



Cairo University

SHORELINE MANAGEMENT PLAN FOR THE NORTHERN COAST OF EGYPT: STUDY CASE FROM MARINA EL-ALAMEIN TILL MARBELLA RESORT

By

Bassam Gamal El sayed Gabr

A Thesis Submitted to
the Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

In

IRRIGATION AND HYDRAULICS ENGINEERING

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

**Shoreline Management Plan for the Northern Coast of Egypt:
Study case from Marina El-Alamein till Marbella resort**

Key Words:

Shoreline changes; Sediment transport; One-line model; Coastal structures; Energy balance equation

Summary:

One of the enormous coastal problems is the coastal erosion. The Northern Coast of Egypt (NC) from Marina El-Alamein recreational center (MA) to Marbella resort (MR); located at a distance about 50 kilometers east of MA was suffering from a significant shoreline changes. In this study, a large stretch of the coast was modelled to attain the appropriate protection countermeasure. Firstly, shoreline change rates were calculated by analyzing the available shorelines extracted from satellite images using Digital Shoreline Analysis System (DSAS) tool in GIS. The shoreline changes were simulated using one-line numerical model. The model determines the shoreline changes due to wave induced long-shore sediment transport considering different types of coastal structures. The model was calibrated by field measurements and shorelines digitized from satellite imagery. The nearshore waves used in the shoreline model were estimated using a phase average wave transformation model based on Energy Balance Equation (EBE). The proposed coastal countermeasure involves using system of groins, system of detached breakwaters or mix of them with some recommendations for each case.

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Abstract

The coastal environment constitutes a fragile and complex ecosystem that is an important resource for most nations, especially for Egypt which is one of the countries that have long coasts attracting many investments. Focusing on the northern coast of Egypt, we found a continued and extended development since the last few years for a better enhancement of recreational facilities. We can't assure that the possible great benefits come with no corresponding problems like undesirable shoreline changes that need more logical treatment and proper management.

Starting by Marina El-Alamein (MA) recreational centre at the Northern Coast of Egypt (NC) which is located about 90 km from Alexandria, the resort was subjected to growing erosion patterns eastward of the executed structures. Erosion growth extended to the neighbouring resorts' beaches along the coast east of Marina which introduces a threat to these resorts. One after the other of these resorts will be forced to save their beaches. Various types of hard structures were already constructed along the shore of Ahlam resort just east of Marina. Marbella resort (MR) also constructed a series of offshore detached breakwaters that allow limited bypass to the east. Thus, the reach from Marina till Marbella can be considered as a single sediment cell with a great need for coast management to protect the shoreline. The current study aims to provide a global solution for the whole study area better than the limited local solutions assigned to certain resorts.

The research plan involved capturing long stretch of the coast to build a study domain; about 55 km starting by Marina El-Alamein and ending at Marbella to the east. Shorelines were extracted from satellite images recorded at several years and were used to define erosion and accretion regions. The shoreline change rates were estimated by different statistical methods. The bathymetry needed for wave modelling was prepared by compiling the available data from Google Earth, Admiralty Charts, and GEBCO data. The offshore waves were acquired from wind wave hindcasting. Phase average model based on energy balance equation was used to simulate coastal processes and calculate average waves' properties evolution from deep water to near-shore zone. The shoreline from Marina to Marbella was modelled using One-line shoreline change model. The model was calibrated at two different locations, i.e. Marbella and Ahlam resort.

Data and methodology has been prepared and were used to investigate the impacts of any coastal structures placed along the study area. The Model has been used to predict the future shoreline changes of the existing situation and due to several countermeasures including detached breakwaters and groins. With more trials of optimization, there would be more alternative scenarios that can be placed; either system of groins or series of detached breakwaters distributed along the shore. However, a mix of them would be the convenient strategy among of the studied alternatives.

Chapter One: Introduction

1.1. General

The coastal regions are attractive environment for most of people. These regions constitute an escape for people outside the overcrowded cities during the hot summer or holidays. Moreover, the urbanization of these regions encourages the migration to it because of the availability of work opportunities there corresponding to the growing development from year to the other.

Therefore, many of countries finances and approves construction of touristic resorts and recreational facilities, harbors and its related marine structures. The resorts owners always seek to enhance their recreational facilities (safe swimming areas, calm zones for boating and fishing, swimming pools and the marinas). That may require construction of hard structures such as breakwaters or inlet stabilization jetties in case of artificial lagoons. In fact, all of them may cause undesired shoreline changes if the impact assessment is not well investigated in the preliminary designs.

Unfortunately, since humanity decided to concern the coastal environment with modifications, that led up to undesired impacts and uncompleted understanding of their consequences. And despite the advance of coastal engineering and environmental sciences, there are a lot of problems existing till now all over the world waiting for an effective response.

One of these enormous problems is the shoreline recess and the reduction in beaches because of sediments loss. Either that was due to natural causes or man-made, both cases represent a hazard to the developed coastal zones. May these changes occur in case of on-going sea level rise related to the climate change through long time spans. Alternatively, the shoreline retreat may be due to some of motivated coastal processes developed in the nearshore zone. Additionally, coastal structures have direct effects magnify the coastal erosion.

Regarding sediment transport process, it can be divided in to two divisions; cross-shore and along-shore sediment transport. Cross-shore sediment transport always occurs with magnified amounts and controlled by short-term severe changes. For the long- term computations, it may be ignored assuming the loss of sediments will get back to the shore with the progress of time. On the other hand, the along-shore sediment transport is considered the dominating in the long-term analysis of shorelines.

In long-shore sediment transport, offshore waves propagate onshore and transformed over a bathymetry to near shore zone. The developed long-shore currents force the sea bed sediments to move along the coast. The simulation of this process requires collecting field data, implementing laboratory experiments, setup of a physical model or developing a numerical model.

The nearshore waves need to be estimated. There are many of intensive research directed to modelling of waves to investigate their effects on beaches morphology.

These models are required include refraction, shoaling, diffraction and wave breaking as well as considering existence of complicated bathymetries.

After modelling of waves, simulation of sediment transport process and predicting the shoreline changes, the expected erosion must be mitigated. The mitigation of such erosion may be achieved by placing coastal countermeasure. The common used structures are hard measures such as groins, seawalls and detached breakwaters. There are other alternatives also contribute in mitigation of coastal erosion. These alternatives may be the soft countermeasures such as beach nourishment or vegetation.

All of these protection measures constitute a constraint to the shorelines, especially the hard structures. They need a special treatment taking into consideration their nature of sediment blockage. They may cause undesirable shoreline changes for the adjacent beaches. It is recommended to execute a detailed comparison of hard against soft protective alternatives to maintain a reliable application of shoreline management plan.

Since, there is a conflict between the development in coastal regions and resulting problems due to poor design. There is a great need to investigate solutions to mitigate the potential problems. Such tasks go to researchers to accomplish compromising of the conflict and let the policy to the decision makers.

Finally, shoreline protection needs to develop an effective tool for shoreline prediction and that is the objective of the present research. Proper shoreline management requires a well understanding and evaluation of the whole factors affect the beach morphology i.e. wave climate, beach characteristics, bathymetry and the induced coastal structure. Also, taking into consideration other factors such as beach nourishment, rocky beaches and marinas inlets.

1.2. Problem Definition

The western part of the Northern Coast of Egypt (NC) was observed suffering from significant shoreline changes. These shoreline changes appear along the stretch as series of eroded beaches at several partitions. Starting from Marina el-Alamein (MA) recreational center which was implemented around an artificial lagoon there. This lagoon was in the past in the form of three closed lakes isolated and with hyper salinity including sabkha. These lakes were separated from the sea by chains of sand dunes extending along the coast there. Its water was stagnant without any source to renew.

In an urbanization stage, these lakes were deepened and connected to the sea to create a large recreational lagoon and the resorts around it. In this aspect, four inlets were adapted to provide access to this lagoon and ensure water circulation. These channels were dredged with relevant dimensions and then started in operation. With time advance, the dredged channels were subjected to a severe sedimentation affected the vessels movement and the water quality inside the lagoon. One of the mitigation actions which were expected to solve this problem required an interference of hard structures to protect and stabilize these channels. Series of jetties with variable lengths were placed around the four lagoon inlets. That caused shoreline changes in term of erosion to the east of these structures and accretion west of them. Additional defense

structures (groins) were constructed but they motivated the erosion growth east of MA. This erosion growth extended to the neighboring resorts' beaches along the coast east ward of MA which constituted a threat to them and their recreational facilities. So, one after the other of these resorts was forced to resist the shore retreat to save their beaches. Consequently, various types of hard structures were implemented along the shore of Ahlam resort just east of MA. Adding up, Petro beach at the eastern side of Ahlam decided to construct protective structures. MaRbella (MR) resort also constructed a series of offshore detached breakwaters that allow limited bypass to the east.

Thus, the reach from MA till MR can be considered as a single sediment cell. There is a great need for coast management to protect the shoreline either by soft protection methods such as nourishment and vegetation or other hard structures. The shoreline from MA to MR was studied using a developed tool for shoreline management. The alternative plans of shoreline protection were discussed. This study provides a solution for the complete coastal reach rather than provide limited local solutions to certain resorts.

Figures from (1-1) to (1-6) show the location, the extent of the study area and shoreline changes due to protection structures at particular sites along the NC.



Figure (1- 1). Study area location on Egypt map

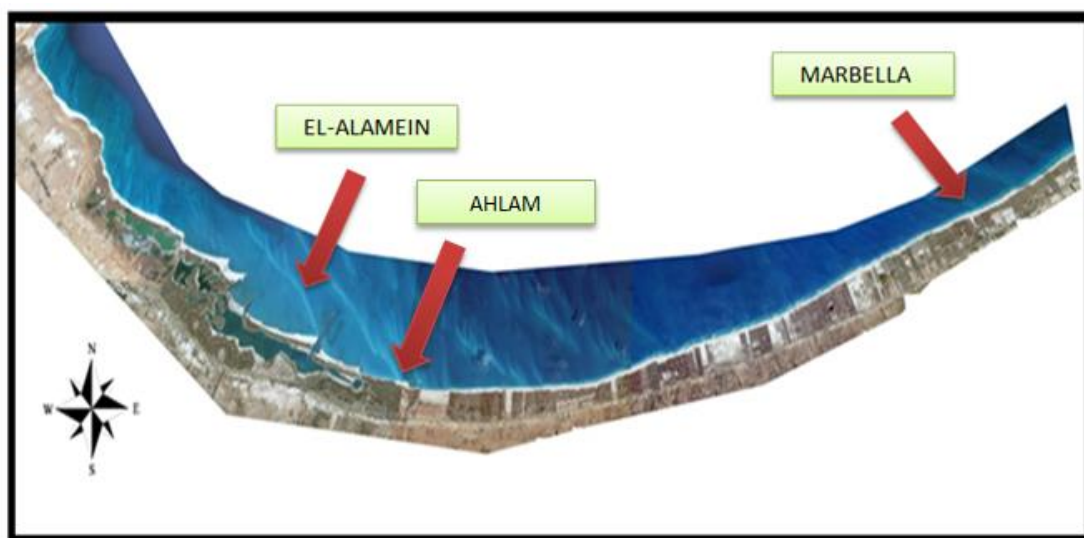


Figure (1- 2). Extent of the study area



Figure (1- 3). Google satellite image showing shoreline changes at Marina El-Alamein resort



Figure (1- 4). Google satellite image showing shoreline changes at Marbella resort