EO to Monitor the Coastal Erosion of the Nile Delta

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1. Introduction

It is common that deltaic regions are highly vulnerable due to its physical characteristics of low topography with high flood probability, significant land erosion and high sensitivity to climatic changes. Nile Delta coast is highly dynamic landscape due to various earth surface processes that control the formation of various landforms (Abou El-Magd and Hermas, 2010). These earth surface processes include both coastal and hydrodynamic processes and aeolian processes (Allen, 1997). Since the construction of High Aswan Dam in 1964 the Nile Delta has seriously impacted due to the reduced sediment and water flow. It was recorded that the average sediment load and fresh water arriving to the Mediterranean coast was 134 Million tons and 55 Billion m3 (before the construction of High Aswan Dam), respectively (Abu-Zeid and El-Shibini, 1997). This is has led to undergoing to extensive erosion caused by natural coastal processes. It is anticipated that climate changes will worsen the level of erosion at the Nile Delta coast of Egypt. In low-lying deltas, rising sea levels would, in all areas, bring the risk of inundation, higher rates of erosion and increased saline intrusion into rivers and aquifers.

2. Methods

Two dates (1990 and 2014) of satellite images covering the last 25 years were processed to monitor and determine the coastal erosion of the Nile Delta. Both images (for 1990 and 2014) were geometrically corrected to the Universal Transverse Mercator (UTM) projection, Zone 36

North and the WGS84 datum. The images were then corrected radiometrically and converted to irradiance at sensor. To evaluate the shoreline changes at the coastline of the Nile Delta in the last 25 years, both dates (1990 & 2014) of the satellite images were traced. Resolution merge was applied between the panchromatic channel (15m) and the visible and infrared channel (30 meter) to improve the spatial resolution of the satellite image to 15 meter. This merged image was then used to trace the coastline, which was conducted via two approaches;

a. An auto-identification approach of the coastline using a single Infrared Band (Band 7) to binary classify the satellite image into two separate classes of water mass and land. These two classes were then converted from raster to vector to identify the coastline.
b. A manual digitizing approach of the coastline was handled by the authors

A validation process was carried out between both approaches to obtain a higher accuracy level of the coastal shoreline in 1990 and 2014. Last, both dates of the shoreline converted into vector GIS layers that were overlaid and analyzed using ArcGIS package 10.x to identify and determine the areas under either erosion or accretion.

3. Results

The mapped shoreline from both dates of the satellite images was spatially analyzed to determine the changes in the coastal shoreline and locate the area of either erosion or accretion during the last 25 years. The general trend of the Nile Delta coast is the smoothing of the shoreline with areas of continuous erosion and others of deposition. The coastal line extended for about 350 Km from Alexandria to the west and Port Said in the east, with major areas of erosion at the promontories of the Nile River Branches (Rosetta in the west and Damietta in the east). Figure (1) shows the changes of the coastal shoreline of the Nile Delta

There is a historical record of shoreline erosion in some places along the Nile Delta that ranged from 10-21 m/year from different locations, time dimension and methodologies. For example Frihy (2003) found the rate of erosion at Alexandria is nearly 13 m/year, however, White and El-Asmar, (1999) determined an average rate of shoreline retreat of -20.97m/yr at Baltim and 15m/yr at Ras El Bar. Since the construction of High Aswan Dam and the low momentum of water and sediment flow from Nile River to the sea has accelerated the erosion and the vulnerability increases with the expected sea level rise (Sestini1989, Stanley and Warne 1993, El Raey et al. 1999)

In this research the spatial modelling of the shoreline and comparative analysis showed that there are areas of severe shoreline erosion such as the Rosetta and Damietta Promontories. However the general trend of the Nile Delta showed smoothing of the coastline (i.e. west-east current moves eroded sediments to be accreted it in other places). So, the overall picture shows a pattern of areas of erosion followed by areas of accretion (figure 1). The total area eroded from the coastline is 19.64 Km^2 in the last 25 years and the total area accreting is 16.94 Km^2 during the same period reflecting an area of about 2.7 Km^2 is taken by the sea (Figure 1).

Results showed that the highest rate of coastal shoreline retreat was at the mouth of the Rosetta and Damietta branches, which gave a maximum retreat of 823.2 m and 1330 m at Rosetta and Damietta, respectively. The total area taken by the sea at both locations was 3.8 Km^2 at Rosetta and 5.3 km^2 at Damietta. This unfortunately provided a high average yearly rate at both promontories with 25 m/year and 36 m/year, respectively (Figure 1).

At the spit systems downward the Damietta promontory there was a high rate of deposition and advancement of this spit system reaching a maximum of 1002 m length of deposition with an average yearly rate of 28 m/year. The total area deposited in the spit system was 3.14 Km^2, this means that the sediment eroded from Damietta promontory carried by the current (W-E) and deposited in the spit system. Spatial comparison of the area eroded and deposited at the mouth of Damietta branch showing deficit of about 2.16 Km^2 of land that went to the sea (Figure 1). This spatial analysis of the shoreline position is agreed with time dimension analysis in the period from 1990 to 2000 by El-Banna and Frihy (2009) at the same location given a pattern of erosion reached ~15 m/year. This was influenced with the pattern of natural processes of wave induced alongshore currents and sediment transport from west to east. In other locations; such as Burullus bay; Erosion was detected (Figure 1). The construction of beach groins at this area causes controversial phases of accretion and erosion with shoreline advance of +39.6 m/yr and retreat of -8.53 m/yr. respectively due to construction problems in five of these groins (at the eastern side of Rosetta Bay, Figure 1). These groins were constructed too close to each other with small interval distances in between which may help in consequent accretion processes.

The area between the two Nile River branches were went under smoothing process of the coastline, the spatial analysis of the area eroded was 4.44 Km^2 however, the area accreted in the same time frame was 6.53 Km^2 which reflect much deposition rather than erosion. This support the hypothesis of the WE current movement and the sediment transportation that always been

transported from the west to the east creating more potential of accretion in the inter-embayment of the shoreline. In the last few years, the Egyptian Coastal Protection Authority (ECPA) has installed few engineering projects to protect the coastal zone, which is probably fostered the accretion at some places and erosion at others. The overall shape of the coastal shoreline of the delta takes a series of crescent shape which is the result of such protection constructions. These wave breakers and the coastal breakers enabled more deposition at other appropriate locations. The overall comparison in this location showing an increase of the deposition rate than the erosion rate creating a land area of 2.09 Km^2 added to the terrestrial land.

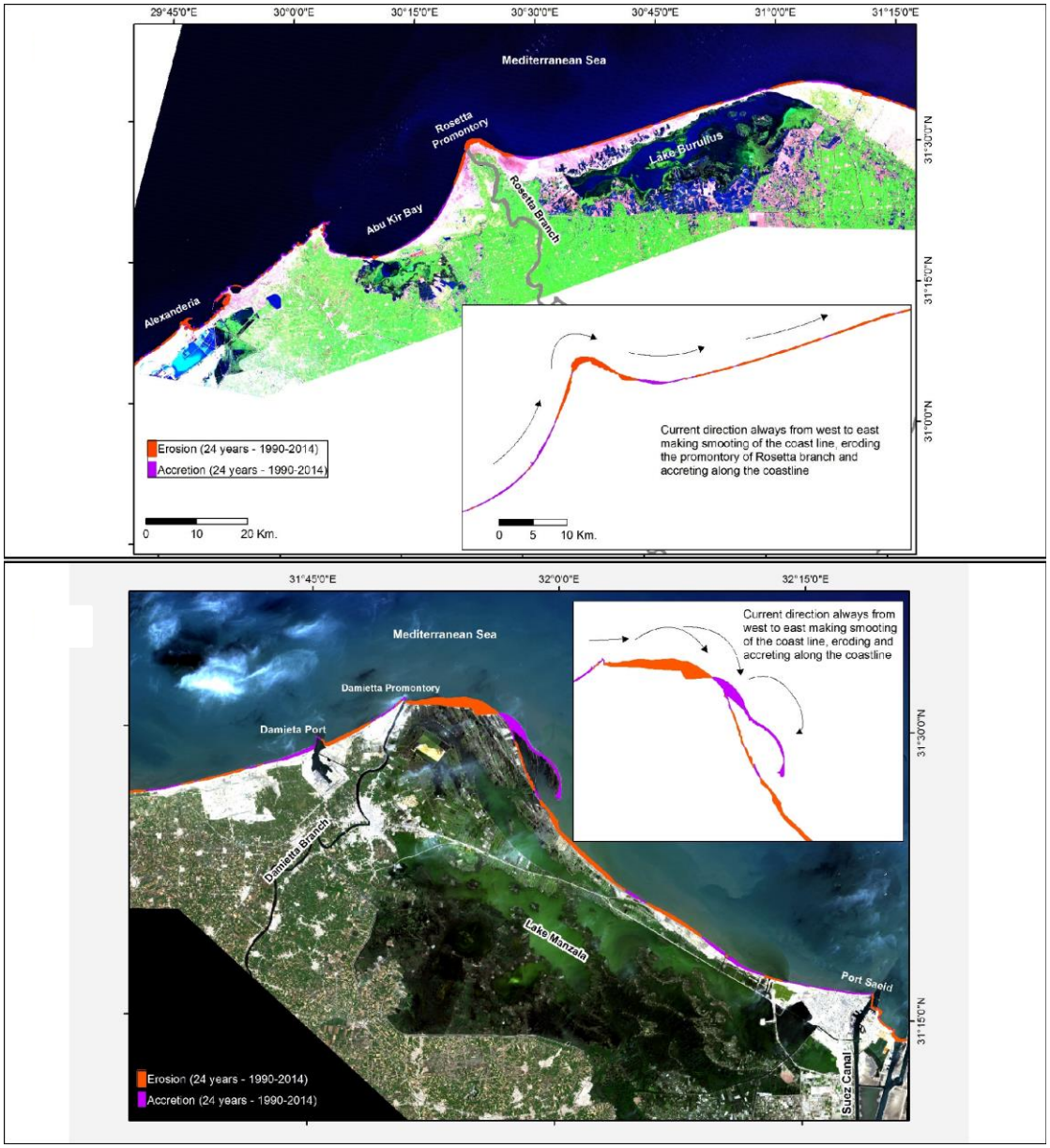

Figure 1 - the coastal erosion and accretion in the Nile Delta coastline

4. Discussion

The coastal zone of the Nile Delta lodges high population cities such as Alexandria, Damietta and Port Said and many small towns and villages with major populations of fishermen and farmers. The area hosts the main country's harbors in Alexandria, Damietta and Port Said with other industrial capacities. It represents the major industrial, agricultural, and economic resource of the country. This is why this area is one of the heavily populated areas in Egypt.

The localized extensive coastal processes caused also a significant coastal erosion and accretion along the Nile Delta coastal shoreline. The low flow of water and sediment to the Nile Branches since the construction of Aswan High Dam in 1969 has made an extra force by the sea to accelerate the erosion of these promontories. Results determined some areas with maximum erosion rates such as that located at Rosetta (24 m/year) and Damietta (36 m/year) promontories; this created a total land area taken of 3.8 Km^2 at Rosetta and of 5.3 Km^2 at Damietta.

However, the coastal protection agency has made some protections along the coastline in the last twenty years; the coastal erosion of the Nile Delta is continued to take place. The overall pattern of the Nile Delta coastal shoreline is subjected to smoothing where there are areas of erosion and areas of accretion; with a total area of 2.7 Km^2 was taken from the land to the sea in the last 25 years. The general trend of the currents at this area is from West to East, which always carries the eroded sediment and deposited it in the eastern side. The presence of the wave breakers that constructed to protect the coast has made the general shape of the Nile Delta shoreline as series of crescents; as these wave breakers accelerated the deposition process behind them and fostered the erosion between them. The determined highest rate of deposition was at the spit system next to Damietta promontory with about 3.14 Km^2, with most of the sediment came from the erosion of the Damietta promontory and other locations in the western side.

5. References

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