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MONITORING CHANGING POSITION OF THE SHORELINE ALONG BURULLUS-BALTIM, NILE DELTA, EGYPT, AND THE RULE OF COASTAL DUNES AS A NATURAL DEFENSE AGAINST EROSION IN A GEO-HERITAGE SITE: REMOTE SENSING APPLICATION

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ABSTRACT

Monitoring the coastal area along the Burullus-Baltim coast shows that it is a fragile coastal area composed of loose sand eroded from the old Sebennitic Promontory since historical time of more than 1000 years, then enhanced after the construction of Aswan High Dam (AHD).

The interplay of waves, wind and sands along this coast led to construction of a unique geomorphosite with the characteristic barchan and linear sand dunes. Due to the high threshold velocity that reached at Baltim (Vt) 19.38 cm sec^{-1}, such velocity is able to blow sands with diameter D_{50} of 250um. The velocity need for suspending the D_{50} to an elevation Z (Vz=5m) is equal to 630 cm sec-1. Contrary is the case to the east at Gamasa where the Vt equal to 16.3 cm sec-1 and the Vz for suspending the D_{50} (180 um at Gamasa) is equal to 560 cm sec^{-1} . This may explain why the dunes at Baltim are coarser in grain diameter and together withthe tight back desert strip explain the presence of Baltim dunes at elevations more than 20m, while at Gamasa not exceeds 5m. These dunes represent natural defence measures for the barrier beach separating the Burullus Lake from the Mediterranean Sea. Due to human intervention including urban extension and agricultural activities much of these dunes were deteriorated and diminished from 174.8km^2 to 6.4km^2. The project of extraction and concentration of heavy minerals from sand dunes seem uneconomic. Although the heavy mineral concentration is more than 5%, more than half of the detected minerals is Ilmenite, which is neitherstrategic nor economic mineral. Such project may add new form of hazards. Although the defence measures seem effective in protecting the coast, several rates of erosion and accretion were detected along the studied sectors, and the shoreline does not retain its present position in many areas of the coast since 1984.

Keywords: Burullus, Baltim, Gamasa, Shoreline, Coastal dune, Environmental hazard, Remote sensing.

INTRODUCTION

The Nile Delta coast is a fragile one, composed of fine sands and silt sensitive to the interplay of water, wind and land. This coast is suffering some environmental pressures almost due to a wide range of natural and anthropogenic stresses. Among the natural hazard that threatening the Nile Delta is the shoreline change due to erosion and accretion, which is a major concern for coastal zone management. Aswan High Dam (AHD) is the ever hub project, which positively changed the life of the Egyptians, however, it is represent one of the major anthropogenic hazards affecting the Nile Delta coast.Sediments discharge at Aswan High Dam was averaged 160 x 1012 m^3 yr^{-1} of which 100 to 115 x 106 m^3 yr^{-1} were reached the Mediterranean coast along the Nile branches. Amount of sediments estimated between (400,000 to 3.2 x106 m^3 yr^{-1}) spatially distributed by longshore sediment transport (Frihy, et al. 1991; El-Fishawi, 1989). These are sufficiently large enough to maintain a reasonably stable shoreline, even with shoreline accretion (Sestini, 1989; El-Asmar, 1994; Fanos et al 1995; Frihy and Lawrence, 2004). After construction of the (AHD), the discharged sediments trapped, and the water released from the dam for downstream use since dam construction has averaged 55.5x109m^3yr^{-1}, approximately 35% less than prior to the construction of the dam. However, the discharge reaching the Rosetta and Damietta estuaries is significantly lower, averaging less than 5x109 m^3yr^{-1}. The suspended sediment load of the water released from the dam is negligible, contributing to the cut-off in sediment supply to the coast causing coastal erosion (Orlova and Zinkovich, 1974; Smith and Abdel Kader, 1988; Lotfy and Frihy, 1993; Stanley, 1996). Then the coast of the Nile Delta transformed from a fully dissipative (Nafaa and Frihy, 1993) divergent, low-gradient beach face composed of fine to very fine sand, to new reflective pattern (El-Asmar et al 2016). Simultaneously, an average sea level rise of 2.2 mm/year (El- Fishawi 1989) and local subsidence of the delta coast of up to 5 mm/year (Stanley 1990; Stanley and Warne 1993) have also contributed to shoreline retreat.Previous studies of the shoreline position and sediment budget along the coastline of the Nile Delta demonstrate that coastal zones can be partitioned into a progression of discrete sedimentation compartments called "littoral cells" (Frihy et al. 1991; Fanos et al., 1991). These sub-cells are commonly situated between the delta promontories and significant designing structures between them. The chief origin of sediment for every cell is the promontories that, through erosion, supply huge amounts of sand to sink zones. These sinks possess bays, embayments and saddles that by and large lie toward the east, exemption of west Rosetta.The Historical maps between 1800 and 1900 (Sestini, 1976) showed that, the Rosetta promontory advanced 3.6 km (36 m yr^{-1}) while the Damietta promontory advanced about 3.0 km (30m yr^{-1}). However, the history of erosion along the Burullus headland and Baltim stretch started earlier since the ninth century AD, at the point when the ancient Sebennitic branch appears to have turned out to be inert and its water and sand were redirected to both the Rosetta and Damietta branches (CRI/UNESCO/UNDP, 1978).

It is worth to mention here that the old Sebennitic branch formed the central headland of the Burullus 1,000 years ago (Orlova and Zinkovich, 1974). The Burullus headland subjected to erosion, the rate of erosion was about 6 m yr^{-1} causing erosional damage to El Burg village (Tetra Tech, 1984; Fanos et al., 1995). Burg El-Burullus village, east of Lake Burullus outlet, had already been removed to the south two or three times because of a continuous trend of shoreline retreat (CRI/UNESCO/UNDP, 1978). Erosion happened from 1909 to 1964, after construction of the western jetty at the Burullus Lake outlet in 1971, which impounded the solid net easterly transport, gradual deposition struck the west of the outlet (Fanos, et al., 1995). The western barrier between the sea and Burullus Lake has a history of southward migration due to wind-blown sand transported from the coast side to the lake side where it is deposited (Shereet, 1990; El-Asmar and Al-Olayan, 2013).

Remote sensing application as a tool for monitoring coastal changes along the Nile Delta has been used since Klemas and Abdel-Kader (1982). They focused on mapping the shoreline with potential updating map that distinguishing sites of erosion and accretion (Smith and Abdel Kader, 1988), what's more, prompted subdivision of the coast into subcells of convergence and others of divergence waves (Frihy et al., 1991). Rather, a procedure of thematic mapper imagery (El-Asmar and White, 2002) was utilized with the end goal of incorporated coastal zone management along the Nile Delta utilizing segmentation process, based on the orientation, and nature of shoreline and the implemented defence measure. Later, Dwidar and Frihy (2010) estimated rates of shoreline changes from three statistical approaches of Digital Shoreline Analysis System (DSAS) are validated with ground observations of beach profile survey data at the same corresponding positions. El-Asmar and Hereher (2011) used two techniques to estimate rate of shoreline retreat. The first technique is corresponding to the formation of automated shoreline positions by digitizing for mapping erosion/accretion pattern. The second one is for estimating rate of shoreline change based on data of remote sensing applying Digital Shoreline Analysis System (DSAS) software. The End Point Rate (EPR) was calculated by dividing the distance of shoreline movement by the time elapsed between the earliest and latest measurements at each transect. Due to the detected rates of erosion, the government started since 1983 a plan of coastal stabilization of the Nile delta. At present time, the Nile Delta coastline protection plan is partially achieved, at least locally along highly eroding low-lying sectors where massive protection measures have been implemented. About 60% of the Nile delta coast is partially stabilized by engineering structures and sand dunes (17.5 and 42.5%, respectively), while the remaining coast (40%) is not protected (Frihy and El Sayed, 2013).

THE STUDY AREA

Burg El-Burullus-Baltim stretch located between latitudes 31 °30' 00" to 31 °40' 00"N and longitudes 31°00′ 00″ to 31°15′00″E (Fig. 1). It is a coastal sensitive area bounded from north by the Mediterranean Sea and from south by the Burullus Lake. The coast is 18.3 to 25km long, consisting of very active coastline of a sandy beach, where the land interacts with wind and water. The beach defended against erosion due to natural accumulation of coastal sand dunes, these attract thousands of people from the adjacent delta region during the summer. Human interventions in the delta's coastal region resulted in continuous erosion and deterioration of the natural defence system of the coastal dunes purposes of agriculture and material buildings uses (El Banna, 2004), The severe erosion led to implement of different measures of coastal protection. The most effective is the detached breakwater system at Baltim resort, is found about in halfway among Rosetta and Damietta promontories. It comprises of nine detached breakwaters built in the dynamic surf zone at a water profundity of somewhere in the range of 3 and 4. These breakwaters were built in stages somewhere in the range of 1993 and 2002 and front a shoreline of about 6.5 km long. Every individual breakwater stretches out somewhere in the range of 250 and 350 m parallel to the sea shore and at a distance of 220 m from the shore, and the breakwaters are dispersed 320 to 400 m separated (El-Kolfat,1999). Later, from 2002 to 2006 another five breakwaters in addition to 9 groins were built eastward up to the Kitchener Drain (Ali et a., 2017).

The aims of this paper are (1) to update data related to LU/LC, (2) to monitor environmental changes resulted due to human activities on this fragile area of the coast, and (3) to draw attention to the existing hazards from both natural and human. This area is receiving a huge investment projects among are resorts and rural urban expansion in addition to an expected project related to heavy minerals extraction from sand dunes.

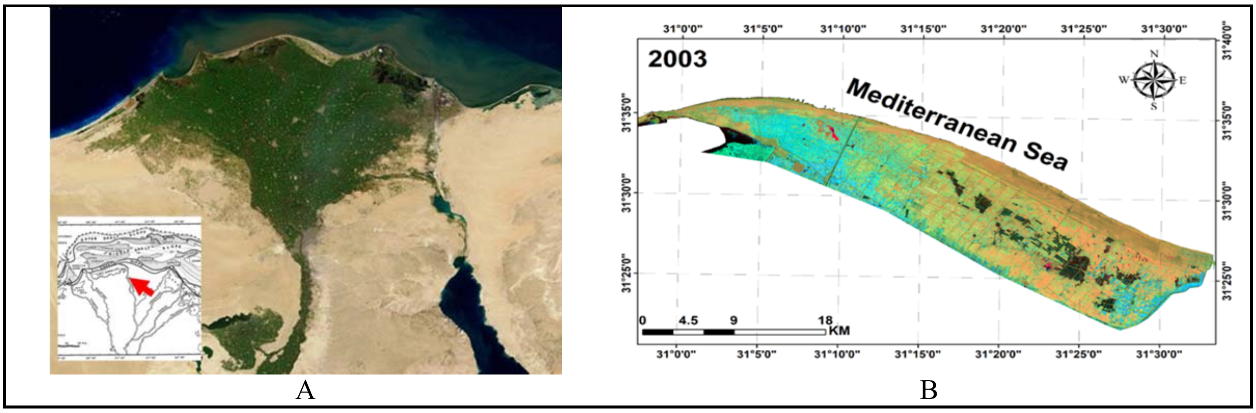

Fig.1: Satellite image of the Nile Delta showing the study area as it borders on the Mediterranean Sea with old Nile branches including the Sebennitic branch (red arrow), who open at the Burullus (a). Close up showing the coastal plain between Burg El-Burullus and Gamasa satellite image 2003 (b)

MATERIALS AND METHODS

Change detection is the method of observing the condition of a target area at different times to identify variations that occur within this area (Chen et al., 2017). Land-use/land-cover (LULC) change is the impact of human actions on nature followed by unexpected outcomes (Rimal et al., 2018). In order to identify environmental changes in the research area, Images from three sensors were utilized in this work. Three multi-temporal Landsat images (path 177, row 038) were used, one from the Multispectral Landsat8-OLI (dated 9 September 2019) and two from the Landsat TM (dated 16 September 2003, 1 September 1984), Sentenal2 sat and world view2 (Fig. 2). These All the images were obtained from Earth Explorer Website (http://earthexplorer.usgs.gov/),(https://www.satimagingcorp.com/satellite-sensors/worldview-2/). ENVI 5.1 and ArcGIS 10.4 programming were used in this exploration. Atmospheric correction of all Landsat image was satisfied utilizing the FLAASH (fast line-of-sight atmospheric adjustment of spectral hypercubes) model (Perkins, et al., 2005) to address air impacts. Since the images being gained in various seasons, it was significant to make an atmospheric correction and radiometric standardization to images so as to get equivalent information at a similar level (Chander et al., 2009; Tyagi and Bhosle, 2011). All the optical images, after geometric and radiometric revisions, were then carefully processed using the Water Index method (Braud and Feng, 1998; Mahboob and Atif, 2016). The technique targets getting the sharp edge among water and land. The sharp edge between the two classes alludes to the shoreline.

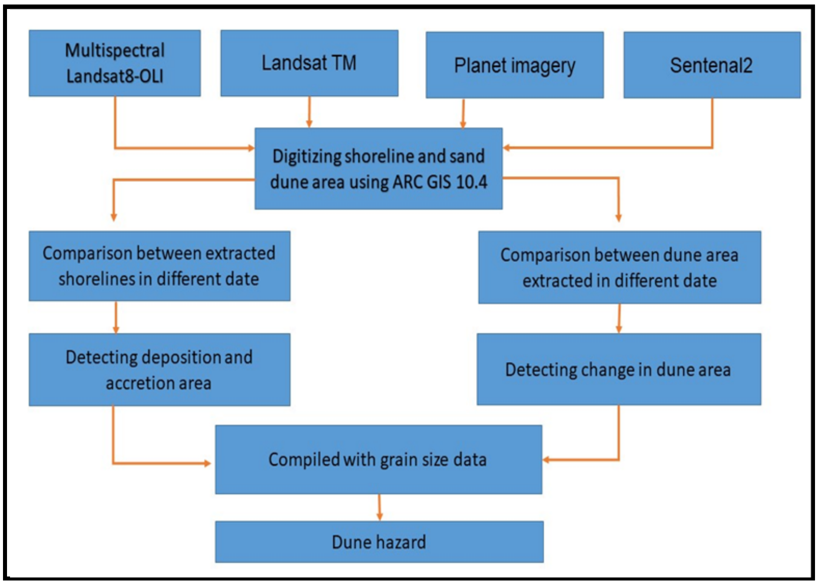

Fig. 2: The Flow chart showing the methodology used in this study.

Then using GIS techniques to extract shoreline by digitized it (Thieler et al., 2005), and the layers of multi date shorelines were set up for 1984, 2003, and 2019 in the line feature class. Utilizing the overlaying activities and spatial analyst tools the examination for spatial and temporal change identification had been done. For visual understanding of the information a False Color Composite (FCC), which is a blend of IR, Red and Green situated in R, G, B separately is accustomed to getting the zone of sand dune by digitizing. The True Color Composite of RGB might be wasteful in such circumstances. Yet, the utilization of FCC improves our comprehension of different features in study area (Lillesand and Kiefer, 1994).

RESULTS AND DISCUSSION

Why Dune Fields at Baltim is a Geomorphosite?

The dune fields between Burg El- Burullus -Baltim and Gamasa is a unique geomorphsite along the Nile Delta coast (Figs. 1b, 3e). This is in fact due to the long term erosion history (more than 1000 years) of the Burullus headland, since the flow of the Sebennitic (Fig.1, 2b) branch of Nile River had stopped (Taha, 2018). The mouth of the Sebennitic promontory is the present day Burullus outlet, the Sebennitic promontory started eroding in amount that led to the shift in the Burg El-Burullus village some of 6km, added to that the effect of AHD that increases the erosion to some 6m yr^{-1} (Frihy et al., 2011). Erosion of the Sebennitic promontory and associated lobe sediments were intensified as flow through the distributary began to decrease at 3000 B.C. and as the sea level continued to rise. Most eroded sands transported eastward with longshore current, the coarser the grain diameter sand the most deposited after a shorter distance. Most of the coarse sand accumulates along the coast of Burullus-Balim transported by wind to form coastal dune sands (Fig. 3e). The finer sand transported with long shore current for longer distance and transported to a sink subcell embayment (Frihy et al., 1991) at Gamasa. Most coastal sand dunes along the Nile Delta occur along the stretch between Baltim and Gamasa are deteriorated either due to urban expansion or due to human using in building materials. Two forms of dunes were originated, the linear and the barchan dunes (El-Banna, 2004). The types of dunes are in relationship with the prevailed wind direction and the amount of sediments supply (El-Asmar, 2000). There is a relation between threshold wind velocity (Vt), mean grain size diameter (D_{50}) and the distance of sand transportation (Livingstone and Thomas, 1993). The lowest the wind velocities are the finer of the grain size supply, the highest the dune elevations and short distance of transportation, whereas, the highest threshold velocity is usually associated with the coarser sand supply. The more distance of transportation and relatively low elevation (El-Asmar, 2000). Representative samples collected from dunes at Baltim and Gamasa show that the grain size diameter (D_{50}) at Baltim is coarser than that at Gamasa being 250 um and 180 um respectively. The threshold velocity (Vt) at Baltim is equal to19.38 cm sec^{-1} and the velocity need for suspending the D_{50} (250um) to an elevation Z (Vz=5m) is equal to 630 cm sec^{-1}. At Gamasa the situation is reversed is Vt equal to 16.3 cm sec^{-1} and the Vz for suspending the D_{50} (180 um at Gamasa) is equal to 560 cm sec^{-1} (Yongliang Tain,1988). This may explain why the dunes at Baltim are coarser in grain diameter, and due to the high velocities, sands accumulate forming the highest dune along the study area reached up to 20m (Fig. 3e). However, these dunes move relatively for a shorter distance 3myr^{-1}, which explained as due to the narrow land of the coastal plain backshore of the Burullus head land (Fig. 3a), extensive agricultural fields (Fig. 3d) and acceleration of urbanization processes and construction of the international coastal highway (Fig. 3c, e). The situation is different at Gamasa where the wind velocity is low and the grain diameter is finer then transported for a long distance.

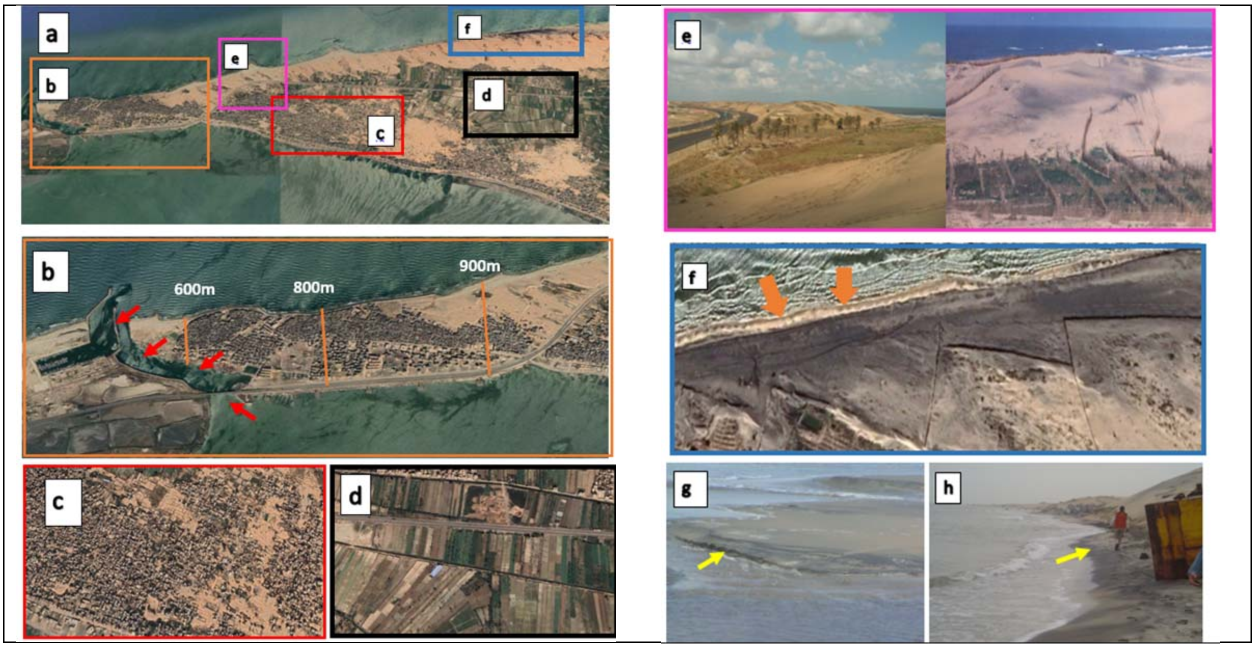

Fig. 3: The Burullus promontory (a) showing the fragile narrow barrier beach averaged 800m width, separating the Burullus lake from the Mediterranean (b), it also shows the Burullus outlet the open of the old Sebenniti branch who was open more than 1000yrs. This area is vulnerable to submerge due to sea level rise. This barrier beach is threatening human impacts such as u ago (red arrows). Urban expansion (c) and agricultural fields (d) that representing together hazard pressure along the fragile coast. The barchanoid dunes at Burg El-Burullus crossed by the international coastal high way, with the characteristic heavy mineral in black at top and fences for dune stabilization (e). The economic heavy mineral concentrated to form black sand beach (f) (orange arrows). The sea waves attack the sandy beach and dunes, and concentrate black minerals due to mechanical separation of waves (yellow arrows) (g, h).

The backshore flat between the beach and dunes is wide in places but absent in others. The dune area was 174.8km^3 during 1984 and 29.4 km^3 during 2003 (Fig. 4). Due to a selective action of waves along Burg El-Burullus –Balim (Fig. 3f, g, h) most of the heavy minerals concentrated along the coast due to high specific weight and form what is called black sand beach (Fig. 3f). A large scale project is under consideration for industrial mining of heavy minerals at the Burullus and Baltim coastsl dunes. This project based on the results of Halawa (2005), who confirmed the existence of approximately 5% total economic minerals in those dunes. In the present study, heaviest minerals detected in decreasing order of abundance are Ilmenite 58.96%, Garnet 7.34%, Zircon 6.68%, Magnetite 3.00%, Rutile 2.6%, and 0.43% monazite. Although these heavy minerals represent more than 5% of the total sands and consider vey economic, the present study shows that, these minerals do not have such economic values to the extent to establish a project for heavy mineral extraction. This is in fact due to two reasons; the first is the sand volume is critically dimensioned from 174.8 km^3 to 6.4 km^3, the second is that most of the heavy minerals detected is ilmenite which is of low economic and strategic values(Halawa, 2005).It is important to keep this area save, it is important as a natural defence against erosion (Frihy and Deabes, 2011; El-Asmar et al., 2012), without these dunes, the Burullus lake will be invaded with waves and may damage the ecosystem and imply severe hazards. The barrier beach separating the Burullus lake from the Mediterranean is very narrow with and average 800m width (Fig. 3 a, b) (El-Asmar et al., 2012). It is suffering also urban pressurethat may add plus hazards together with agricultural activities (Fig. 3 b, c, d). That is lead to confirm the importance to declare this area as a national protectorate.

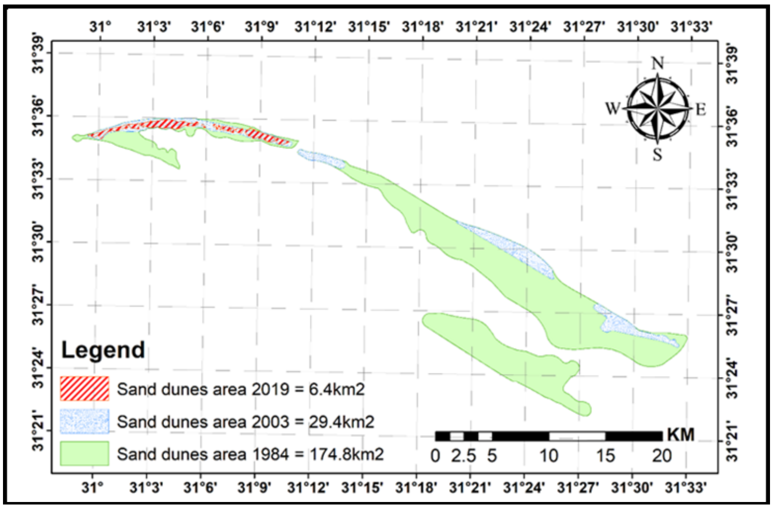

Fig. 4: The distribution of dune fields along El- Burullus-Gamsa showing areas of coastal sand dunes and how dunes are moved or deteriorated and dimished from 174.8 km^2 to only 6.4 km^2.

Shoreline movement along The Burullus- Baltim

Monitoring changing the position of shoreline along the Burg Burullus-Baltim shows that, the coastline at Baltim is partially backed by a ~18 km long of dune system ranges from 500 to 800 m in width, In addition to a system of coastal protection defence measure. This system begins ~2.5 km east of the Burullus lagoon inlet and ends at the Kitchener Drain (Figs. 1b, 2a).

In this study the coastal zone is subdivided into three segments one at Burg El-Burullus and west Baltim (Fig. 5a) which represent stage 3 of Ali et al (2017). It is part of the Burullus promontory that was protected with the coastal sand dunes. Later it subjected to erosion that led to construction of groin and two detached break waters. Correlation of satellite images of 1984, 2003 and 2019 confirms the erosion with rates between 60 and 85 m during the period from 1984 and 2003 (Table 1). The situation is changed after the construction of defence measures correlation of satellite image of 2003 with 2019 shows accretion and saline formation of 127m while spaces between detached breakwater still suffering erosion of 52m. Segment 2 (Fig 5b) the erosion at points 5, and 6 of the sector was very high and led to damage of resort facilities at Baltim enhanced to become a social problem due to the resort was frequented by intermediate levels. In 1993 a project was started for a detached breakwater system and due to technical problems all detached breakers form tombolos with a total accretion 231m, 255m from 1984 to 2019. At present, time the detached breakwater points 5 and 6 (Fig. 5b) became inland, while the other points form saline and tombolo (Fig. 5b and Table 1). Three points 9, 10 and 11 are about to connect to form tombolos with accretion of 99. 82m, 226.08m and 202.15m respectively. This segment shows that the area lost by erosion from 1984 is almost gained again after the construction of the detached breakwater system in a period from 1993 to 2019. Segment 3 (Fig. 5c; and Table 1) shows total erosion along the studied points ranging from 60 to 85m during the period from 1984 and 2003. The erosion was severe and continued from 2003 to 2019 at some points (Fig. 5c; and Table 1 at point 14) and changed to accretion on other points (Fig. 5c; and Table 1 at points 13, and 15). This was contemporaneous to the stage VI of the breakwater system started in 2001 and finished at May 2006 (Ali et al., 2017). However, since 2006 13 years elapsed and the shoreline does not retain its 1984 position (Fig. 4c). As seen in this figure (5) variations in the sediment volume fluctuates between loss and gain of sediment in the alongshore direction (Frihy and Deabes, 2011) reported sediment loss of -0.21 x 103 m^3 m^{-1} occurred along the unprotected sectors east of the basalt revetment and down coast of the detached breakwater system (-0.44 x 103 m^3 m^{-1}). In contrast, the net sediment accretion of 1.85 x 103 m^3 m^{-1} occurs near the detached breakwaters system and locally on the up drift side (1.11 x 103 m^3 m^{-1}).

Table1: Shoreline change detection along Burg El-Burullus-Baltim

No. of point	Change detection 1984/2019	Change detection 2003/2019	Change detection 1984/2003
Area1			
1	+ 231.54	+ 79.56	+ 143.69
2	+ 255.95	+ 293.61	- 37.6
3	+ 153.74	+ 233.61	- 72.69
4	_ 52.01	+ 310.27	- 337.77
5	+ 99.82	+ 157.82	- 104.85
6	+226.08	+85	+120
7	+ 202.15	Zero	+ 215.99
Area 2			
8	- 60.74	+ 31.7	- 80.34
9	- 87.74	- 34.95	- 45.95
10	- 90.86	- 62.23	- 43.16
11	- 290.73	- 305.71	zero
Area 3			
12	- 52	Zer0	- 63
13	+ 104.43	+ 127.47	- 60
14	- 125.23	- 108.50	- 67
15	- 52	+ 50	- 85

CONCLUSIONS

The study of coastal strip between Burg El-Burullus and Baltim extends for about 25km show that it is fragile coastal area composed of loose sand eroded from the old Sebennitic Promontory and recorded severe erosion with rate 6m yr-1continued for more than 1000 yrs since the Sebennitic branch ceased. This led to change the position of Burg El-Burullus village for more than one time. Amount of sediments estimated between 400,000 to 3.2 x106 m^3 yr^{-1}) spatially distributed by longshore sediment transport. These sufficiently large enough to maintain a reasonably stable shoreline, the erosion enhanced after the construction of Aswan High Dam, which prevent about 55.5x109m^3 yr^{-1}, approximately 35% less than prior to the construction of the dam. Such sands transported across the coast by wind to form coastal sand dunes of barchan and barchanoids elevated to up to 20m between Burg El-Burullus and Baltim due to the high threshold velocity that reached at Baltim (Vt) to19.38 cm sec^{-1} which able to blow sands with diameter D_{50} (250um). The velocity need for suspending the D_{50} to an elevation Z (Vz=5m) is equal to 630 cm sec^{-1}. This is explaining why the dunes at Baltim are much elevated than at Gamasa. Such high dunes represent natural defence against erosion of the coast, and retreat of shoreline of the fragile area of study and prevent critical role in protecting the central Nile Delta from submergence. Due to human intervention including urban extension and agricultural activities much of these dunes were deteriorated and diminished from 174.8km^2 to 6.4km^2 and concentrate at present time at the backshore of the study area. The project of extraction and concentration of heavy minerals from sand dunes seem uneconomic. Although the heavy mineral concentration is more than 5%, more than half of the detected minerals are ilmenite, which is neither strategic nor economic mineral. This project also may add more hazards to the study area. Although the defence measures seem effective in protecting the coast, several rates of erosion and accretion were detected along the studied sectors, and the shoreline does not retain its present position in many areas of the coast since 1984.

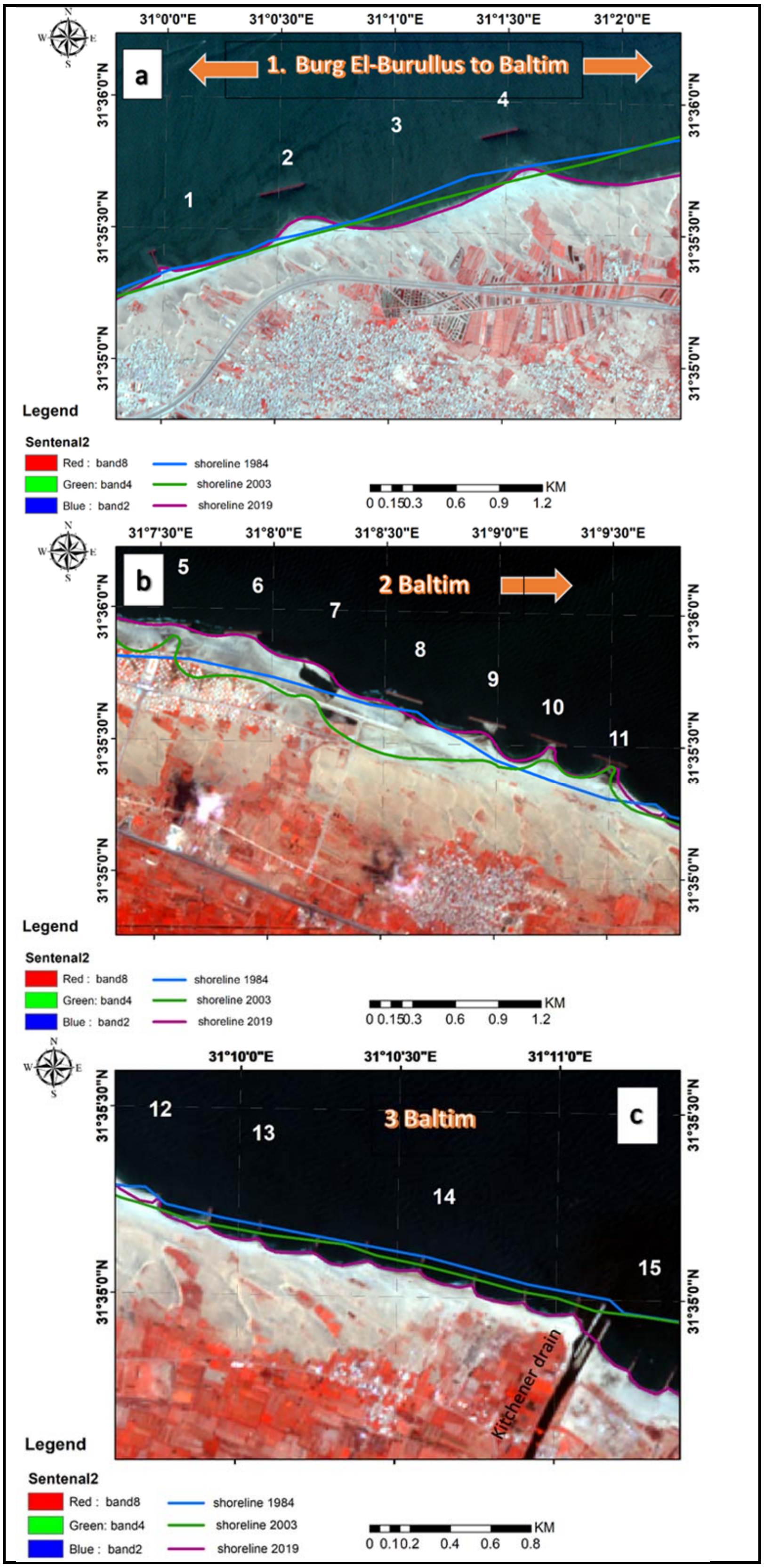

Fig. 5: Three segments along the Burg El-Burullus- Baltim coast showing the shoreline changing position from 1984 (blue) to 2003 (green) correlated with the present shoreline 2019 (pink). Since the construction of protection measures during 1994 to 2006, the coast does not retain the eroded area and the shoreline position of 1984.

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مراقبة الوضع المتغير لخط الشاطيء على طول ساحل البرلس- بلطيم، دلتا النيل، مصر. ودور الكثبان الرملية كحماية طبيعية للساحل من التآكل والحفاظ على موقع تراث جيومورفولوجي هام: تطبيقات الأستشعار عن بعد

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الخلاصة

من مراقبة المنطقة الساحلية على طول البرلس- بلطيم يتضح أنها منطقة ساحلية هشة مكونة من رمل فتاتية تآكلت من رصيف سبينيت القديم منذ الزمن التاريخي لأكثر من ١٠٠٠ عام، وقد تم تعزيزه بعد بناء السد العالي في أسوان وإنحسار رواسب النيل . أدى التفاعل بين الأمواج والرياح والرمال على طول هذا الساحل إلى بناء جيومورفوسيت فريد من نوعه مع الكثبان الرملية الهلالية والطولية المتعرجة. ولقد لعبت سرعة الرياح في انتقاء حبيبات خشنة تكونت منها كثبان بلطيم كما ان السرعة اللازمة لقذف الحبيبات مسافة ٥م كانت كافية لترتفع بهذه الكثبان لما يقرب من ٢٠ م أو يزيد ، كما كان لضيق الظهير الصحراوي خلف الكثبان سببا في عدم انتشارها افقيا عللى العكس إذا ماقورنت بساحل جمصة الممتد بظهير صحراوي متسع وحبيبات رملية دقيقة ساهمت في تكوين الكثبان الطولية بإرتفاع لا يزيد عن ٥م. تمثل هذه الكثبان الرملية تدابير دفاعية طبيعية لحماية الشاطيء الحاجزي الذي يفصل بحيرة البرلس عن البحر الأبيض المتوسط . لقد أدي التدخل البشري المتمثل في البناء العشوائي والأنشطة الزراعية إلى تدهور الكثير من هذه الكثبان الرملية وتقلص مساحتها من ١٧٤.٨ كيلومتر مربع إلى ٦.٤ كيلومتر مربع . إن مشروع استخراج وتركيز المعادن الثقيلة من الكثبان الرملية يبدو غير اقتصادي ، على الرغم من أن تركيز المعادن الثقيلة يزيد عن ٥٪ غلا ان معظمها من الألمنيت، وهو ليس من المعادن الاقتصادية. قد يضيف هذا المشروع استنتزاف هذه الرمال من خلال هذا المشروع مزيدا من المخاطر التي تحيط بالمنطقة. على الرغم من أن التدابير الصناعية لحماية الشاطيء من التآكل تبدو فعالة واسترد الساحل أجزاء كبيرة مما فقده إلا أن خط الشاطيء لم يسترد موقعه السابق عام ١٩٨٤