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Geohazards studies of the coastal plain in Egypt

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Abstract

Sea level rise, flash floods, faults, Tsunami, Earthquakes and shoreline erosion are a variety of natural hazards regularly threaten the North Western coast inhabitants and Matruh in particular. Large Coastal rock boulders are found at a great distance inland or supratidal zone and upslope from the subtidal zone on Romel coastal shorelands of Marsa Matruh. It proves that large waves like tsunamis and high energy storms have detached, dislocated and triggering them from the submerged plateform of Pleistocene ridge shoreward. The study shows that Romel is considered as hazardeous area in Marsa Matruh coasts and it is recommended to avoid the housing and the problems resulting for constructing tourist villages along the shoreline in these areas.

Key Words:

Geohazards-Tsunami-coastal erosion-Sea level rise.

1. Introduction:

Costal hazards are considered important environmental issues in a lot of parts of the world. A Large quantity of the world's population lives in coastal areas.

With the increase in the number of human settlements and infrastructure, coastal danger evaluations and preparing are demanding for sustainable development. Flood by large waves is an important hazard that danger many coasts with extreme storms and tsunamis begin the most important source of high energy, low frequency marine steam.

The effect of unusually large waves on a coast able to be found in the geomorphological and sedimentological record as erosional and sediment features. Along rocky coasts, the detachment and landward displacement of mega-clasts is considered as obvious evidence of the impact of high-energy waves (Dawson, 1994, Nott,1997, 2000, 2003; Noormets et al., 2004; Goff et al., 2004, 2006; Morton et al., 2006; Gotoet al., 2007; Imamura et al., 2008; Stewart and Morhange 2009; Barbano et al., 2010; Etienne and Paris, 2010; Nandasena et al., 2011, 2013; Engel and May, 2012; Shah-hosseini et al., 2011 and has extended area of coastline along the Mediterranean Sea Egypt 2013).

Around 35 million people in Egypt, about 45 % of the country's population are living in areas below 10 m above sea level and prone to coastal inundation. The population density, particularly in Nile delta, is high and reaches 250–1000 people/km2 (NASA's Earth Observing System Data and Information System—EOSDIS). Shoreline erosion, earthquakes, tsunami, and sea level rise are a variation of natural hazard natural threaten the northwestern cost people.

In Egypt, the northwestern coast extends along 525 km on the Mediterranean Sea, in Alexandria west.

This favorable region has brought many tourists with large expenditure.

2. The Theoretical Framework:

The accretion phenomenon has greatly affected coastal areas along Egypt's Mediterranean coast and is considered a major environmental problem (El-Bayomi.,2009) (Figure 4).

Properly assessing the impacts of these changes and designing feasible land use and conservation strategies requires simultaneous monitoring of coastal changes (Frihy et al., 1990).

Earthquakes trigger tsunamis when the seafloor suddenly deforms, causing the water above to move from a stable position. The degree of vertical deformation of the seafloor is a major contributor to the initial size of the tsunami. Figure (١) shows seismic activity in Egypt (Mohamed et al., 2012).

However, other disturbances can also throw large bodies of water out of equilibrium location and trigger tsunamis, such as undersea landslides, violent marine volcanic eruptions, aerial landslides, glacier collapse, and asteroid impacts.

Tsunamis in the eastern Mediterranean have a long history since the cuneiform era (Stiros, 2022). Many of them were unusual because they came after onshore earthquakes, such as those along the Dead Sea Transform, suggesting that they were triggered by seismogenically induced submarine landslides/slumps (Salamon et al., 2007). The 2023 Turkey-Syria event broke the long tsunami quiescence in this region, which had persisted since the tsunami associated with the 1953 ML 6.2 Cyprus earthquake (Ambraseys & Adams, 1993).

Shanmugam (2006) reported tsunami-related deposition to be a purpose of four developing steps: triggering, propagation, shoaling–breaking and deposition followed by outflow. Although it slightly recognized in history, the tsunami hazard possibility is extremely high along the African coast of the Mediterranean caused by the presence of major active faults. Roman historian, Amiano Marcellino has informed that tsunami of 365 AD which damaged Alexandria port and killed about 50,000 people (Mastronuzzi et al., 2013). Another huge tsunami in 1303 hit Alexandria which destroyed a large part of the city wall and the notable beacon (El-Sayed et al., 2000; Ambraseys, 2009).

Coastal geomorphology is significantly impacted by variations in sea level, which might be eustatic, caused by isostatic depression and crustal recovery, or by orogenic movements. Based on their projection of the future effects of greenhouse warming, Peters and Darling (1985) calculated that sea level rises of 50 to 340 cm, or an average of 5 to 30 mm per year, may be anticipated by the year 2100. These rates, which are significant because they take into account the partial melting of the West Antarctic ice sheet, are the highest that the several studies have estimated. Sea level rise is predicted by the IPPC's third assessment report to be between 25 and 88 cm during the next century.

Coastal instabilities refer to the backward movement of land (erosion) and the forward movement of land (accretion) (Mondal et al., 2017). Beach erosion and coastal cliff retreat are frequent occurrences on rocky and open shores all over the world (Stanchev et al., 2018).

Planning for the next 50 years should reportedly include for 50 centimetres rise in sea level due to ground subsidence in the coastal zone (McCarthy et al., 2001).

Shorelines are dynamic features that alter shape and location across a range of timescales under both natural processes and human activities (Mondal et al., 2017, Stanchev et al., 2018). Natural coastal forces such as wind, waves, tidal currents, geotectonic, natural disasters, and coastal flooding are fundamental in the dynamics and alteration of the shoreline (Appeaning Addo et al., 2012a, Mondal et al., 2020, Pourkerman et al., 2018). Contrariwise, anthropogenic activities, including urbanization and expansion of socioeconomic activities in the coastal area result in severe stress on the coastal dynamics, which leads to coastal instability (Appeaning Addo et al., 2012b, Bacino et al., 2020, Hossen and Sultana, 2023). Furthermore, the impacts of climate change, such as accelerated sea level rise and increased storminess, exacerbate shoreline movement (El-Masry et al., 2022, Griggs and Reguero, 2021).

Even with the lower projections from Van der Veen (2002), rates of 2.8–6.6 mm / year by 2085 AD are still around two–four times higher than the 1–2 mm / year rise that has dominated the previous century.

Since crustal changes of tectonic or isostatic origin typically accompany glacio-eustatic movements of sea level, regional sea level curves are varied on a global scale (Pirazzoli, 1991). In contrast to many other parts of the world, the Holocene transgression rises around 3 meters above current sea level along the coasts of Brazil (Delibrias & Laborel, 1971; Martin et al, 1980, 1985; Fairbanks, 1989; Angulo and Lessa, 1997).

According to Martin et al. (1980), the process of hydro-isostatic rebound, which has rates of RSL change of 1 to 10 mm/yr, is currently responsible for such high sea level stands (Clark & Bloom, 1978).

The eastern coast of Australia (Hopiley, 1980; Baker & Haworth, 1997) and the coasts of west Africa (Laborel & Delibrias, 1976) also showed evidence of high Holocene Sea levels.

Numerous vermetids and coral samples that have been submitted for a known period of time to mid-littoral erosion throughout the course of the last 15 years have been seen in the Mediterranean, and these samples can be used to compare standards with specimens from tropical and subtropical raised shorelines (Morhange et al, 1998).

3.Methods of Research and the tool

Shoreline erosion along the coast is derived with the help of GIS software from the DEM 30m resolution in ArcGIS 10 Spatial analyst module.

4. Results of Research:

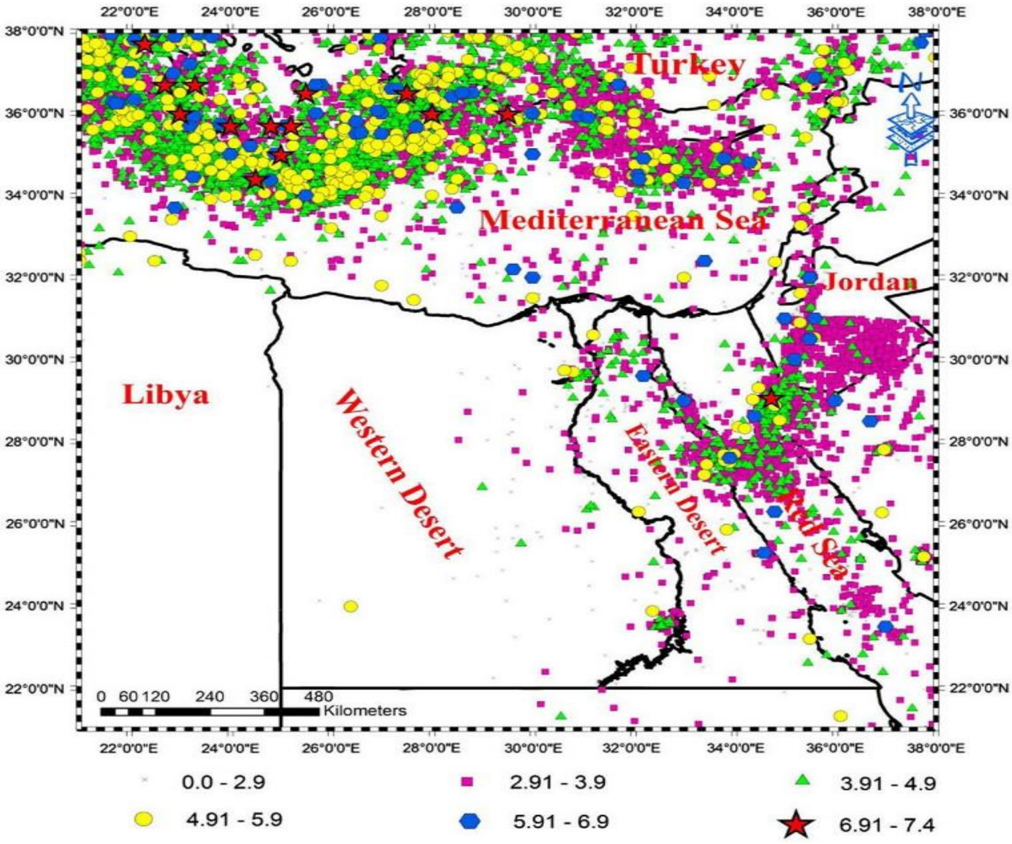

Figure (1): Seismicity of Egypt (Mohamed et al, 2012).

Figure (2): Vermites at Romel.

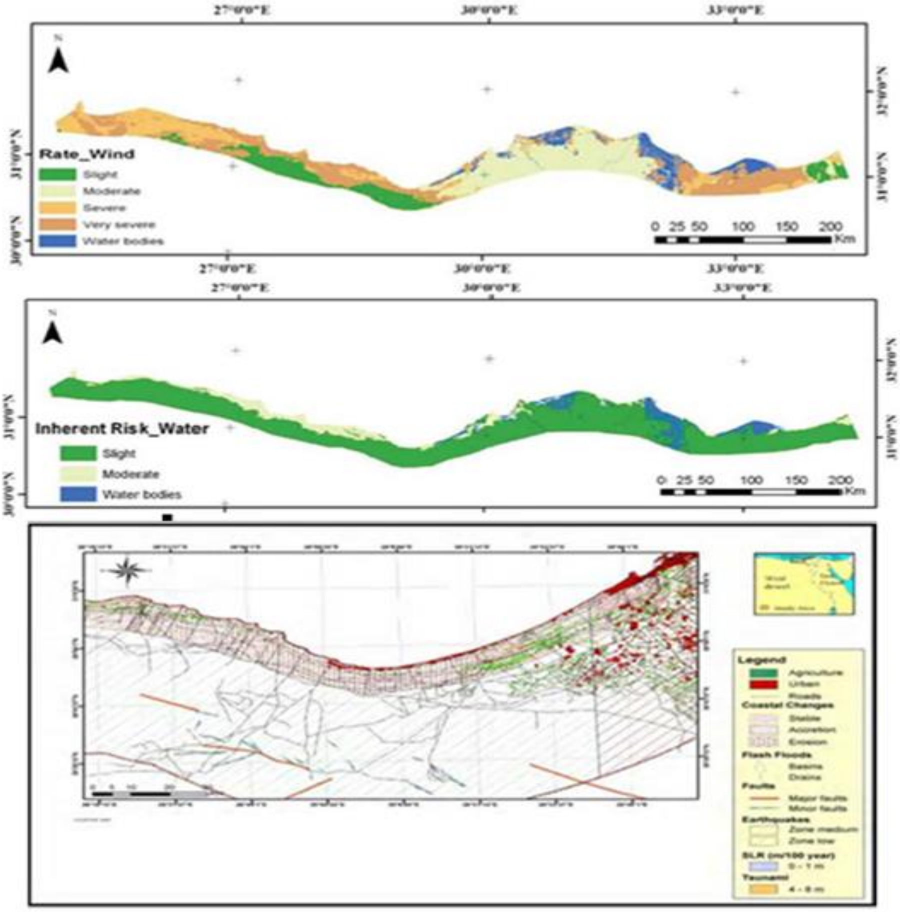

Figure (3): According to El-Bayomi (2009)

A- The wind erosion rate.

B- The water erosion rate.

C- The change between (1991 – 2007).

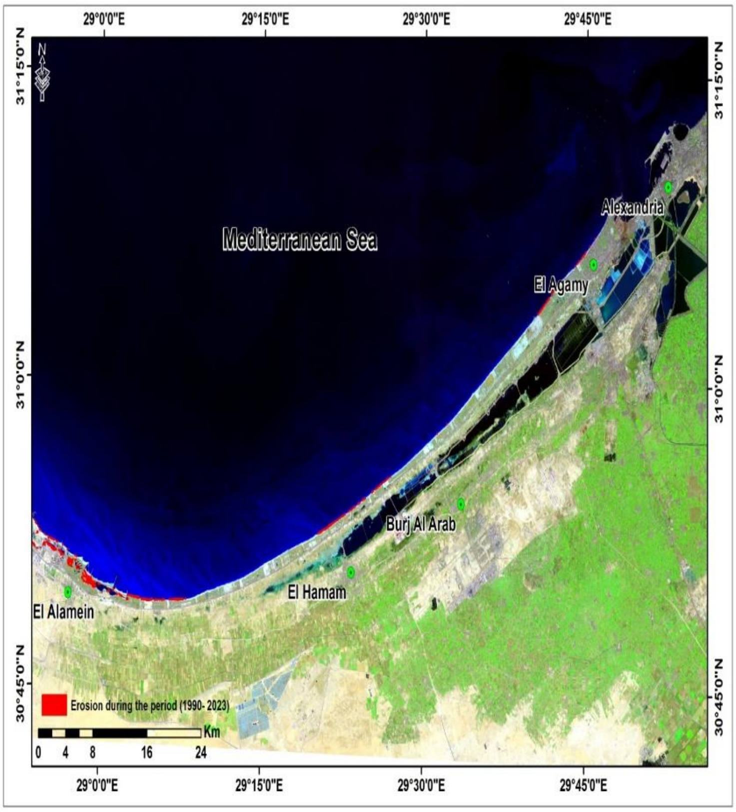

Figure (4): Shoreline erosion during the period (1990- 2023)

5. Interpretation of Results:

Large coastal rock boulders can be found well inland or above the tideline on Marsa Matruh's Romel shorelands. It demonstrates that huge waves, such as tsunamis and high-energy storms, have disconnected and dislocated from the buried plateform of the Pleistocene ridge shoreward.

Boulders and blocks made up of marine organism remnants are evidence of origin or a long period spent in a submerged environment. Two identical marine biomarkers have been identified to determine the timing of emergence of the boulders: **i)** Lithophyllum byssoides is an algae carbonate that expands at the base of the intertidal zone, with the lower population indicating biological sea level (Laborel et al., 1994). **ii)** Vermetus triqueter is a hold-fast gastropod noticed in the subtidal zone, with the population peaking near biological sea level (Laborel et al., 1994) (Figure 2).

Furthermore, these two bioconstructions have the advantages of low contamination and controlled life duration, as well as being more suitable for age inspections than the rock boring bivalve Lithophaga, which has a longer life span (Kleemann,1973) in our study vermites flourish on coastal platform encrusting gastropods.

Encrusting gastropods belonging to the family Vermitid flourish on hard substances (Keen, 1971) and set up structures' alike reefs in the clear troubled warm water of tidal environments. Examples: coasts of Florida, edges of the Bermud platform and rocky shorelines in the Mediterranean, "trottoir" (Pérès, 1967).

The presence of mega-boulders is taking into cosideration as one of the most impressive evidence of extreme wave effect on the Mediterranean coasts and whose cumulative have been attributed both to tsunamis and storm events (Mastronuzzi and Sansò, 2000, 2004; Mastronuzzi et al., 2007; Scicchitano et al., 2007, 2012; Barbano et al., 2010; Vacchi et al., 2012; Raji et al., 2015).

The transport stages of boulders are reconstructed in four phases according to the bio-indicators:

(1) Separate of the initial block from its premier intertidal location.

(2) Submersion phase authenticated by the development of vermetids.

(3) Transfer of the block to the supratidal zone.

(4) Collapse into boulders then the rotation of the latter.

Furthermore, the horizontal bedding, the existinse of subvertical interruption and also the poor geo-mechanical properties of the oolitic limestone rocks play an essential role in the fracturing and separations of large blocks from the Matruh coastline.

In addition, many of the boulders recently deposited by surges have been moved, displaced, and migrated landward. In order for the boulder to be removed mechanically, a first crack must exist.

According to (Torab et al.2015), waves deposited boulder fields during winter storms or paleo-tsunami surges, which were mostly uprooted from the ocean platform and distributed within 90 m of the coastline, up to 4 m above present sea level. Daily mean sea level. Storms and tsunamis can deposit these boulders, especially on the northwest coast of Egypt, where many earthquakes or tsunami events have been recorded during the Holocene (23 AD, 365 AD, 746 AD, 881 AD, 1202 AD, 1303 AD, the 1870 tsunami advertising 1908 AD) in Alexandria, archaeological excavations and historical data have proven this. Tsunami waves and storms, due to their immense energy and sculpting ability, cause large boulders to be moved from the seafloor and submersible platforms (platforms) onto the beaches. It is also capable of pulling other boulders out of the land and placing them back on the beach or shore.

He also pointed out that the city of Matruh Port is the area expected to be most affected by the tsunami disaster on the northwest coast of Egypt and is currently greatly affected by the recent storm.

In the Mediterranean region and other coasts around the world, numerous studies have shown offshore boulder accumulation caused by tsunami or storm impacts (e.g., Mastronuzzi and Sanso, 2000, 2004; Morhange et al., 2006; Mastronuzzi et al., 2007; Sciccitano et al., 2010; Raji et al., 2016).

The Mediterranean basin is located in a tectonically active environment with significant volcanic activity and a long history of earthquakes and tsunamis (Papadopoulos and Fokaefs, 2005; Salamon et al., 2007; Stewart and Morhange, 2009; Anzidei et al., 2014; Papadopoulos). et al., 2014).

In many cases, energetic sediments are associated with historical or prehistoric tsunamis, especially in the eastern Mediterranean.

However, studies on coastal hazards on the southern shores of the Mediterranean are rather rare. Severe storms are considered an important source of catastrophic large waves in the Mediterranean (e.g., Lionello et al., 2006; Sabatier et al., 2012), and many studies have linked displaced boulders to extreme storm events (e.g., Barbano et al., 2010; Paris et al., 2011; Shah-hosseini et al., 2013).

Figure 4 shows the erosion rate affecting the coast by wind and water. Comparing the rate of erosion between (1991 – 2007) in figure 3 and that between during the period (1990- 2023), we can notice that the erosion along the coastline increase.

In addition, important infrastructure is also concentrated in these coastal areas. To understand the potential dangers on a particular coast, it is important to understand the history of past events.

Compared with other regions of the world, the historical record of disaster events in the Eastern Mediterranean is long and relatively complete (e.g., Soloviev et al., 2000; Papadopoulos and Fokaefs, 2005; Salamon et al., 2007; Papadopoulos et al., 2014).

However, the early historical record of coastal Egypt is considered relatively incomplete due to the low population density outside major ancient cities such as Alexandria (e.g., Frihy, 2001). Given these limitations, extensive research is essential to identify and explain past events.

The study uncovered displaced coastal rocks as evidence of the impact of large waves along a stretch of Egypt's Mediterranean coast. This study contributes to a better understanding of the vulnerability of Egypt's Mediterranean coast to natural disasters.

6. Conclusion:

Disaster risks are expected to be at their most severe by 2030 due to climate change and the continued expansion of cities and tourism in new locations affected by natural disasters.

Risks of seawater inundation, coastal erosion and water shortages are higher, as are earthquakes, subsidence, and flooding.

Furthermore, climate change can have negative impacts on public health (El Kafrawyi et al., 2003).

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