NILE DELTA SHORELINE PROTECTION BETWEEN PAST AND FUTURE

El Sayed W.R.,Khalifa A.M.

Coastal Research Institute, walidelsayd@yahoo.com
Coastal Research Institute, ahmed_khalifa7575@yahoo.com

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ABSTRACT

Nile Delta coast line is covering about150km from east of Rosetta Nile Branch to west of Damietta Nile branch. The protection constructions, mainly hard structures type, had been executed along this stretch during the period 1984– 2015 with a total cost of about 1.2 billion L.E. The coastal protection works executed along Nile Delta coast are studied to assess the current situation and to propose the future protection. The field data is collected by the Coastal Research Institute (CoRI) has been analyzed to study the shoreline changes and to use these data in mathematical model input and calibration. Two models:Mike-21 2-D model, Litpack Module&GENESIS model were used for shoreline prediction under various protection conditions to confirm the results. Two solutions are suggested to overcome the shoreline retreat problems, which are continuing construction hard structures or using sand nourishment. Comparison between the two solutions for shoreline protection, side effects and the cost is evaluated. The study shows that using sand nourishment is more effective and less expensive related to using hard structures.

Keywords: Nile Delta Coast, sand nourishment, shoreline protection.

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1 INTRODUCTION

Erosion problems appear along the Nile Delta Coast, Figure (1), since 1900. As the water flow and sediments carried out by the Nile River two branches to the sea have been reduced due to: the climate changes, the construction of dams and control works along the river Nile itself, the continuous use of water for permanent irrigation requirements and man interference with the shoreline. The erosion rate has been accelerated since the completion of the High Aswan Dam in 1964 which trapped all the sediments transported by the River in its upstream side, (Fanos, 1999).

Two master plans were done for protecting the Nile Delta Coast from erosion. First one was made by TetraTech Company in 1986. The plan was to protect the entire Nile Delta coast from erosion such as Rosetta promontory, Baltim city at El Burullus headland and Ras El Bar city at Damietta promontory. In 1995 this master plan was modernized by Sogoria Company.

Shore Protection Authority (SPA) constructed a lot of coastal protection to protect the shoreline during the period 1984–2015 with a total cost of about 1.2 billion L.E, (SPA, 2015). Most of these coastal structures were constructed along the Nile Delta coast line covering the 200km from Rosetta Branch in the west to Port Said City in the east, Figure (1).

The main type of these structures is rubble mound breakwater, these structures include: groins perpendicular to the shore-line; breakwaters whether they are detached or connected to the shore, emerged or submerged; seawalls parallel to the coastline and revetments to protect slopes.These hard structures have side effects as they cause erosion and accretion in the down and up drift respectively i.e. they divert the problem to adjacent areas as they stop the sediment motion totally or with high percentage partially. This side effect take place nearly in all the coastal protection works along the Nile Delta, i.e. Rosetta Promontory, (El Sayed et.al., 2007) and Ras El Bar and Baltim, (Frihy et.al, 2004). Also, they may create weak circulation causing water stagnation which will affect the water quality badly such as what happened in El Asafra project in Alexandria, (Frihy et.al, 2006) and 6th October Resort in the Northwest coast, (Iskender, 2007).

The historical measured wave data from 1977 to 2010 are examined to investigate the effects ofclimate change on wave climate in front of the Nile Delta coast, (Iskander, 2013). Results show that there is an increasing trend in the mean significant wave height during theperiod from 1985 to 2010 by a rate ranging from 2.6 to 2.9 cm/year. Increase in wave heightcoincides with a decrease in wave period ranging from 0.01 to 0.26 sec/year. Wave energy in front of the coastal structures within this area will increase by about 20% within high storms and decrease by about 1 % within the normal conditions in the next 50 years. Nevertheless, most of the Egyptian coastal structures are over designed and will not be affected by the increase in wave energy due to the climate change.

This paper presents a study of the stretch of Nile Delta coast from east Rosetta promontory to the west of Damietta promontory showing how to overcome the shoreline erosion. Two solutions are proposed one is continuing constructing hard structures and the other one is using sand nourishment. Two mathematical models (1-D) wereused for shoreline prediction under these conditions.

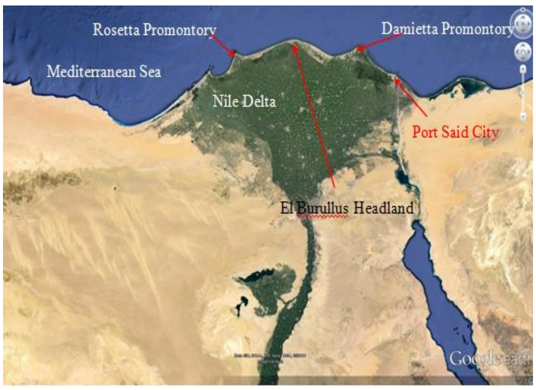

Figure 1. Location map of the study area

2 METHODOLOGY

The remaining coastal protection structures were studied with their side effects. The complete shoreline protection of the Nile Delta coast is studied by using two techniques. First solution is to continue constructing hard structures and the other one is using soft solution sand nourishment.

The effect of using these two solutions on the shoreline stability is studied by using Mike-21 2-D model,Litpack Module (DHI, 2016) and GENESIS (1-D) model (Hanson, 1987)to compare between the outputs of the two models to be sure of the model results. The model is used to select the best solution has the minimum effect on the shoreline stability. Also, the cost of the two solutions is presented.

Field data collected by CoRI has been analyzed to get shoreline behavior, Figure (2). Also, the field data collected by CoRI have been compared by the available field data collected by Shore Protection Authority (SPA) at some places such asKetchner and Rosetta. Comparing the two field data the differences were small between them. So we can trust in the field data.The shoreline measured by DGPS with accuracy less than 1m accuracy, this instrument is carried by a technician and collects the shoreline coordinates (latitude and longitude) every second. The wave characteristics (height, periodanddirection) were measured by high accuracy instrument S4DW, which fixed near the sea bottom and collects the data every 6 hours for one year.
Also, these mathematical models need field data used for model input and model calibration. The field data are: shoreline survey data from 2004 to 2014, wave data from 1985 to 2005, tide data from 1990 to 2000 as well as longshore current data from 1992 to 2004, (CoRI, 2015) & (CoRI, 2014).

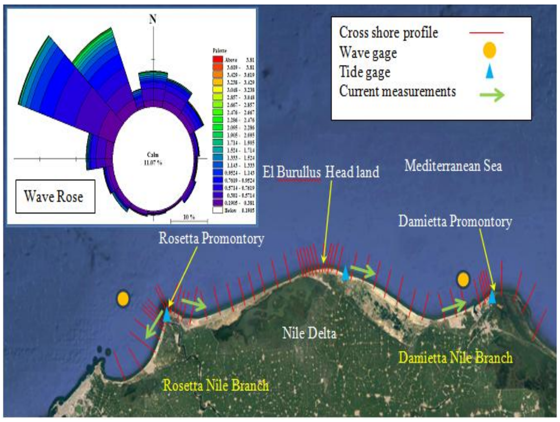

Figure 2. Field Work and collected data along the study area

3 RESULTS AND DISCUSSIONS

3.1 Current Shoreline change due to coastal structures

The shoreline change was studied along the Nile delta coast to assess the remaining situation after constructing the coastal structures from 1984 to 2016. The study starts from east Rosetta promontory to the west of Damietta promontory.

3.1.1 Rosetta promontory

After constructing the High Dam, the situation of shoreline change of Rosetta promontory became very serious as the erosion rate was 147 m\year in the west side and 80 m\year in the east side. This retreat of the shoreline threats the agriculture areas. So Shore Protection Authority SPA executed two do losrevetments during the period 1989-1992, in land one on each side of the promontory, with 5 Km long; 1.5 Km in the west side and 5 Km in the east side, figure (3).The sea wall was finished in 1992. Unfortunately, the erosion begun in front of the seawall and the sedimentation inside the inlet. The shoaling of the inlet leads to hindering the navigation process of fishing boats. The results of testing a huge number of proposed alternative solutions to sustain the stable conditions of the Rosetta promontory/mouth were executed by using Coastal Modeling System model, (Masria et. al, 2014). The results indicated using only hard structures or soft measures without nourishment is not capable of keeping the Rosetta promontory/outlet stable. Only combination of both hard structures and soft measures with application of nourishment can improve the situation towards sustainable stable conditions (Negm et.al, 2015).Also, the erosion begun in the adjacent areas at the end of the walls i.e. the problems translated to the adjacent areas. A Bazalt wall with 200m length was constructed in 2003 to protect TabiatElAbd, which is located to the west of the western seawall. SPA has been executing a groin system; nine groins spaced every 550m, to protect 5.5 km shoreline length located down drift of the western seawall. East of the eastern Rosetta seawall, a system of groins consisting of five groins spaced every 900m was constructed for protecting 4.5 km shoreline from erosion. The shoreline located east of this groin system is retreated by average rate of 35 m/year for 3.5 km shoreline length, figure (3).

Figure 3. Rosetta promontory coastal structures

3.1.2 El Burullus headland

The erosion problems caused that the Burg El-Burullus village has been moved inland several times in the past. In 1989 a sea wall in front of the village was constructed with 400m length. The erosion starts in the shoreline east of this seawall. So SPA extended this seawall up to a length of 1900m. Due to this seawall the erosion transferred to the adjacent area called El Banayeen village so protection works such as groin and breakwater were constructed to protect El Banayeen shoreline with length 3100m, figure (4). The shoreline located east of this protection system is retreated by average rate of 20 m/year for 2.6km shoreline length. Going to the east by 6.5 km Baltim resort is located. To save this resort from shoreline retreat, a system of detached breakwater was constructed to protect 7.0 km shoreline length. This system transfer the erosion to the adjacent area, so a short groin system(nine groins), was executed to protect the shoreline till Kitchener drain with length of 2.1 km, figure (4). Due to these protection works, erosion problem found in the eastern side of Ketchner drain, figure (4). The shoreline located east of this groin system is retreated by average rate of 25 m/year for 3.0 km shoreline length and the Kitchener drain outlet is transferred to east causing water flow problems. So, CoRI and SPA had been studying protection system as rapid solution to overcome this problem and to stabilize the drain mouse. Two jetties and a groin system (15 groins) with sand nourishment in the east had been proposed to stabilize the shoreline with length of 3.0 km east ketchner drain. It is expected that the shoreline located east of this groin system will need protection, (CoRI, 2016).

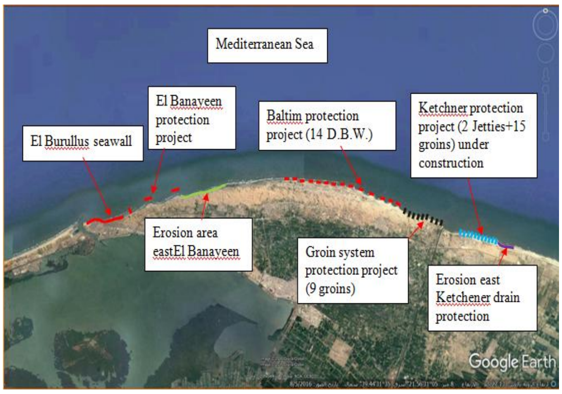

Figure4. El Burullus headland coastal structures

3.1.3 Damietta promontory

Damietta promontory is located on the east side of the Delta Coast, fig (1). This area was formatted as a head in the sea from the Nile sedimentation from ancient centuries So Shore Protection Authority SPA executed a system of detached breakwaters about 8 breakwaters in front of Ras El Bar summer resort at the western side of Damietta promontory, to cover about 3 km shoreline, fig (5). Also two jetties were constructed to keep the Nile outlet saves and one headland and one groin executed between the breakwater system and the western jetty of Damietta outlet. Two seawalls were executed around Damietta outlet, one in the west with about 0.80km length. The other is in the east of Damietta outlet with 6.5 km length.Ras El Bar protection works are located between two coastal structures, the eastern jetty of Damietta harbor and the western jetty of Nile branch, so the side effect of these coastal structures doesn't transfer abroad to adjacent areas.

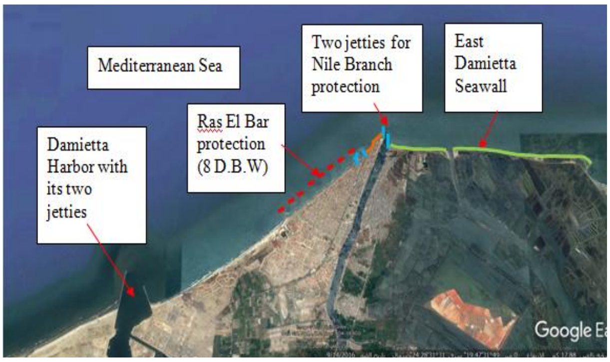

Figure5. Damietta promontory coastal structures

3.2 Waves

Wind waves are the principal driving force for the transport of sediments on the coasts and the chief agent in near-shore coastal processes (erosion and/or accretion). In order to obtain a more complete description of wave climate; a directional wave recorder CAS (Cassette Acquisition System) has been used during the period from 1985 to 1990 (Elwany et al., 1988) and then followed by S4DW Directional Wave Meter up to 2005. CAS device was installed in two locations; Rosetta and Ras El Bar. S4DW was installed in Rosetta, Damietta, Abo Qir bay and El Dekhilla port. These wave data have been subjected to statistical analysis and it is concluded that waves had significant wave height of 1.12 m and average peak wave period of 6.0 sec and coming from the NW. The maximum wave height is 5.5m with 13 sec corresponding wave period. The predominant wave directions are from WNW, NNW, N, and W as shown in Figure (2) , with a small portion of waves arrived from the NNE and NE especially in March and April (El Sayed et al., 2007). These wave data were used as main input for GENESIS (1-D)&Mike-21 2-D model, Litpack Module.

3.3 Using hard structures for shoreline protection

Since 2006 Shore Protection Authority (SPA) has been using the groin system or groin like T section in shore protection. So, the groin system will be used in this study for shore protection for the erosion areas.Mike-21 mathematical model was used to calculate the shoreline change due to constructing this system. Mike-21,Litpack Module–Lit line sub-modules is a famous model is studying the shoreline changes and movement of sediment along the shore, whether without marine constructions or with marine constructions such as breakwaters and detached breakwaters (DHI, 2016). The model calculates the shoreline change mainly under the effect of waves. The output of the model is to predict the shoreline, whether the progress towards the sea or to retreat toward land.

The study used also GENESIS mathematical model to calculate the shoreline change under same conditions. GENESIS numerical model is a powerful software package for the purpose of engineering uses and research; it was developed jointly by the Department of the Army (Waterways Experiment Station, Corps of Engineers, Vicksburg, MS, USA) and the Department of Water Resources Engineering (Lund Institute of Technology, University of Lund, Sweden). This shoreline evolution model has demonstrated its predictive capabilities in numerous projects (Hanson, 1987).

The main input data for Mike-21, Litpack Module are: shoreline, wave data, cross shore profile and sediment characteristics. The model is calibrated using the measured shoreline data. The shoreline was measured by using DGPS (Harley et al., 2011) with accuracy less than 1m accuracy; this instrument is carried by a technician and collects the shoreline coordinates (latitude and longitude) every second. The model output for east Rosetta is presented as a sample of model results.

3.3.1 Rosetta promontory

The groin system is proposed for protecting the eroded area east the groin protection, figure (3). Mike-21,Litpack Module–Lit line sub-modules was used to calculate the effect of constructing the groin system in this area. The used input data is the measured shoreline for 2013 and 2014 for 6 km shoreline length including the eastern seawall, wave data measured at Edcocity (about 15 km west Rosetta) in 2002 and sediment characteristics data. Figures 6&7 shows the model outputs for the shoreline change as the horizontal axe is the distance along the shoreline from the origin and the vertical axe shows the distance from the baseline, in a simple way it shows the coordinates of the shoreline in plan. The model calibrated using the measured shoreline in 2014 which was predicted after one year (this line is under the name ofModel 2014shown in Figure 6) compared this with the measured one in 2014 (this line is under the name of calibration 2014 shown in Figure 6). The model results showed a standard deviation of 9 m with (CV) error percentage of 12% which is a reasonable result for a 1D-Model. Comparing the model simulated shoreline change rates with calibration data (Figure 6), the model is obviously found to be completely satisfactory and equivalent to the present situation of the shoreline changing phenomenon in the study area.

Proposing hard structure for shoreline protection using groin system, the groin length is about 250m spacing 250m for protecting 1km shoreline length, for example. The model results show that the shoreline of this area is going to be stabilized but the erosion is transferred to the adjacent area, Figure 7. The length of new erosion area will be about 2.0km with 30m rate of shoreline retreat. So the hard structure system needs to be extended to reach the west jetty of El Burullus fishing port with shoreline length of about 53 km, figure (8). Based on SPA last tender of executing groin system, the cost for 1 km shoreline is about 40 million L.E. So about 2120 million L.E are needed for stabilize the shoreline east Rosetta promontory.

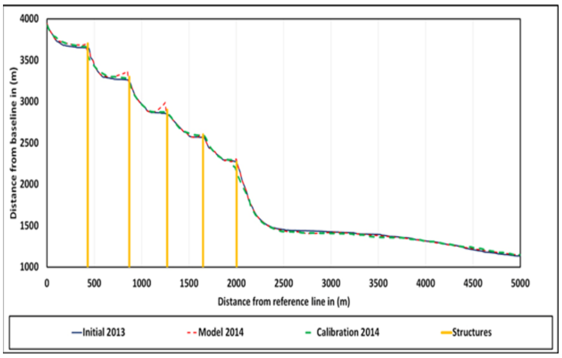

Figure 6. Model calibration for East Rosetta study area

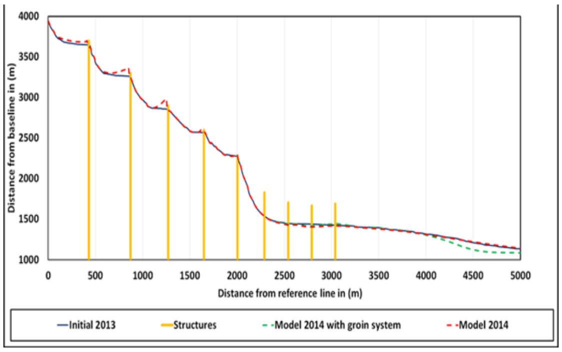

Figure 7. Model output for using groin system at east Rosetta study area

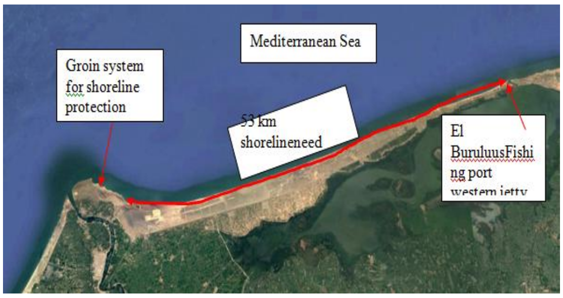

Figure 8. Shoreline between current groin system east Rosetta and El Burullus fishing port

3.3.2 El Burullus headland

There are two areas that need protection; the first one is in the east of El Banayeen village protection works with shoreline length of about 6.5 km, figure (4). This shoreline has a small length related to the others so it can be protected by the groin system. This protection will cost about 260 million L.E. The other one is the area down drift the in-construction protection. CoRI model expected erosion in the down drift of this groin system, (CoRI, 2016). So there is a need to protect this coastal area till the west jetty of Gamasa drain with shoreline length of about 36km, figure (9). The cost will be about 1440 million L.E for stabilize this shoreline.

From the above results of the shoreline changes study due to coastal structures from the field data and model outputs, it is clear that any coastal structure will transfer the erosion problem to adjacent area.

The cost of hard solution for protecting the east Rosetta and ketchner area will be about 3560 million L.E with 10% annual maintenance cost 356million L.E.

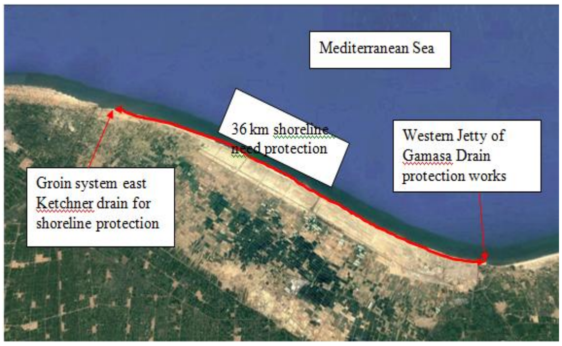

Figure 9. Shoreline between current groin system east Ketchner and Gamasa drain

3.4 Using sand nourishment for shoreline protection

3.4.1 Rosetta promontory

Mike-21,Litpack Module–Lit line sub-modules was used to calculate the sand nourishment for overcome the erosion problem. Figure (10) shows the shoreline after one year, (Model 2014 after nourishment in the figure), will not be retreated after using 470 000m^3 sand nourishment. So, it is concluded that using 470 000m^3 sand nourishment every year will stabilize the eroded shoreline. There are two source of sediments one is thedredged sand from the navigation channel of Egyptian Liquefied Natural Gas project at Edco city about 25 km from the erosion area or from offshore. The proposed solution which is sand nourishment is using worldwide as an example in Italy, Germany, Netherland, France, Denmark, Spain and United Kingdom,(Hansona et al., 2002).The uses of beach fill in the countries of the European Union are studied and discussed with respect to the general situation, project type and objectives, design and evaluation procedures, legal framework, and financial aspects. Significant differences were found among the investigated countries,(Hansona et al., 2002).In recent study of problems were with various types of hard structures, (Masriaet.al., 2015) encouraged the coastal engineers to think about new types of environmental friendly structures which can work better with ecological situation. They conclude that there is a predominant approach towards the soft engineering, the eco-engineering techniques, or a combination between them in order to enhance the ecological situation.

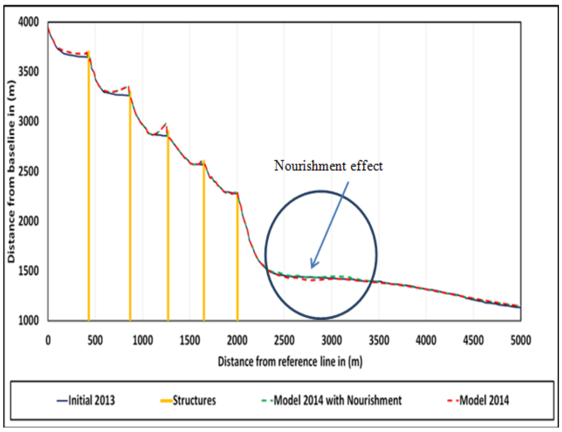

Figure 10. Model output for using sand nourishment at east Rosetta study area

3.4.2 El Burullus headland

It is concluded that from the previous study that the east ketchnerdrain needs sand nourishment system every year to nourish the beach by sandquantities of400 000 m^3/year, (CoRI, 2016). This quantity can be acquired from dredged sand of navigation channel of Damietta harbor or borrowed from offshore.

The total quantity for sand nourishment is about 1.0 million m^3/year. The cost of one cubic meter for sand nourishment will be about 100 L.E, so the total cost will be about 100million L.E.

3.5 The cost difference between hard and soft solution

For the two solutions El banayeen areas with 6.5 km shoreline will be protected by groin system which will cost about 260 million L.E.So it will not be included in the comparison. The cost of hard solution for protecting the Nile Delta coast will bethe cost of the groin system of east Rosetta and ketchner area which will be about 3560 million L.E with 10% annual maintenance cost 356million L.E. Also, this project will take about 20 years for construction.On the other side, the total quantity for sand nourishment is about 1.0 million m^3/year. The cost of one cubic meter for sand nourishment will be about 100 L.E, so the total cost will be about 100million L.Ewhich is less than the one third ofannual maintenance cost of hard structures. This project can be executed in one year.

3.6The difficulties face the soft solution and the start

The borrowed sand from offshore or from the navigation channel will be fine so the sediment quantity will be nearly duplicated to overcome the lost sediment. Research works shows that the dredged sand of navigational channels and Lake Inlets can be used. The compatibility analysis of core samples collected from the dredging areas with the native eroding beaches was performed. Results indicate that the compatibility of the dredged borrow sediments to the native material varies locally from fairly compatible (Rosetta estuary, Burullus harbor, Damietta approach channel, and El Gamil inlet) to incompatible (Abu Qir bay), (Frihy et al. 2016).Also, this technique isn't used before by SPA, so it is not easy to find the contractor with reasonable price. So it is prefer for SPA to establish a new unit for sand dredging and nourishment and buy a marine dredger. Now, Egypt is in need for this operation such as sedimentation in the Nile Delta Branches outlets (Rosetta &Damietta), coastal Lake inlets (Edku, El Burullus, El Manzala and El Bardaweel) , main drain outlets (Ketchner, Gamasa, El Gameel) and the navigation channels of the harbors located on the Nile Delta coast (Damietta, Edku). Also, problems due to coastal structures for development projects like erosion problems east Marina resort.

3.7 The benefits from sand dredging and nourishment technique

This operation, sand dredging and nourishment, will enable SPA to solve all erosion problems in one year with very low cost comparable with hard structure trend. These nourished sediments will move along the coast which can be trapped along the coast building the sand dunes protecting the coastal area from flooding. This will encourage solving the accretion in the up drift and erosion in the down drift problems of the hard structures constructed for infrastructures projects to be solved by using this operation. This can be obvious clear in Marina Resort, Damietta harbor,…etc. Also, it will enable SPA to solve the other sedimentation problems in harbor navigation channel, Nile Branch outlets, drain outlets on the coast and coastal lake inlets.This soft solution was used before by Shore Protection Authority which is responsible for the shore protection for shore protection in Alexandria in 1988 i.e. since 28 years by using sand nourishment from land. This work succeeded to overcome shoreline retreat.Also, the current UNDP Egypt project: Adaptation in Egypt through Integrated Coastal Zone Management (2016) proposing two main approaches for shore protection.The two approaches are: 1- using dredged sediment from navigation channel as sand nourishment to overcome the shoreline erosion, 2- constructing dikes (like sand dunes) located 100m from the shoreline in land to overcome sea water flooding in land.So the proposing soft solution in the paper is compatible with this project.

CONCLUSIONS

The shoreline along the Nile delta coast between East Rosetta Promontory and west of Damietta branch was studied. Erosion areas were concluded based on collected field data. It was found that there are about three main areas suffering from erosion which are east the groin system located east the eastern Rosetta seawall, east El Banayeen protection system at El Burullus and east the protection system of Ketchner drain at El Burullus. Mike-21,Litpack Modulewas used for solving the erosion problemby using hard and soft solutions. Groin systemwas proposed as hard structure solution for solving the erosion problems like SPA projects. Sand nourishment from offshore or from dredged sediment from the navigation channel was used as soft solution. The study shows that using soft solution is very effective in cost and efficiency to overcome erosion problems along the Nile delta coast in less time.

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REFERENCES

Adaptation in Egypt through Integrated Coastal Zone Management (2016).www.adaptation-undp.org/projects/sccf-czm-egypt.

CoRI(2016) Study of the erosion of Ketchener Drain, Technical Report, May 2016.

CoRI (2015) Studying Shoreline Changes along El Burullus Coastal Zone, Nile Delta Coast during the period (2004 - 2014), Technical Report, June 2015.

CoRI (2014) Studying Shoreline Changes along Rosetta Coastal Zone, Nile Delta Coast during the period (2004 - 2013), Technical Report, June 2014.

DHI, "dhigroup," DHI, 2016. [Online]. Available: http://www.dhigroup.com/. [Accessed 2016].

El Sayed, W.R., Ali, M.A., Iskander, M.M., Fanos, M. (2007) Evolution of Rosetta promontory during the last 500 years, Nile delta coast, Egypt. In:Eighth International Conference on the Mediterranean Coastal Environment.MEDCOAST, Alexandria, Egypt.

Elwany, M.H., Khafagy, A.A., Inman, D.L. and Fanos, A.M(1988)Analysis of wavesfrom arrays at Abu Quir and Ras El-Bar, Egypt. Advances in Underwater

Technology, Ocean Science and Offshore Eng., Vol. 16,pp. 89-97.

Fanos, A. M (1999)Problems and protection works along the Nile delta coastal Zone.Fifth International Conference on Coastal and Port Engineering in DevelopingCountries, Cape - Town, South Africa, 19-23 April 1999.

Frihy, O.E.; Deabes, E.A., and Helmy, E-El.D.F.(2016) Compatibility analysis of dredged sediments from routine pathways and maintenance of harbor's channels for reuse in near shore nourishment in the Nile Delta, Egypt.Journal of Coastal Research: Volume 32, Issue 3: 555-566. 2016

Frihy O.E., Iskander M.M., El Sayed W.R. ,Abo Zeid A.I., Sliem M.A., Hassan M.S. andBadr A.M. (2006) Environmental Impacts Monotiring of the Emerged Breakwaters at Asafra-Mandara Beach, Alexandria, Egypt. The First International Environmental Forum about a New Strategy for Developing Communities and Environment, Tanta ,Egypt, April 2006.

Frihy O.E., El Banna M.M., El Kolfat A.I. (2004)Environmental Impacts of Baltim and Ras El-Bar Shore –Parallel Breakwater system on the Nile Delta Littoral zone Egypt.Environmental Geology, January, 2004, Vol. 45, No; 3 Pages (381-390).

Hanson, H. (1987) GENESIS: A Generalized Shoreline Change Numerical Model for Engineering Use. Ph.D. Thesis, University of Lund, Lund, Sweden.

Hansona H., Bramptonb A.,Capobiancoc M., Detted H. H, Hamme L., Laustrupf C., Lechugag A., SpanhoffhR. (2002) Beach nourishment projects, practices, and objectives—a European overview.Coastal Engineering Journal, Volume 47, Issue 2,December 2002, Pages 81–111.

Harley M.,Turner I.,Short A. and Ranasinghe R. (2011)Assessment and integration of conventional, RTK-GPS and image-derived beach survey methods for daily to decadal coastal monitoring. Coastal Engineering Journal, El Sevier, Volume 58, Issue 2, February 2011, Pages 194-205.

Iskender M.M., El Ansary A.E, Abd El Mooty M.M., Nagy H.M.(2007) Investigating the value of monitoring the implemented coastal structures along El Agami beach, Alexandria, Egypt: case study. Journal of coastal Research, Vol.23, Issue 6, Pages 1483-1490.

Iskander M.M. (2013)Wave Climate and Coastal Structures in the Nile Delta Coast of Egypt, Emirates Journal for Engineering Research, 18 (1), 43-57.

Masria, A., Iskander, M. &Negm, A. (2015). Coastal protection measures, case study (Mediterranean zone, Egypt). Journalof Coastal Conservation,June 2015, Volume 19, Issue 3, pp 281–294.

Masria A, Iskander M, Abdelazim Negm, Oliver C. Saavedra (2014) Numerical modeling of Rosetta river mouth, Egypt. International Water Technology Journal 4: 190-207.

Negm A., Masria A., Iskander M.andSaavedr O. (2015) Towards a Sustainable Stability of Coastal Zone at Rosetta Promontory/ Mouth, Egypt . Oceanography 2015, 3:1. SPA (2015) Shore Protection Authority Achievements and Challenges, 75p.