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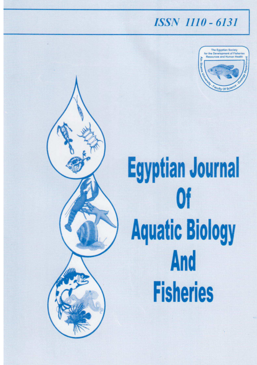

Assessment of shoreline stability and solidity for future investment plans at Ras El-Bar Resort (Egypt).

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ABSTRACT

Ras El-Bar resort located in the northeastern Egyptian Nile Delta coast includes a very active sandy beach coastline, which extends roughly 12 km west of Damietta Nile branch. Erosion along the coast of Ras El-Bar resort has been mitigated by constructing a series of coastal engineering structures that include jetties, groins, seawalls and detached breakwaters. The Project of protecting Ras El-bar resort started early in 1941 and ended in 2010 and aimed to decrease the continuous erosion and protecting the investments at the Ras El-bar resort. Studying shore line change at this region is important in making the development plan of protection works along the Egyptian northeastern coast by evaluating the effect of constructed detached breakwaters on shoreline. The purpose of this paper is to calculate the change detection rate of Ras El-bar shoreline at the last 15 years (2000-2015) and to evaluate the effect of basaltic stones and dollos blocks that constructed to re-protect the western jetty and fanar area by mitigating beach erosion. Besides, this study aimed to determine the degree of shoreline stability and solidity for future investment plans. Remote Sensing (RS) technique was used as a low cost method to Evaluate the morphologic changes (erosion/accretion patterns) from analysing Landsat-8, spot4, ETM+, and Egypt sat satellite images that acquired in the period from (2000-2015) to get the shoreline vector position of each date year. It was found that the shoreline change rate at Ras El-Bar resort at present study in the period from 2000-2015 has reached an erosion rate of (-0.1:-1.1m/yr) and a rate of accretion that reached to (+0.2:+4m/yr) at maximum. These rates values consider as the ideal values for stable beach and enabled us to give a clear conclusion that Ras El-Bar's beaches behind the detached breakwaters are stable and no need for future protection in the near future. Therefore, this study did not examine the area hydrodynamiclly because there is no need for that, since the message given by the stable beach for a long time is a strong testament refers to a balance of bilateral dimensions within the depths of coastal zone. As long as the beach is stable, the surf zone is stable.

INTRODUCTION

At first ages of this area history, erosion occurs, which promotes the Egyptian Shore Protection Authority (ESPA) to implement detached breakwaters parallel to shoreline. The accretion sector behind the system of detached breakwaters is protecting Ras El Bar resort, which characterized by growing the shoreline with maximum rates of 4.2 m/year as calculated in present study in the period from (2000-2015).

Processing techniques for satellite Images used at this study has been done usingERDASImagine.2013, Envi.5, and ArcGIS 10.2, which used to enhance the image resolution by the layer stacking and merging function. Additionally, change detection of Ras El-bar shoreline has been calculated using DSAS method.

Image processing applied in this study included geometric rectification; atmospheric correction; on-screen shoreline digitizing of the "2000:2012" (ETM+), 2006 (Spot4), 2010 (Egyptsat), and "2013:2016" (Landsat- 8) images for monitoring the shoreline position along Ras El-Bar Detached breakwater resort. The USGS ETM+ images have a technical problem, since the sensor of the satellite was not oriented correctly, based on that all the images after 2003 has sharp stripes. However, the USGS explained on their site, how to remove these stripes (destripe) with deferent methods and different softwares. At present study the strips have been removed by using two methods one of them at ENVI 4.7 and the other at ERDAS Imagine 2013.

The most common methods applied for change detection include band ratio, band differencing, principal component analysis, vegetation index differencing, and post-classification change detection. Howarth & Wickmore (1981) and Nelson (1983) considered rationing to be a relatively rapid means of identifying areas of change. Dewidar (2000) used band ratio images to enhance spectral differences between rocks and suppress topographic effects. Sonka *et al*. (1993) applied Edge detection technique to delineate the land/sea boundary by passing a spatial convolution filter kernel over the image. White and El-Asmar, (1999) recommend automatic extraction of shoreline vector by computer, since it is more objective without the bias of a person.Lu *et al.* (2004) explained that change detection includes the application of multi-temporal datasets to quantitatively analyze the chronological change of the phenomenon.

Kaiser (2004) summarized that; one can use three basic methods of re-sampling images; nearest neighbour, bilinear interpolation and cubic convolution and found from Modelling and remote sensing results that eroded material from the down-drift sites is deposited at the up-drift sites and that previously eroded materials are now being redistributed along the Nile Delta coast. Remote sensing results of land thematic mappers acquired along the Nile Delta coast in the period from 1984-2000 indicate that the planform area decreased from sediment lost at a rate of $–4.6*10^4$ m^2/yr before engineering structures to $-2.6*10^3$ m^2/yr after engineering protection became effective. El Banna (2009) testified that both naturaland anthropogenic factors have influenced the Nile Deltacoastal area. These factors include: Coastal processes, land subsidence, change in the Nilesediment supply, andweakening of natural habitats.

Pardo *et al*. (2012) assessed the process of extracting shorelines from Landsat images by obtaining a RMSE that ranges from 4.69 m to 5.47 m. The process considers the automatic extraction of the boundary land-water and the geo-referencing coastline system, both with subpixel accuracy. Sánchez-García et al (2015) analysed the shoreline position extracted from Landsat TM and ETM+ imagery and applied a statistical analysis of results to characterize the medium and long term period changes occurring on beaches to assess the validity of extracted Landsat shorelines knowing whether the intrinsic error could alter the position of the computed mean annual shoreline or if it is balanced out between the successive averaged images.

MATRIALS AND METHODS

STUDY AREA

Ras El-Bar resort, which contains a very active coastline consisting of a sandy beach, located in the northeastern Egyptian Nile delta coast, and extends roughly 12 km westward from the mouth of the Damietta Nile branch (Fig. 1).

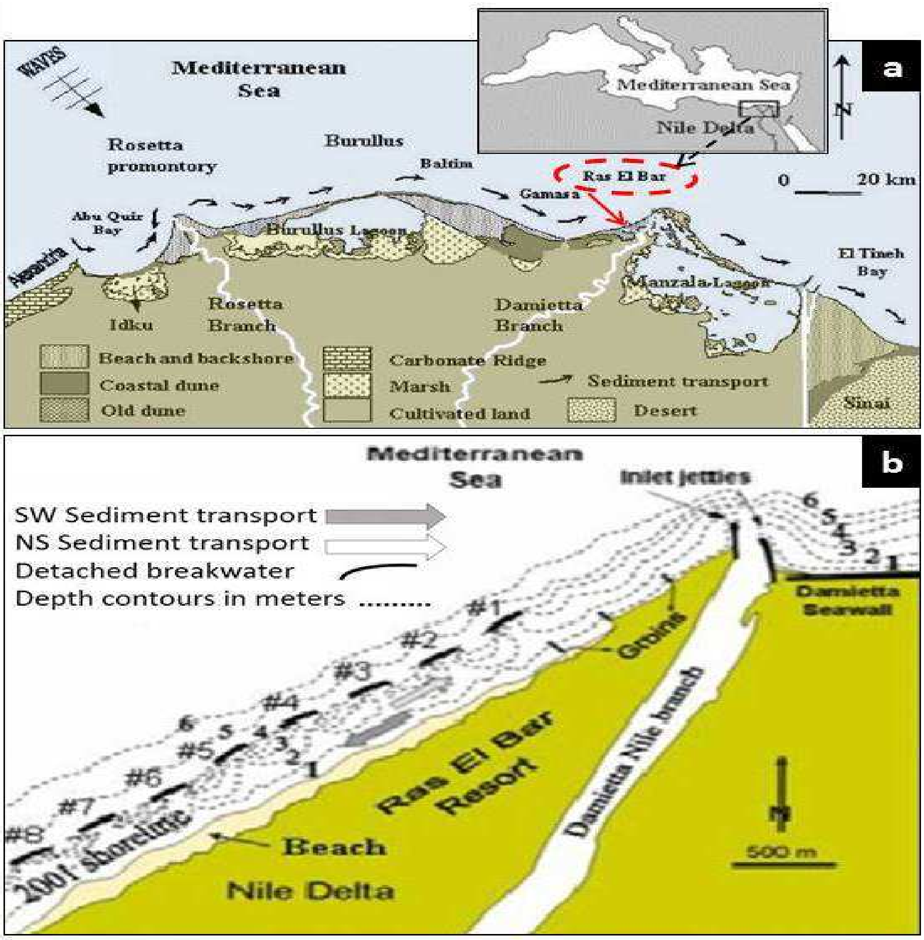

Fig.1. Map of Nile Delta showing (a): the location of study area at Ras El-Bar resort and (b) the Protection works along Ras El Bar resort include (Inlet Jetties- Detached breakwaters- Groins, and seawall) and the direction of sediment transport, (Updated and Modified from: Frihy *et al*. (2003); Dewidar and Frihy , 2010).

Erosion along the coast of Ras El-Bar resort has been mitigated by the construction of a series of coastal engineeringstructures including jetties, groins, seawalls and detached breakwaters as presented in Table (1). The Protection wok along Ras El-Bar from 1983-2010 are illustrated in Figure (2).

Table1: Protection wok along Ras El-Bar from 1941 to 2010 (Source: ESPA).

Date	Type of protection work	Reason of Construction
1941	Westren jetty	was constructed on the western side of Damietta Nile branch to reduce the deposition of drifted sediment
1963	Seawall	At the southern end of the western jetty,a concrete seawall was constructed in to stop erosion of the shore.
1971	3 Groins	Three concrete groins were constructed to the southwest of the seawall with basalt fill between.
1976	Eastren jetty	was constructed on the eastern side of Damietta Nile outlet to reduce siltation and shoaling at Damietta branch outlet
1983 to 1984	Wall of basaltic stone	Was constructed between Groin.2 and Groin.3.
1985 to 1986	Basaltic Wall	Was constructed to protect the western Jetty and the space between Groin.1 and Groin.2.
1985 to 1986	wall of dollostone	Was constructed to protect the area west of Groin 3.
1988 to 1989	wall of dollostone	Was constructed to protect the area below the western jetty on river Nile Damietta Branch.
1989 to 1995	5 detached break water & nourishment	Was constructed west of the three groins to protect Ras El Bar city shoreline from erosion.
1986 to 2000	3 detached break water	Was constructed west of the previous 5 detached BWs to protect Ras El Bar city shoreline from erosion.
1994	5 ton of dollos block	Was constructed to protect the area between the western Jetty and Groin1.
1998 to 1999	basalt stones, dollos blocks	Was constructed to Re-protect the area between the western Jetty and Groin1.
1999 to 2002	basaltic stones, dollos blocks (concrete blocks with various weights)	Was constructed to Re-protect the western jetty and Fanar area to mitigate beach erosion..
2003 to 2010	concrete blocks above basalt carpet.	Was constructed to protect the shoreline infront of Groin.3.

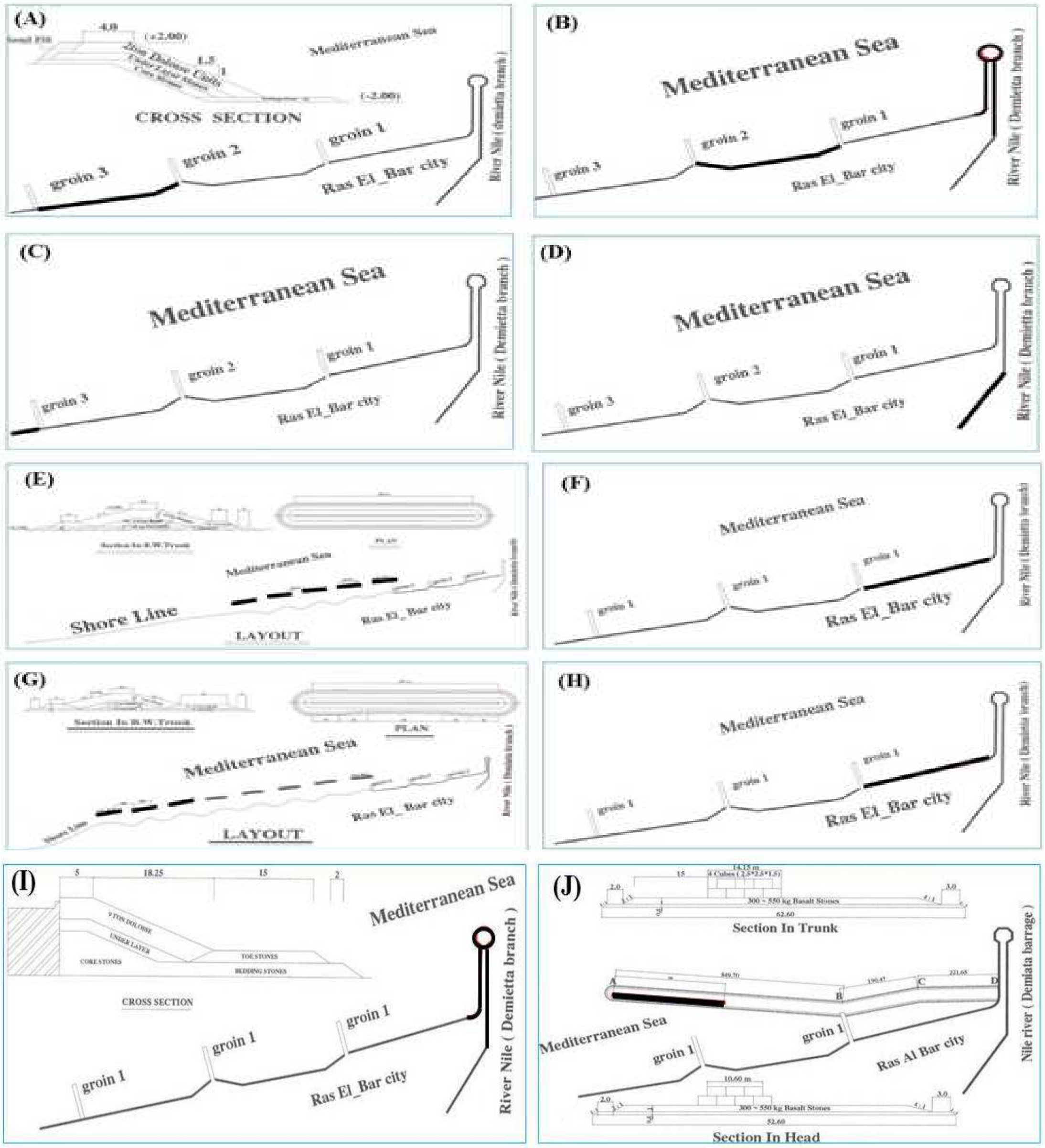

Fig. 2: Protection wok along Ras El-Bar from 1983-2010. (A)- Wall of basaltic stone;Implementation year: from 1983 to 1984. (B)- Basaltic Wall; Implementation year: from 1985 to 1986. (C):- basaltic stones; Implementation year: from 1985 to 1986. (D):- wall of dollostone; Implementation year: from 1988 to 1989. (E):- 5 detached break water & nourishment; Implementation year: from 1989 to 1995. (F):- 5 ton of dollos block; Implementation year: 1994. (G):- 3 detached break water; Implementation year: from 1986 to 2000. (H):- basalt stones, dollos blocks; Implementation year: from 1998 to 1999. (I):- basaltic stones, dollos blocks (concrete blocks with various weights); Implementation year: from 1999 to 2002. (J):- concrete blocks above basalt carpet; Implementation year: from 2003- 2010. (Source: ESPA) ESPA: Egyptian Shore Protection Authority

Dataset for Landsat Image

This research presents remote sensing and Geographic Information System (GIS) based application in the analysis of Shoreline change in Ras El-Bar resort to evaluate the stability of the area in the last 15 years for future developments.The shoreline position of Ras El-Bar locality was extracted from satellite images obtained from within 15 years' time span. In present study, the dates from "2000-2011" LANDSAT ETM+ were downloaded from the USGS Global visualization Viewer (http://glovis.usgs.gov) with their multi-coloured 7 bands with a resolution of

30m*30m for pixel size and the panchromatic band of 15m pixel size resolution for each date has been downloaded as well. Dates (2006) and(2010) brought from the National Authority for Remote Sensing and Space Sciences (NARSS) and they are as follows: Date 2006 is (Spot4) image with 10 m resolution after merging the coloured bands with the panchromatic band. Date (2010)is EgyptSat image with 7.8 m pixel size resolution. Dates from (2013 to 2015) are Landsat-8 OLI with their different multi-coloured 11 bands. All these images are acquired in summer and are cloud free.

The extracted shorelinesfor dates (2013, 2014, and 2015) along Ras El-Bar resort from the 11-band landsat-8, OL I was downloaded fromthe U.S. Geological Survey (USGS), where the acquired satellite data are from online open resources with no cost (http://usgs.gov/EarthExplorer).

Pre-processing of the satellite images

The pre-processing of used satellite images is an important step to prepare the data for analysis. The purpose of this step is to normalize the imagery to allow inter-comparison between scenes. This normalization can be achieved by: removing the effects of atmospheric scattering; noise removal with Principal Components Analysis (PCA), and de-striping removal by ENVI 5 software.

Remove the effects of Atmospheric Scattering

Some light is scattered by water vapor and aerosols, mainly at lower wavelengths in the blue part of the Electro-magnetic spectrum. An empirical correction common method is used in ENVI -5 software called the Dark Object Subtraction (DOS). This method assumes that reflectance from dark objects includes a substantial component of atmospheric scattering. Therefore, we can measure the reflectance from a dark object, such as a deep lake, and subtract that value from the image

Noise Removal – Principal Components Analysis (PCA)

Principal Components Analysis for Landsat-7 ETM+ imagery acquired after the SLC failure in 2003, which creates striping problem. PCA transforms the image data into a set of uncorrelated variables using statistical methods. The PCA is used in hyperspectral remote sensing to reduce the number of bands used in image analysis without reducing the information content by reducing redundancy. The result of PCA is an image dataset in which each band is uncorrelated with the other bands, where each band shows unique information. By using the PCA method, redundancy can be reduced and the uncorrelated variables which are ‘hidden’ beneath the correlated data are highlighted.

De-striping Removal

The full-quality ETM+ Landsat 7 dataset (SLC-on mode) was launched on 15 April, 1999. Where, in May 2003 an unrecoverable fault occurred, severely impairing the satellite operations. However, NASA and USGS continued to offer Landsat 7 imagery (so called SLC-off mode), but using such kind of imagery needs lots of processing and enhancement with different tools in order to be valid for usage. These strips of gaps can be processed by remote sensing software, such as ENVI-5 and ERDAS Imagine 2013.

Satellite images Geometrical Correction and Band Combinations

All used image data were geometrically corrected based on the Universal Transverse Mercator (UTM) projection system- zone 36N.A number of29 Ground Control Points (GCPs)were selected based on well-known features in a Geographic Information System (GIS) to register the corrected images.Band combination of (RGB) 3:2:1 is used to displaythe best contrast between land-water boundaries to identify the shoreline insatellite image.Landsat-8 OLI images composed of 11 different bands, each representing a different portion of the electromagnetic spectrum. The sensor of Landsat-8 OL I includes a new coastal - aerosol band (band1), which can be used with two other bands for closer investigations of coastal waters and estimating the concentration of aerosols in the atmosphere.

Quality Measurements (IQ) of imagedata

Two quality measurements methods were used in this study for the satellite images to avoid human interfere. 1): Qualitative method and 2): Quantitative method. The qualitative method depends on human visualization used in ArcGIS by digitizing the shoreline positions of different dates. The quantitative method depends on mathematical measures for the shoreline vectors extracted from satellite images. As the satellite images used in this research are collected from different sensors, spatial resolution was down sampled to be 15m for all images. Many studies have been done on image quality measurements based on different techniques such as pixel-difference, correlation, and edge detection, Neural Networks (NN), Region of Interest (ROI) and Human Visual System (HVS).

Automatic algorithms using MATLAB software was used to assess images quality. MATLAB software is identical for dealing with graphics since it has an image processing tool box, beside it got lots of built in math function that can help in evaluating many statistics. Algorithms code is written in MATLAB to assess Image quality measurement. The input for the code is the measured data field of GPS 2014, which exported from the ARCGIS as a shape file tiff image and the algorithms deal with it as an original image. The digitized vector of Landsat image-8 of year 2013,2014,2015 ; Landsat 7 ETM for dates, 2000, 2001, 2003, 2009, 2011, 2012; Egypt sat 2010, and spot4 2006 are exported from ARCGIS as shape file tiff image and uploaded to MATLAB as the test image "distorted" to be compared mathematically to the original measured data.

The algorithms code calculatedthe single to noise ratio (SNR), Mean Square Error (MSE), Root Mean Square Error (RMSE). From the results in Table (2) and Figure (3) below, it is clear that as the value of PSNR increase, as the quality of image increase. This is clear in image dates (2001, 2009, 2014 and 2015). Likewise, as MSE values increase, as the quality of image features measured is the best and this is clear in image dates (2010, 2013, 2014, 2015) , while in case of RMSE measures as the value decreased, as the quality of data measures is the best and this clear at image dates (2010, 2013, 2014, 2015).

Table 2: Quality measurements for time period (2000-2015)

Quality measures	Year 2000	Year 2001	Year 2003	Year 2006	Year 2009	Year 2010	Year 2011	Year 2012	Year 2013	Year 2014	Year 2015
PSNR	53.04	54.91	54.25	51.91	54.91	51.89	53.99	49.94	48.77	54.721	54.95
MSE	117.79	213.63	134.88	123.41	117.79	237.94	130.9	145.2	238.68	244.07	229.23
RMSE	13.78	10.85	11.27	12.9	15.48	10.9	15.44	14.45	11.13	11.5	10.85

From the values of statistical that applied at this research, and presented in table (2) we can conclude that, the extracted shoreline vector from Landsat-8 image sensor is the best quality measured compared with the measured field data followed by Egyptsat image sensor followed by ETM+ sematic mapper-image sensor.

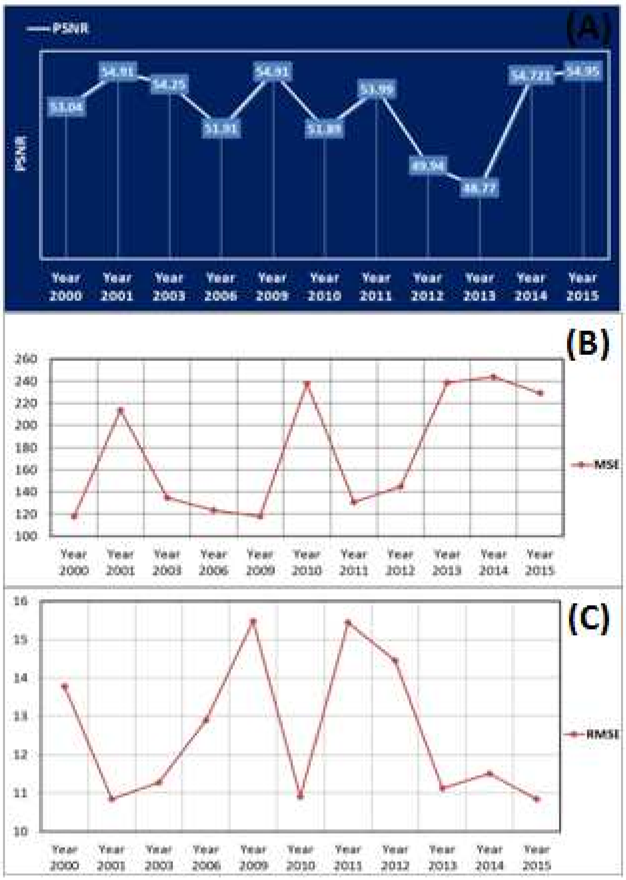

Fig. 3: Results of statistical values for satellite images with different sensors in the period from (2000-2015). (A): Peak Signal to Noise Ratio (PSNR); (B): Mean Square Error (MSE); (C): Root Mean Square Error (RMSE).

Digital Shoreline Analysis System (DSAS)

The Digital Shoreline Analysis System (DSAS) was used to calculate the rate of shoreline changes at Ras El-Bar locality. It is a free software application which is working friendly within Geographic Information System (Thieler *et al*., 2009). The data required for the DSAS application are the extracted shoreline from down sampled satellite images of 15m Pixel size Resolutionand a digital baseline; onshore or offshore. The application is carried out through threesteps: (1): Forming transects perpendicular on the baseline and cutting the digitized shorelines by fixed spacing and length; (2): Measuring the transect length between the baseline layer and the shorelines layers, and (3): Calculating the rate of changes in the shoreline with different statisticalmodel methods according to the changes in the shoreline through different dates.

RESULTS AND DISCUSSION

Each method used to calculate shoreline rates of change is based on measured differences between shoreline positions through time. The reported rates are expressed as meters of change along transects per year. Rate of calculations are performed by MATLAB executables bundled within the DSAS installation (Fig.4).214 transects were used to calculate the rate of shoreline change along Ras El-Bar resort for alongshore distance of ~12km started from the Ras El-Bar inlet jetty.

DSAS Models Statistical

The statistical models used at this study are illustrated in Table (3).

Table 3: DSAS Statistical Models

Model	Model Name	Measurement	Methodology
NSM	Net Shoreline Movement	Distance	This represents the total distance between the oldest and youngest shorelines.
SCE	Shoreline Change Envelope	Distance	This represents the distance between the shoreline farthest from and closest to the baseline at each transect (not related to their dates)
EPR	End Point Rate	Rate	is calculated by dividing the distance of shoreline movement by the time elapsed between the oldest and the most recent shoreline.
LMS	Least Median of Squares	Rate	In this method, the median value of the squared residuals is used instead of the mean to determine the best-fit equation for the line.
LRR	Linear Regression Rate	Rate	can be determined by fitting a least-squares regression line to all shoreline points for a particular transect

R-squared (LR2)

The R-squared coefficient reflects the linear relationship between shoreline points along a given DSAS transect (Fig. 4). It is a dimensionless index that ranges from 1.0 to 0.0 and measure show successfully the best-fit line accounts for variation in the data. At present study, the R-squared has reached its best fit line to be 5.2.

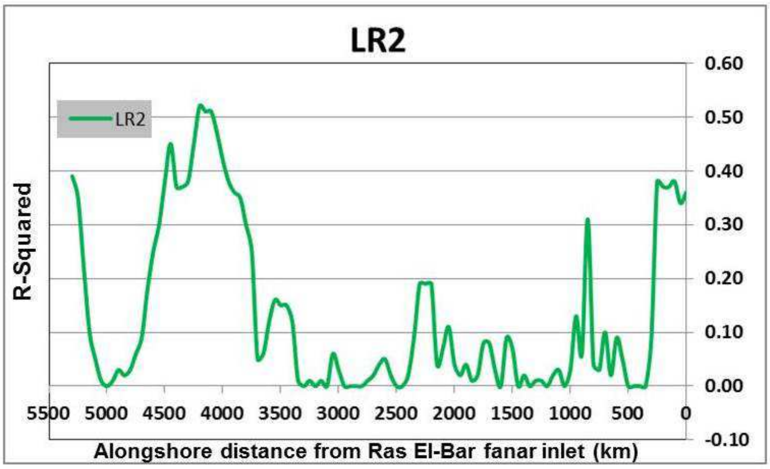

Fig. 4: The R-squared coefficient of used shorelines along a given DSAS transects.

The accretion sector behind the system of detached breakwaters is protecting Ras El Bar resort. This sector is characterized by growing shoreline with maximum rates of 4.2 m/year, that calculated by LLR-Model in the period from (2001-2015). In DSAS, the process of fitting the line to the data points follows the same logic as the LRR method; however, the LMS is determined by an iterative process that calculates all possible values of slope (the rate of change) withina restricted range of angles.

From Figure (5, a), the distance of shoreline movement by the timeelapsed between the shoreline of year 2000 and the 2015 shoreline has reached an accretion value of (+3.5m/y) and an erosion value of (-2m/y). Plot (b) at Fig. (5) shows the median value of the squared residuals that used instead of the mean todetermine the best-fit equation for the line, the values of LMS –Model has reached -10m in front of the seawall area and -7.7m/y in front of the detached breakwater #8.Plot (c) at Fig. (5) shows the net shoreline movement of the total distance between the oldest and youngest shorelines, where the maximum value has reached (+49m) and a minimum value (-30m).

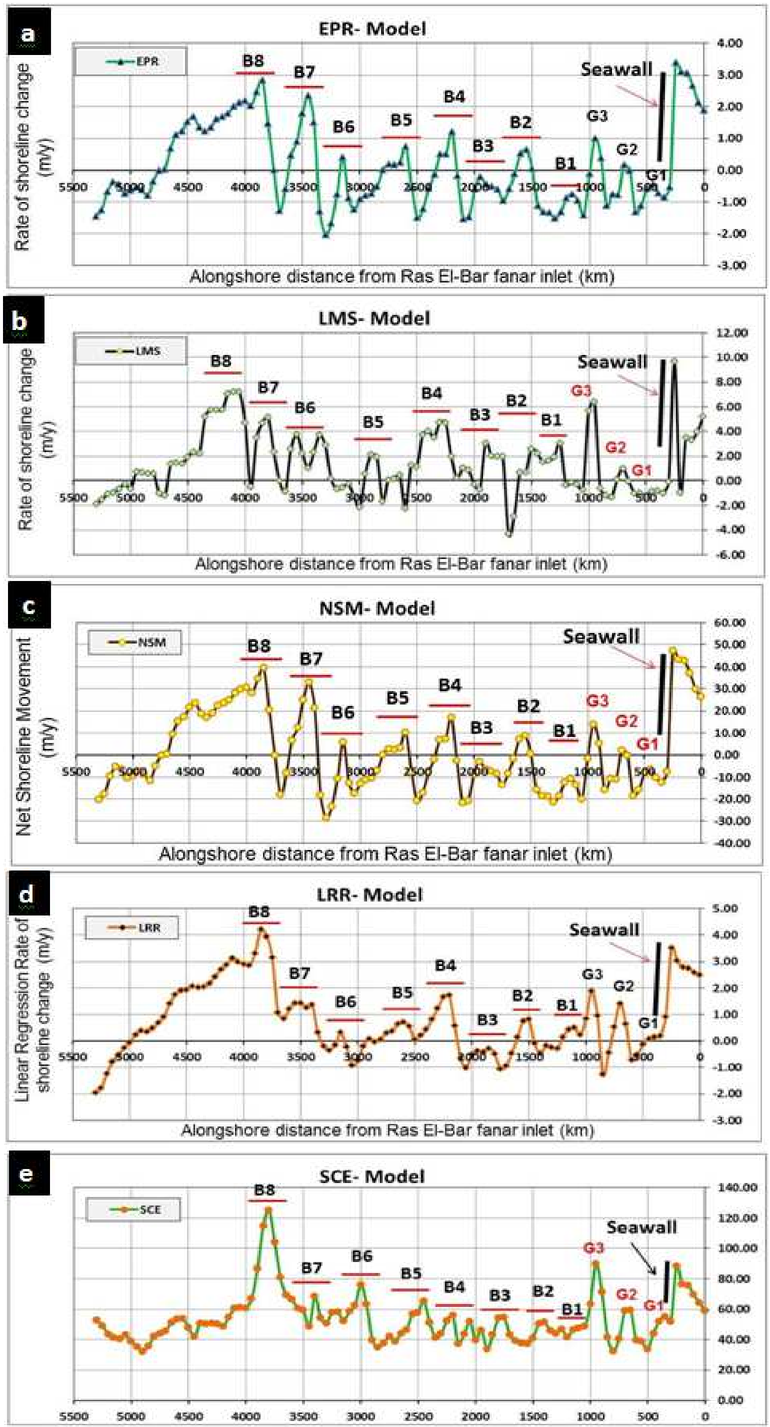

Fig. 5: DSAS different statistical model that used at the study. (a): EPR- Model (b): LMS-Model (c): NMS- Model (d):LRR- Model (e): SCE- Model.

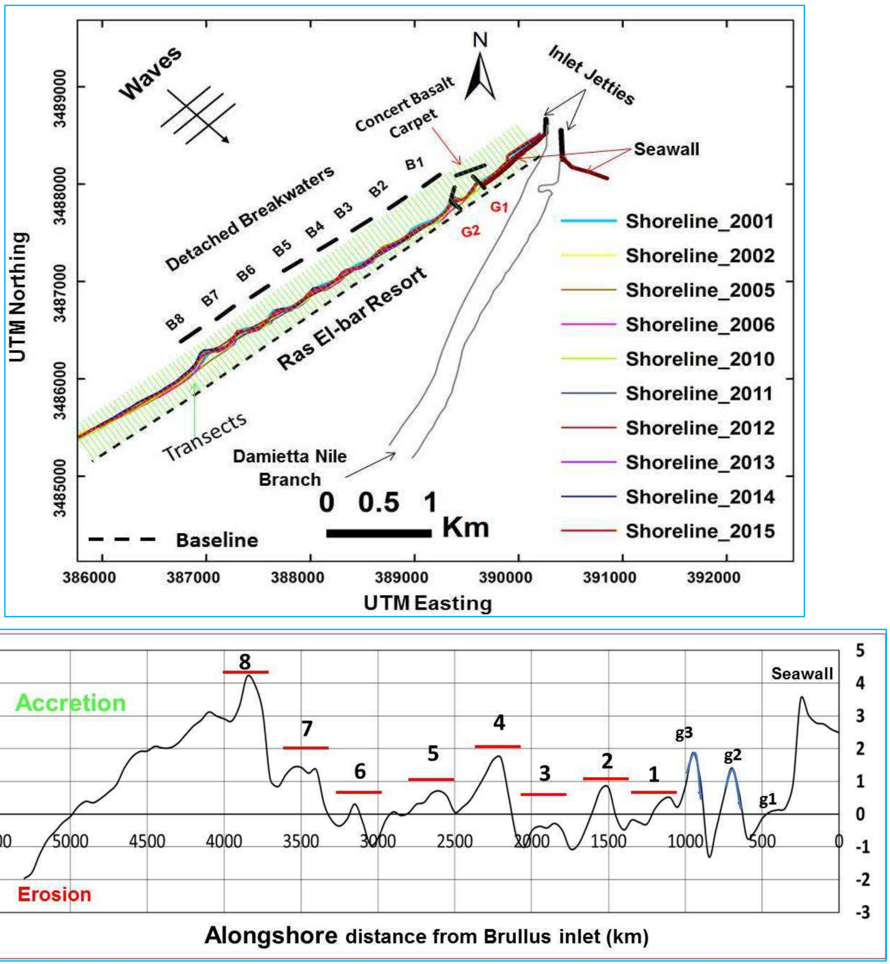

Fig. 6: Ras El-Bar detached Breakwaters Locality shoreline change rate

The LRR- Model, which is the best model gives reasonable values for the shoreline change rate give a maximum rate of accretion that reached 4.2m/yr and a rate or erosion that reached (-1.3m/yr). The distance between the farthest shoreline and baseline has reached 130m in front of detached breakwater #1, and the closest distance from the baseline at each transect has reached 35m in front of groin #1.

SUMMARY AND CONCLUSION

The study of this locality has enabled us to interpret thatthe beach in front of the detached breakwaters was in increasingly change at the beginning of the creation of such barriers, where; prior to protection works at the western flank of the Damietta promontory at Ras El Bar, the area has experienced change that reached (-5.35 m/yr to -10.26 m/yr) and this can be attributed to the early protection of this sector in 1941 according to Frihy and Lawrence (2004) records. However, the beach shoreline was in decline in the rates of erosion and accretion behind the detached breakwaters in that region in the period from 1999 to 2002.

The present study aimed to evaluate the beach changes at this area, to determine the degree of shoreline stability and solidity for future investment plans. The study of shoreline change at Ras El-Bar resort in the period from 2000-2015 has found that the rate of erosion has reached from (-0.1:-1.1m/yr) at maximum, and a rate of accretion that reached to (+0.2:+4m/yr) at maximum. These values of rates consider as the ideal values for sable beach. Therefore, this study did not examine the area hydrodynamiclly because there is no need for that, since the message given by the stable beach for a long time is a strong testament refers to a balance of bilateral dimensions within the depths of coastal zone. As long as the beach is stable, the surf zone is stable.

In summary, the study of this locality enabled us to give a clear conclusion that Ras El-Bar resort beaches the located behind the detached breakwaters are stable and no need for future protection in near future.

To evaluate constructing protection works along the Egyptian coast, these detached breakwaters along Ras El-Bar resort succeeded in:-

- Stopping the erosion along Ras El-Bar resort costal area
- Building new beach behind the detached breakwaters
- The balance of the coastal zone at this locality hydro-dynamically

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ARABIC SUMMARY

تقييم درجة ثبات وصلابة خط الشاطىء لخطط التنمية والأستثمار المستقبلى بمصيف راس البر، مصر.

ولاء عواد على[١]، منى فؤاد قيصر[١]، سوزان خليف[٢]، ميسرة الطحان[٣]
١- قسم الجيولوجيا-كلية العلوم- جامعة قناة السويس- الأسماعيلية – مصر.
٢- المعهد القومى لعلوم البحار والمصايد بالاسكندرية– مصر.
٣- كلية الهندسة- جامعة الأسكندرية– مصر.

خلال العقود الثلاث الاخيرة حدث نحر ملحوظ فى منطقة رأس البر، مما دفع الهيئة العامة لحماية الشواطىء لعمل حمايات بحواجز أمواج متقطعة موازية لخط الشاطىء. ولذلك كان هدف الدراسة الحالية الوقوف على الوضع الحاللخط الشاطىء بتلك المنطقة ومدى احتياجه لمنشئات حماية مستقبلية وذلكلوضع خطة للتنمية والاستثمار فى الساحل الشمالى الشرقى.
وقد أثبتت الدراسة ما يلى:-
١- الشاطىء كان مضطرد التغير فى بداية انشاء تلك الحواجز فى الفترة من ١٩٩٢ الى ٢٠٠٢
٢- معدلات تقدم الشاطىء خلف الحواجز المتقطعة وصل الى (+١٣.٥ م) فى الفترة من ١٩٩٠-٢٠٠٢. ومعدلات النحر فى منطقة ال down-drift التى تتبع منطقة الترسيبات خلف الحواجز المتقطعة قد وصلت الى (-١٢م).
٣- نوعية الرمال المترسبة خلف الحواجز المتقطعة براس البر تُصنف كرمال ناعمة متوسطة الحجم والتى يتغير حجمها الى رمال ناعمة جدا صغيرة الحجم كلما اقتربنا من إتجاه البحر. و وجود الرمال الناعمة ذات الحجم الصغير والفرز القليل توضح ان عملية الترسيب حدثت فى بيئة بحرية تحت تأثير طاقة ضعيفة.
٤- قامت الدراسة على هدف تقييم تغيرات الشاطىء فى هذه المنطقة بعد ذلك للوقوف على ثباتها واتزانها لمدة مستقبيلة وتوصلت الدراسة الى أن معدلات الترسيب خلف الحواجز المتقطعة قد وصل الى قيم تتراوح بين (0.2-4.2 م/سنويا) بينما معدلات النحر وصلت الى (-٠.١: -١.١ م/سنويا) فى الفترة من (٢٠٠٠- ٢٠١٥) وهذه القيم تكاد تكون مثالية لاتزان خط الشاطىء، ولذلك لم تقم الدراسة بدراسة شاطىء هذه المنطقة هيدروديناميكيا لعدم الحاجة لذلك ، وذلك لأن الرسالة التى قدمها الشاطىء باتزانه لمدة طويلة هو دليل فعلى وملموس على الأتزان ثنائى الأبعاد داخل أعماق المنطقة الشاطئية.
وفى ضوء ما سبق، أثبتت الدراسة انه يوجدإتزان فى تلك المنطقة، وعدم الحاجة الى منشئات مستقبلية لها، ويمكننا القول انه نجحت اعمال الحماية بهذه المنطقة بوقف اعمال النحر وتكوين شواطىء جديدة خلف الحواجز المتقطعة باللإضافة الى اتزان المنطقة بعد ذلك دون نحر او ترسيب مضطرد.