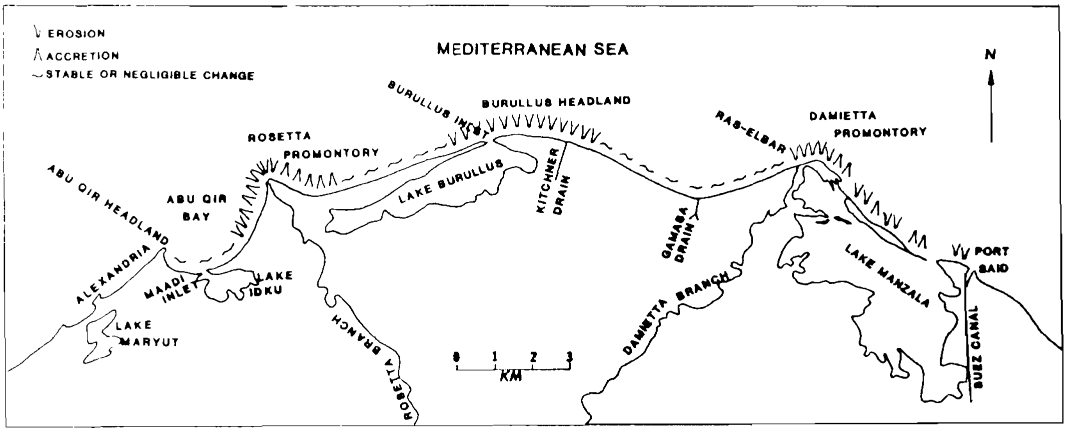

Figure 6. Current Status of Erosion Along the Nile Delta Coast.

land subsidence, may be partly responsible for the retreat of shoreline, however these factors are probably more important influences for the future of the shoreline morphometry than the past. Natural and controlled variation of the Nile's flow is probably the most important single factor affecting coastal erosion since the beginning of this century. Variation of the Nile's discharge has affected the shoreline in two phases: pre-High Dam and post-High Dam. In the pre-High Dam phase (1900 to 1964), the Nile's discharge to the sea decreased for two reasons: a decline of the Nile's natural flow and increased control structures on the Nile. The Nile's natural flow decreased 30% from its original volume, from a high of 109 km3/year during 1870 to 1900 to a low of 83 Km^3 during 1900 to 1949. This low flow regime has continued to the present (RIEHL and MEITEN, 1979).

Superimposed on the natural flow decrease is the affect of the increased control structures such as the Aswan Dam in 1902 that trapped some of the sediment (INMAN and JENKINS, 1984). The relative decrease of sediment discharge since 1900 caused localized erosion at Rosetta, Damietta and the Burullus Headland.

The post-High Dam phase began after 1964. Accelerated rates of erosion occurred in several areas after construction of the High Dam. On the average, rates of erosion increased 3 to 5 times in the post-High Dam phase. In the pre-High Dam phase, the mouth of the Damietta eroded at a higher rate (32 m/year) than the Rosetta's mouth (14-18 m/year). In the post-High Dam phase, the Rosetta mouth eroded at a higher rate (48-90 m/year and 150-275 at specific points) than at Damietta (35-50 m/year). This may be attributed to the fact that before the High Dam, 70% of the Nile discharge reaching the Nile bifurcation north of Cairo was discharged to the sea through the Rosetta mouth while the remainder was discharged through Damietta. Thus, more sediment load (80 million tons/year) discharged at Rosetta. Also, energy flux at Rosetta are higher than at Damietta (INMAN and JENKINS, 1984).

CONCLUSION

Although comprehensive protection measures for the entire Egyptian Mediterranean coast are expensive and therefore impractical, there are economically valuable areas which merit immediate corrective measures. They include Ras El-Bar, the City of Rosetta and Baltim. Erosion of these places should be carefully monitored on a regular and frequent basis.

Remote sensing was found to be a useful monitoring tool in this study for a number of reasons. First, the large size of the area necessitated a synoptic view. No other data source could have provided efficient information at the required scale with the same cost and time effectiveness. Second, this method overcomes the problems of limited access to most of the Egyptian coastal areas due to security restrictions.

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□ RESUMEN □

Desede la construcción de la presa de Aswan en 1964 se ha podido comprobar que la costa de Egipto en el Mediterráneo está sufriendo una erosión creciente. Efectivamente, la presa retuvo el aporte de sedimentos al rio Nilo dejando asi la costa sin capacidad de modelar la costa. Se ha es estudiado la morfologia de la costa mediterránea eqipcia mediante imágenes de satélite, tomadas en 1973, 1978 y 1984 se han comparado con mapas topográficos de 1930 y otras referencias históricas. Aunque este problema erosivo es importante, se encuentra localizado en áreas especificas. Se ha comprobado que el ritmo erosivo de la costa ha crecido desde la construción de la misma. No obstante, parece que la mayor parte de la costa no ha sufrido un cambio radical desde le construcián de le presa.—*Department of Water Sciences, University of Santander, Santander, Spain.*

□ RESUMÉ □

Depuis la construction du barrage d'Aswan en 1964, on a emis l'hypothèse que la côte méditerranéenne eqyptienne serait le siège d'une érosion accrue. Le barrage a effectivement arrêté l'apport de sédiment charrié par le Nil vers la Méditerranée, et a donc dépourvu la côte de cet élément constructeur. L'analyse d'images satellites a permis d'étudier la morphométrie de la côte méditerréenne égyptienne. Des images Landsat obtenues en 1973, 1978 et 1984 ont été comparées à des cartes topographiques établies depuis 1930 ainsi qu'à d'autres données historiques relatives à la côte. Bien que l'érosion le long de la côte égyptienne méditerranéenne soit un sérieux problème, ce phénomène est localisé. Ces sites ont été le siège d'érosions lentes à modérées depuis le début du siècle, suite à la baisse naturelle du débit du Nil et suite aux constructions en travers du fleuve qui se sont multipliées. Après la construction du barrage d'Aswan ces sites se sont erodés rapidement (3 à t fois la vitesse d'érosion avant la construction du barrage). Toutefois, la majeure partie de la côte semble ne pas avoir été touchée par la construction du barrage.—*B. Salvat and M. Amat, Ecole Practique des Hautes Etudes (EPHE), Paris, France.*

□ ZUSAMMENFASSUNG □

Seit dem Bau des Assuan-Staudammes gab es Bedenken, ob durch den gestoppen Sedimenteintrar die ägyptische Mittlemeerküste einer verstärkten Küstenerosion ausgesetzt sein würde. Anhand von jüngeren Satellitenaufnahmen, die mit topographischen Karten aus den 30er Jahren dieses Jahrhunderts vergleichen wurden, kam man zu der Erkenntnis, dass nur bestimme Küstenabschnitte verstärkt seit dem Beginn dieses Jahrhunderts erodiert werden. Durch eine verringerte Wasserführung des Nils, die näturlichen und anthropogenen Ursprings ist, gab es in bestimmten Abschnitten einen Wechsel von leichter zu gemässigter Erosion. Die Erosionsleistung wurde durch den Dammbau noch einaml um das 3-5fache verstärkt. Der grösste Teil der Küstenlinie scheint aber den Dammbau kaum beeinflusst worden sein.—*Ulrich Radtke, Geographisches Institut, **Universität Düsseldorf, F.R.G.***