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Evaluation of stability and Marine Hazards Coastal zoning in southern province of Sistan and Baluchistan using GIS

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Abstract

The study area in the South East of Iran in geological zone Makran. The geographical location of the study area in orbit 25 degrees 13 minutes north latitude and 60 degrees to 25 degrees and 25 minutes and 35 minutes to the meridian of 60 degrees and 55 minutes east is located.This area covers part of the northern coast of Oman Sea. In addition to marine risks, different risks of coastal Makransubduction zone, especially during faults, sea water and its harmful effects on coasts and ports affected are southern province and Sometimes destroys all obstacles on your own.In this study, using hydrological studies, tectonics, using satellite images and aerial photographs using GIS, mapping areas of high risk, low risk and safe to reduce marine and coastal hazards have been identified. One application for this research review Lifeline residential areas for relief is taken when necessary. For example, invasion routes tsunami, mud flows, floods, landslides and loss development in the region, degradation of coastal, safe and risky areas on land and in the South East coast's topography is predicted. Accordingly,in the regionsLipar, Chabaharandtees, thedestructionis high.Greatseabeach resortarea, parkTajMahal(downhill), a beautifulcity, townGolshahrspringandwavepower, you must first gentleuphil-landthendownhillthroughtheturns, With increasingwaveheight, thefloodareasand allvitalarterywillbe cutanddamages-multiplier. In the regionsRaminandbracewitha positiveslope (uphill), damagesand injuriesless(lowrisk) will be.Free industrial and trade zone in Chabahar is one of the safe areas (Such as emergency rooms, hospitals, blood transfusion services, airports, fire departments) should all be transmitted vital artery to Safe areas. It is necessary, lines of communication and highways, to avoid traffic and appropriate relief work to be constructed in the event of coastal hazards.

Key words: Flood, Emergency,Chabahar, Marine Hazards.

1. Introduction

Many coastal areas are already experiencing coastal erosion, sea-water intrusion and sea-flooding. The increased sea-levels due to climate change may aggravate these problems. Productive coastal ecosystems, coastal settlements and islands will be vulnerable to these pressures (Bray and Travasarou 2007; Bray and Travasarou 2009). Tropical and sub-tropical coastlines, which are under significant population pressures, will be significantly impacted by these changes. Salinization of potable ground water, inundation of coastal zone and erosion will be exacerbated (Griffiths and Lane 1999). Climate change will also directly impact coastal wetlands, especially mangroves, coral reefs, lagoons and estuaries. The extent of impacts will depend on the rate of sea-level rise. Strict protection preparation of action plan for each component, regeneration, and providing space for backward movement of species are some mitigating measures.Since early civilization, coastal areas have been attractive settling grounds for human population as they provided abundant marine resources, fertile agricultural land and possibilities for trade and transport (Hong Kong Geotechnical Engineering Office 2007). This has led to high population densities and high levels of development in many coastal areas and this trend is continuing into the 21st century (Sweigard et al. 2011).

Natural disasters are events caused by the forces of nature that adversely effect on human settlements, and environment. The coastal zone is the transitional area between land and sea. It is defined, as a strip of land and sea of varying width depending on the nature of the environment and management needs. It seldom corresponds to existing administrative or planning units. The natural coastal systems and the areas in which human activities involve the use of coastal resources may therefore extend well beyond the limit of territorial waters and many kilometers inland. The worldwide average width of the coastal zone on the terrestrial side is said to be 60 km. The zone occupies less than 15% of the Earth's land surface, yet it accommodates more than 60% of the world's population. Furthermore, only 40% of the one million-km of coastline is accessible and temperate enough to be habitable. As a result, coastal zones are marked by above-average concentrations of people and economic activity. This coupled with their proximity to the ocean makes them one of the most sensitive zones for natural disasters. In the future, it is estimated that about 600 million people will occupy coastal flood plain land below the 1000-year flood level by 2100 (Nicholls and Mimura 1998; Griffiths et al. 2011). Effects of climate change on coastal has been mostly considered from the standpoint of sea-level rise. Increase in air-sea and sea-surface temperatures, changes in wave characteristics, storminess and tidal regions will also impact coastal zones. Sea-level rise will impact the low-lying areas such as deltas and coastal plains. More severe storm-surge flooding, saltwater intrusion and sedimentation will be some of the potential impacts of climate change on coastal areas (Hoomehr et al. 2013; Hoomehr 2014). Tsunamis are characterized as shallow-water waves, with long periods and wave lengths. They are often observed with wavelengths in excess of 100 km and period on the order of one hour. Due to their large wavelengths, tsunamis propagate at high speeds, great transoceanic distances with limited energy losses. As a tsunami approaches shore, it begins to slow and grow in height (White et al. 2009). They inundate and flood hundreds of meters inland past the typical high-water level, damaging homes and other coastal structures. Despite energy losses on approaching shore, tsunamis still reach the coast with tremendous amounts of energy with great erosional potential, undermining trees and other coastal vegetation (Lu 2010; Jeldes et al. 2010; Jeldes et al. 2013). Seas and oceans cover roughly two-thirds of the surface of the globe. Since time immemorial they have provided mankind with food. In our own age they have been found to contain a rich diversity of resources whose exploitation remains a matter of contention. But the waters of the world are more than a prime instance of nature's munificence, or a handy dumping ground for the refuse of civilization (Abramson 1996; Gutierrez et al. 2008; Hoomehr et al. 2012). They can be formidable obstacles to societies lacking the will or the means to cross them. Equally they can be a powerful stimulus to technology and a challenge to the skills of those who, for any reason, seek to use them. They can unite the cultures and economies of widely dispersed and radically different peoples, allowing knowledge, ideas and beliefs to be freely transmitted. The ports that develop along their littorals often have more in common with one another than with the states or communities in which they are sited.

The deposits of the United Arab Emirates Coastline and the floor of the Oman Sea are mostly Pleistocene or recent in age. The Oman Sea is an area of extensive carbonate sedimentation, and the nature and distribution of the sediments is governed by the recent geological history and structural setting of the Oman Sea, the orientation of the coastline and the prevailing winds. The structural and geomorphic features have been discussed by Kassler (1973), whilst the sedimentation along the coastline has been extensively described and more recently summarized by Purser and Evans (1973).

2. Geological and Geographical situation of the study area

Southeastern Iran or Makran zone is located to the south of Jazmurian depression. Its western boundary is Minab fault; to the south, it is restricted by the Gulf of Oman, and to the east, it extends into Pakistan. The northern part is characterized by dominance of east-west trending faults, Bashagard fault being the most important one. Along these faults lies large section of ophiolite series. The oldest rocks in this zone are the ophiolites of Late Cretaceous-Paleocene overlain by a thick sequence (about 5,000 m) of sandstone, shale, and marl. The whole sequence is deformed prior to Early Miocene. Thick sequence of Neogene rock units, in excess of 5,000 m, covers the older series (Geological Survey of Iran 2015).

The study area is located in the south-east of Iran, north-west of the Indian Ocean, and north-east of the Oman Sea at between latitudes 25°23´28´´N & 25° 27´15´´N and longitudes 60°33´15´´E & 60°38´28´´ (Fig. 1). The Chabahar is in southeastern Iran. It is the only Iranian port with direct access to the ocean. The port was partially built by India in the 1990s to provide access to Afghanistan and Central Asia, bypassing Pakistan.

Makran Subduction zone contains one of the largest accretionary wedges on the globe, formed by the convergence between the Eurasian and the Arabian Plates. The study areais locatedon theMakran coast. This area is a part of coastal Makran zone (one of the geological zones of Iran) that had undergone sea level changes along the Late Quaternary. Makran and Zabol-Baluch in SE Iran are post-Cretaceous flysch - molasse belts which join together in SE Iran and continue to the Pakistan Baluchistan Range. The fiysch sediments were deposited on the Upper Cretaceous ophiolites. The Makran Subduction Zone characterizes by the subduction of the oceanic part of the Arabian plate beneath the Eurasian plate. Makran Subduction Zone is unique region in the world due to its geological and seismological characteristics. High sediment input of 7 km, shallow angle of dip and rate of subduction are interesting and distinctive features of this zone. Oceanic lithospherein theArabian plateis movingnorth and is subducted underLutplate and Afghan-Helmand block. The rates of both Arabic and Makran coast in the measurements geodetic is measured between Muscat and Oman 1.9 cm in years, While the current rate of shrinkage in the Makran coast and Chabahar area is measured about 8 mm in years (Vernant et al. 2004; Dolati 2010).

3. Material and Methods

Working as quantitative-qualitative methods (heuristic) and research-oriented and library studies (such as research and scientific resources related to the topic of the previous studies and then collected and examined), field laboratory (in this stage of library studies,

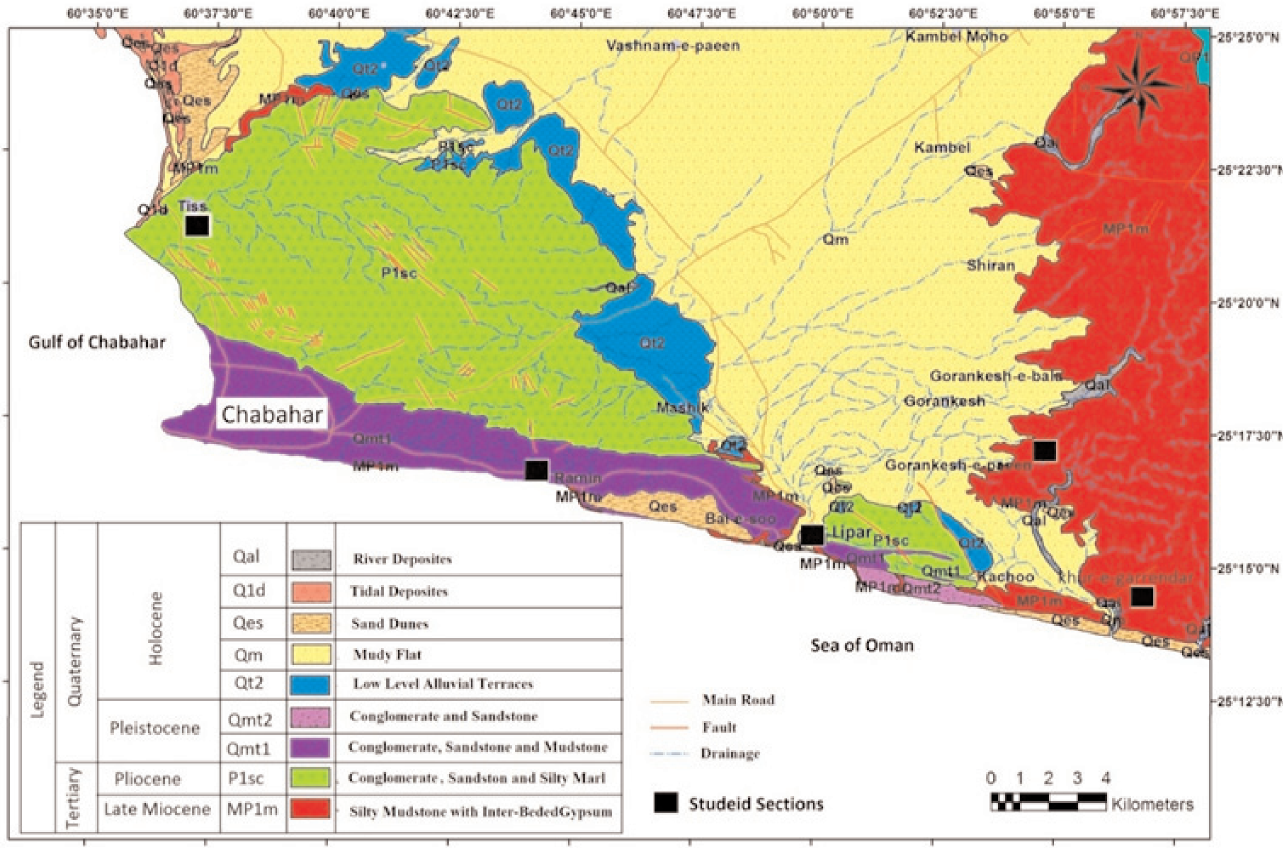

Figure 1. Geologic map of the study area

all satellite images, geological map sheets of Chabahar by Samadian and Jafarian 1375 and such as Gabric-Yekdar by Eghlimi et al. 1375 were collected and studied.), data analysis and conclusions. Also In addition, majority of national and international journals, books and the Internet were collected and investigated. First, using aerial photographs and satellite images, using Google Earth and GIS, geological maps, topography, tectonic and seismic data was conducted. Then, during field visits, registered structural evidence (photographs etc.) was carried out and analyzes the data and conclusions should be reached. The initial processing by computer skills such as Excel and final processing using GIS software was computed.

4. Results

The study was too small tsunami in the region while a tsunami in the region is linked with the history of the earth and geological events. It can be said that the last fourteen tsunami has been done in this region destructive tsunami off the coast of Makran reported the incident 28 November 1945 AD. The tsunami caused by an 8.1 magnitude seismic event in the center of the earth in longitude 24° 50´E and latitude 63° 00´N with a distance of 87 km southwest Baluchistan region of Pakistan occurred (Fig. 2).

Tsunami waves of local origin, which account for most fatalities due to tsunami worldwide, pose a natural hazard on shores of the Arabian Sea. This hazard was demonstrated on the morning of November 28, 1945 (local time). An earthquake of magnitude 8.1 resulted from fault rupture along the Makran Subduction Zone. An ensuing tsunami caused hundreds of fatalities in what is now Pakistan, additional deaths in Mumbai (Bombay). Damage was reported from Iran and Oman as well (Page et al. 1979).

Because of the subduction zone off the coast of Oman, on land and sea were exposed to two environmental factors. The three systems are cross wide fault in the body and thus acted rocky shore of a vast network of joints and cracks and fault wedge shape. In

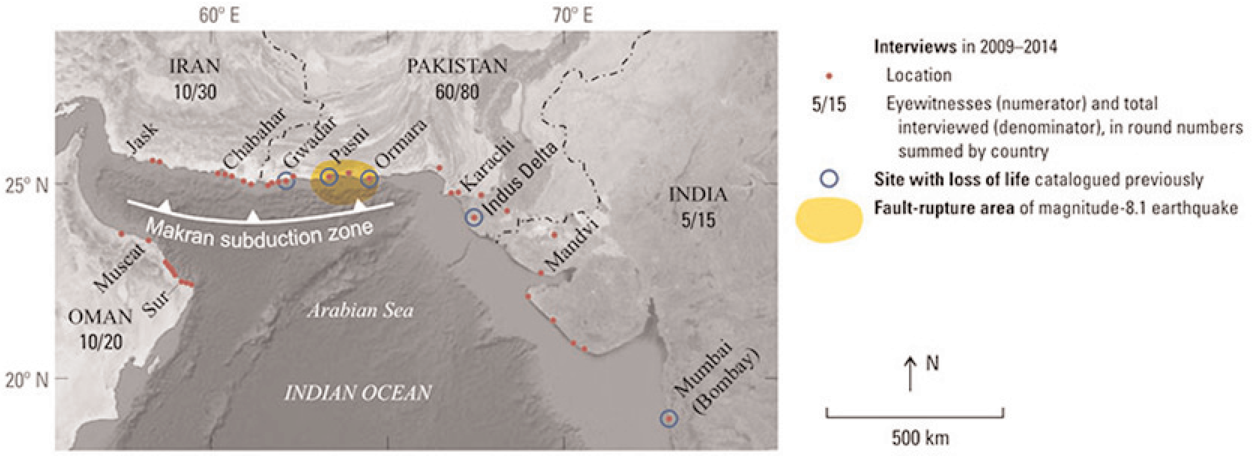

Figure 2. Map of tsunami caused by the earthquake showing how it radiated from the entire length of the 1,600 km (990 mi) rupture

Figure 3. Shellscrunch in Outcrop of

these situations rock units affected by processes such as dissolution petrification analyze and alteration of the components, are increasingly suffering from osteoporosis and beaches in the invasion and hit the waves are very vulnerable position and loading.

Some of the most important evidence of the impact of tectonic activities offered below:

Shells crunch: Geological units outcrop of sandstone, mudstone and conglomerate and Lumachel deposits of fine-grained facies that pool is shallow. In all of these sediments shells of shellfish can be seen that as a result of activities in 1945 were crushed by the tsunami. Shells crunch creatures can be seen in abundance in which there is no orientation or fabric (Fig. 3).

The effects of Gonu´s Storm: The system is 720 kilometers southeast of bambai in India on June 2 and June 3 was the strengthening of the cyclone wind speed of 264 km spread in this day to about 475 km Makran reached on June 4 in the East Oman Sea (Fig. 4). Then gradually approached the coast of Oman and Makran due to low water temperatures and drier weather was poor. The system on 6 and 7 June to the north and northwest and Iran shifted (Fritzet et al. 2007). Gonu caused by more than 200 km per hour wind speed that is unprecedented over the past 50 years in this area and in southeast Iran, with more than 100 km per hour hit the coast. Causing changes in coastal morphology such as dam's coastal estuaries and sea cargo area.

Rip currents: Rip currents can occur at any beach where there are breaking waves on oceans, seas, and large lakes. The location of rip currents can be unpredictable while some tend to recur always in the same place, others can appear and disappear suddenly at various locations along the beach.Makran coast frequently occurs in these trends (Fig. 5). Rip currents can be hazardous to people who are in the water. Swimmers or floaters who are caught in a rip and who do not understand what is going on, and who

Figure 4. Effects of Gonu´s Storm, 2007

Figure 5. Rip currents in Makran coasts

Figure 6. Fractures include Joints and faults in Makran formation.

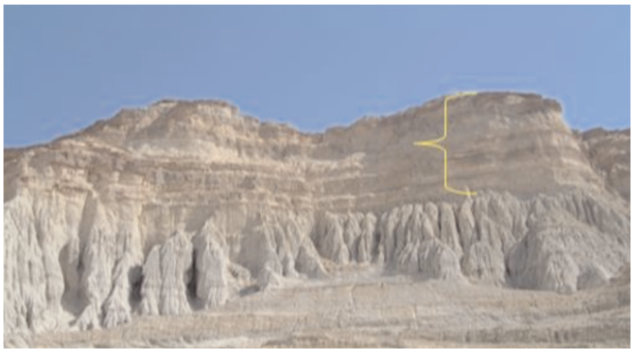

Figure 7. Coarsening upwards in Makran formation

may also not have the necessary water skills, may panic, or may exhaust themselves by trying to swim directly against the flow of water. Because of these factors, rips are the leading cause of rescues by life-guards at beaches, and in the US rips are responsible for an average of 46 deaths from drowning each year.

Fractures (Joints and faults): The Makran Trench is the physiographic expression of a subduction zone along the northeastern margin of the Gulf of Oman adjacent to the southwestern coast of Balochistan of Pakistan and the southeastern coast of Iran. In this region the oceanic crust of the Arabian Plate is being subducted beneath the continental crust of the Eurasian Plate.The Makran Subduction Zone has the highest incoming sediment thickness (up to 7.5 km) of any subduction zone. These sediments have formed a wide accretionary prism (~400 km). Seismicity in the Makran is generally low; however the margin experienced an Mw 8.1 earthquake in 1945 which generated a significant regional tsunami. The evidence can be seen in abundance in the region due to tectonic impact (Fig. 6).

Coarsening upwards: A vertical change in a facies in which the grain size increases with height above the base.Under the influence of tectonic coarse sediment in the area have been exposed to a sample of tees at the entrance to the village is visible (Fig. 7). In this sequence of seven layers of sedimentary deposits in the region shows that self-Coarse visible (Coarsening upwards).

5. The possibility of maritime disasters of the coastal zone

The giant tsunami in the Indian Ocean on 26 December 2004 claiming more than 225,000 lives (Geist et al. 2006; Budhu 2011), has emphasized the urgent need to assess tsunami hazards for various vulnerable coastlines around the world, especially for those neighboring the Indian Ocean (Fig. 8).

Although Makran is the source of the second dead-

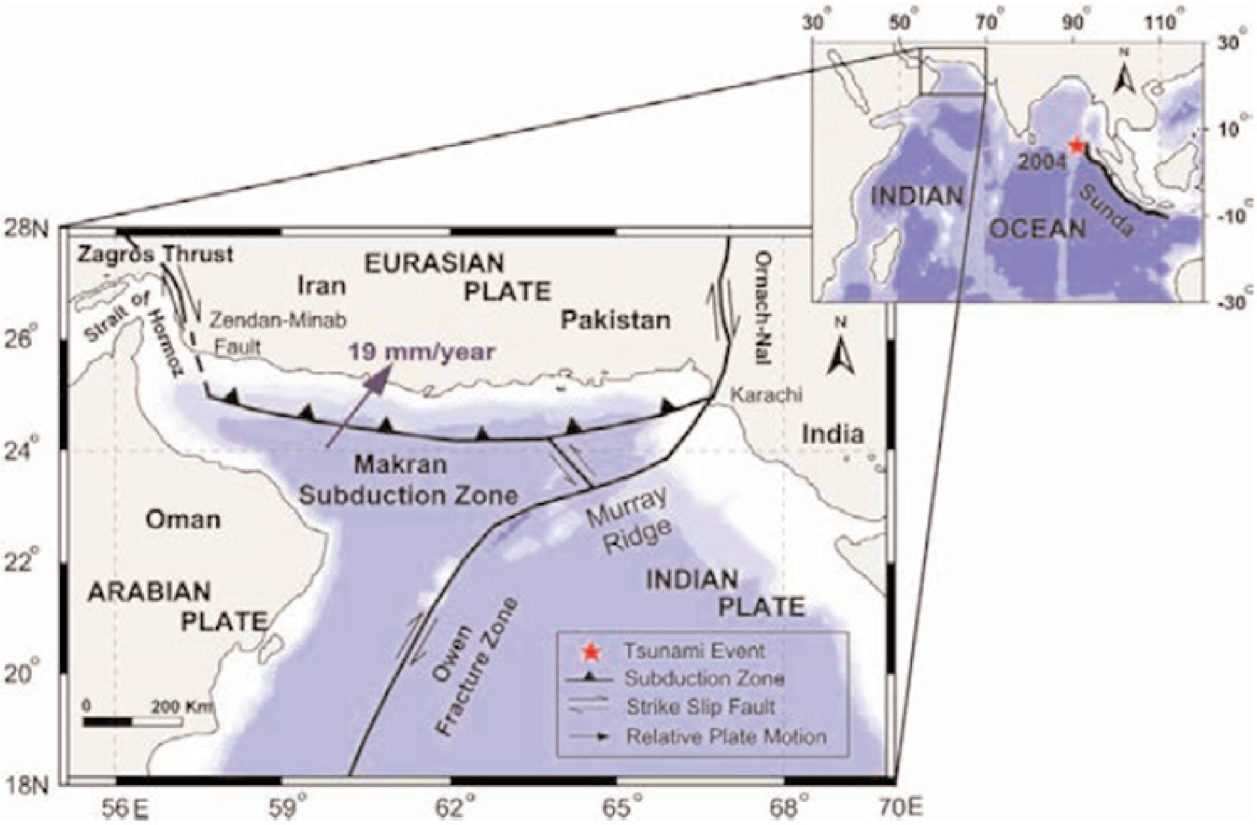

Figure 8. Tectonic map of the MSZ at the northwestern Indian Ocean.

Figure 9. V-shaped inclined areas, Lipar

liest tsunami in the Indian Ocean (The Makran tsunami of 1945 with a death toll of about 4000 people), the tsunami hazard in this region is inadequately understood, and little research work has been devoted to assessing the tsunami generation potential of this region. Most of the shallow large earthquakes in subduction zones produce tsunami (Satake and Tanioka 1999; Schluter et al. 2002; Rieke-Zapp and Nearing 2005). Therefore, it is essential to investigate world's subduction zones for their tsunami potential. At a distance of 1.6 km of coastline region due to factors such as the impact of the waves, flooding and erosion caused by high sediment load (with a height of less than 15 meters above sea level) are at greatest risk of degradation.Based on the tectonic and southern coastal areas of Baluchistan province divided into six groups:

V-shaped inclined areas: In such areas, onshore flow in the rivers of the region are connected to the sea. In these areas, the degradation of the riverbank near the beach and sea Abrmvjhay impact is high. Tis area and Lipar almost V-shaped. In the event of maritime disasters like the tsunami areas along the plains to the north tees Vshnam covered by sea water and Chabahar as harmonic distortion, islanding will be among them. Tis the Chabahar port because it is located inside the eastern edge and the edge of the waves into the tees prevent direct invasion, the less will be the amount of degradation (Fig. 9).

Seasonal active tab: These areas are vulnerable and may be connected with a gentle slope to the sea bed. Therefore rush of water waves acceptance easier and faster done in these areas in the study area are such large areas, including seasonal Strip Lipar (after the Martian mountains in East Chabahar), Hutan Park and Tis (in West Chabahar) noted (Fig. 10).

L**ands with a positive slope (uphill):** This type of morphology, are flat lowlands and in addition to wave attack took root again into the sea takes damaged objects and people that are most at risk. Ramin and braces are of this type. Of course, Beris village due to rocks being positioned on the beach (more than 10 meters height), tsunami with a height of less than 10 meters will have little impact, but in the region Ramin, the tsunami waves have greater impact (Fig. 11).

Lands with a negative slope (downhill): Usually these types of areas cannot be started immediately from the coastline, the wave forces must first uphill and then downhill to reach the gentle slope to the water movement in this area will continue. So that water percolates downward its course until it reaches the proper pit. Large parts of the coastal zone Sea resort, is one of the areas that Rescue & Relief organizationsfor example Emergency, Hospital, Blood Transfusion Organization, fire and more organizationslocated near the coast. (Fig. 12).

Figure 10. Seasonal active Strip, East Chabahar

Figure 11. Lands with a positive slope, Beris

With high and low risk areas: In these areas, the tsunami waves due to very high height over sea effect (Fig. 13). Safe and low-risk areas are almost part of Chabahar Free Zone is located these areas and Rescue & Relief organizations for example Emergency, Hospital, Blood Transfusion Organization, fire etc.One of the requirements of the South in Sistan-Baluchistan province, not one-way streets and highways to avoid hazards in the event of maritime traffic. Easy access to these areas is a necessity in disaster relief.

Hatcheries Port: This man-made structures that are integral to development (ports) in three forms, including single, stretches and finger-shaped, seen in southern Iran. More coastal Hatcheries are the coastal strip of the first type (single) that are less affected by waves. In the future all important structures made in this way so that in addition to reducing the effect of radiation, possibly prevent them from destruction (Fig. 14).

Figure 12. Lands with a negative slope, Beaches of Great Sea.

Figure 13.Chabahar Free Zone such as stable Beaches.

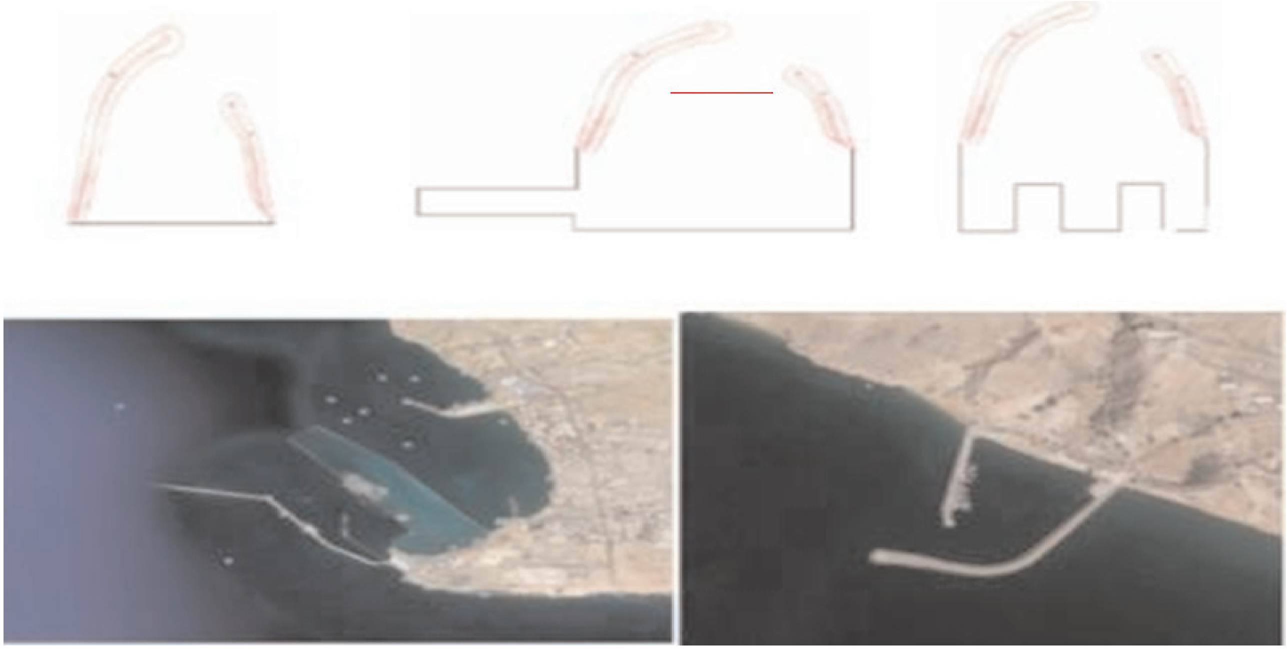

Figure 14. Hatcheries Port, Kalantari jetties.

6. Evaluation of the impact of potential hazards on coastal areas

Due to the structural morphology of the coast of the southern province of Sistan and Baluchestan and evidence obtained using GIS software and application-satellite and aerial photography, in the event of disasters such as tsunamis, earthquakes, mud flows and landslides, invasion routes of each of they are predictable different in coastal areas.The division was mentioned in the previous section, the status of the coastal strip in such a way that there are high barriers that prevent goiter and Pasabandar mainly sea water to the beach.Pasabandar village on the coastal cliff with a height of 20 meters will be built, and the waves are far less impact. Pasabandar and brace the sea off the coast between elevated loads that prevents the waves inland.There is a low height area in the beris enters the waves to shore.Between Liparand Berisbeaches are marine terraces and in some places erosive particles to form a strip of sand dunes, where there is the possibility of waves.Lipar Valley area due to the topography of the area is low-lying and has a large seasonal river connected to the sea, the waves will penetrate further inland. Ramin areas with positive slope (uphill) in addition Waves took root, objects and people affected again takes to the sea. Because in these areas in addition to the construction unprincipled, there is high population density, the most losses and damage will occur. Great Sea resort coastal area (downhill) wave power, you must first uphill and then downhill to reach the gentle, continuous movement of water on this type of land. So that the water flow and its course will be suitable to the ring. Unfortunately, all Nargan relief such as emergency centers, hospitals, blood transfusion, fire and other organizations are located near the coast or in the state and With the increasing wave characteristics, these areas are filled with water and rescue communications outages, and damage will be multiplied. Chabahar free zone is a low-risk area and have all relief centers in the city spreads to these areas. Tees and Konarak height of the waves depends on the location of the epicenter and the tsunami waves is that if the Chabahar East, but high waves in less Tis occurs if the West will be less? Because Tis the port of Chabahar Bay is located on the eastern edge of the edge of the eastern waves into Tees prevents direct invasion, but probably will be more height in Konarak. Since, on the western edge of the Gulf coast of Konarak located west of the edge of the waves into the wave height in tees Konarak prevents it probably will be. At the edge of the Gulf of Chabahar Bay

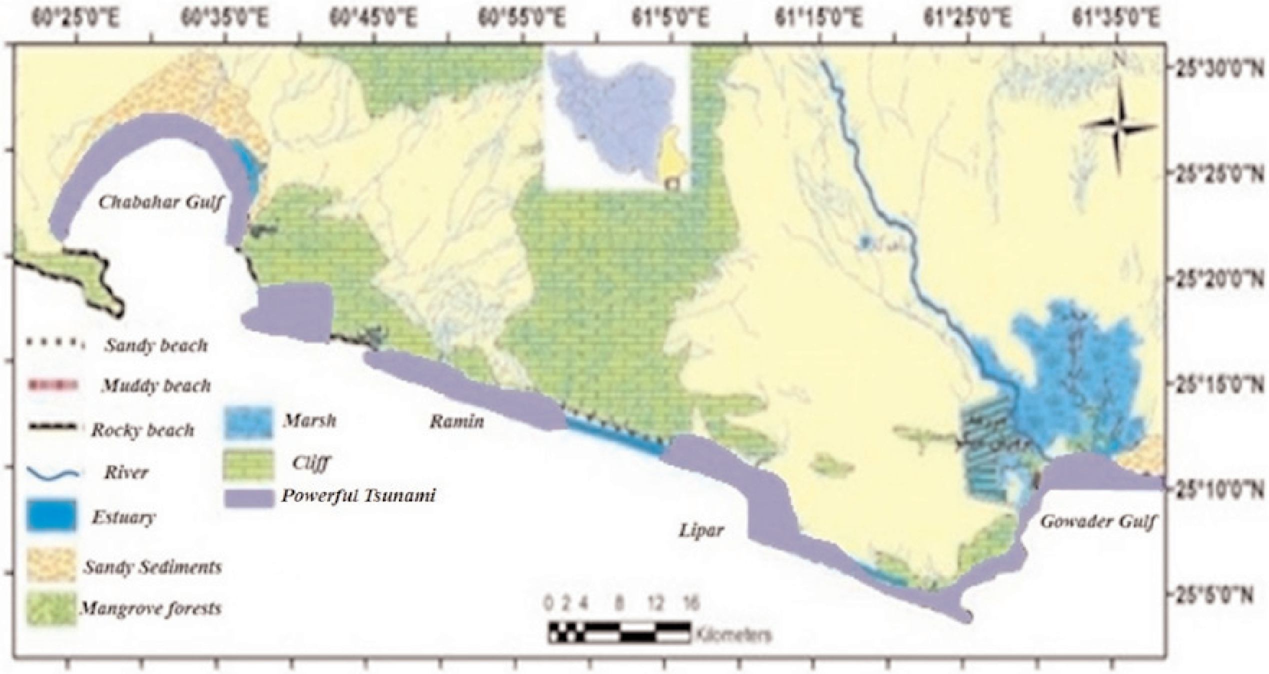

Figure 15. Zone of Tsunami in the coastal areas of Makran

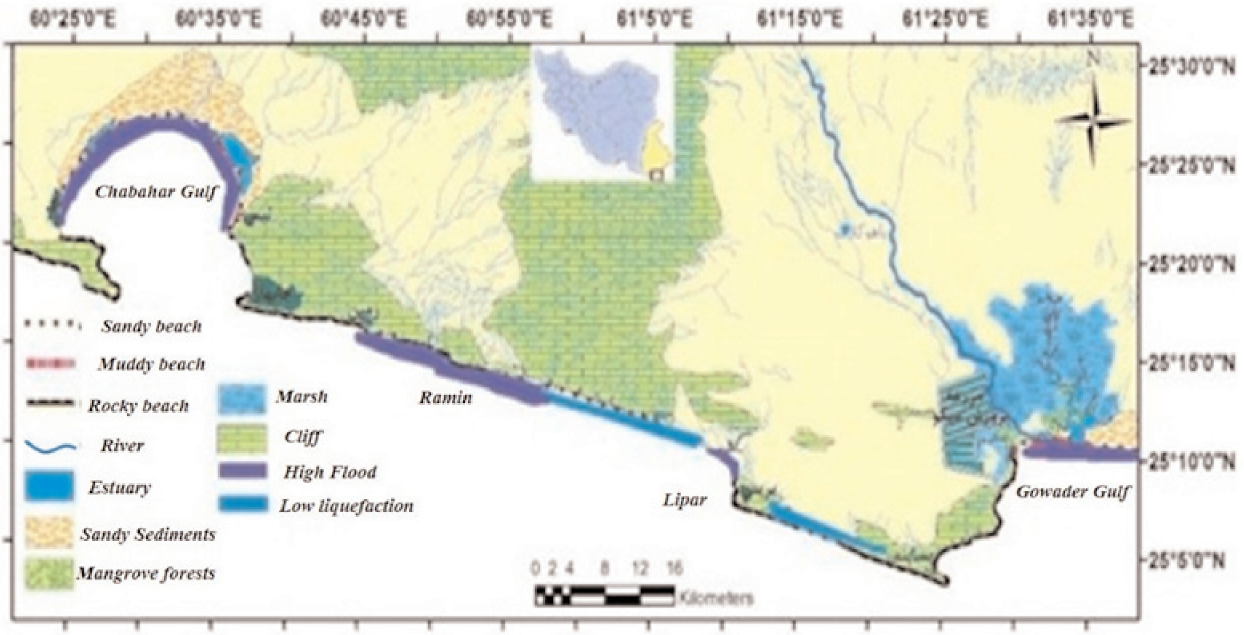

Figure 16. Zone of flood prone areas in the Makran coast

Amgayy such as wave height will be more likely. Because the water inlet bay with its curved edges aligned and waves directly to this part of the deal and more areas are under water (Fig. 15).

In the event of a flood or liquefaction, the status of all risky areasBecause of high precipitation, near the Makran range of mountains to the coastline and parts of Formation sediments, mostly marl and has low permeability,in the short time since the start of precipitation, the occurrence of severe floods and overflow of rivers to follow. The arrival of these high volume flood plains completely inundated area and the estuaries that flow into the sea and in this case the opposite the tsunami. Except that the coastal areas with positive and negative slope, the opposite previous state and the damages will be the same (Fig. 16 and Fig.17).

Makran coast area of engineering geology of rock-proof, low resistance and unstable been established.

The following stones, fast and loose waves caused by impact resistant convened becomes empty and falling rocks and landslides caused slump occurred. Such as previous two phenomena coastal areas of Makran subduction zone south East Iran due to tectonic fractures has type 1 and 2, as well as numerous are sliding and falling (Fig. 18).

In general, coastal areas of the East that there is an earthquake belt, is more volatile in the Highlands area will be doubled risk of instability (Fig. 19).

7. Conclusions

1- Sistan and Baluchistan province in the southern coastal area of engineering geology of rocks resistant, resistant and non-resistant low has been formed.

2- Because of the subduction zone off the coast of Oman in the field of structural and Eustasy were exposed to two groups, the structural factors considered as main factors.

3- In planning and urban development, the use of zoning maps geological hazards in urban areas will be a big step towards sustainable development.

4- Based on the status of geological structure coastal areas of Sistan and Baluchistan province, the intensity the damage and the topography of the coast is divided into 7 regions that including regions of V-shaped, beam active season and with high altitude but low risk areas.

5- According to the terms of seismicity and geological zone of Makran and Sumatra and Geotectonic,

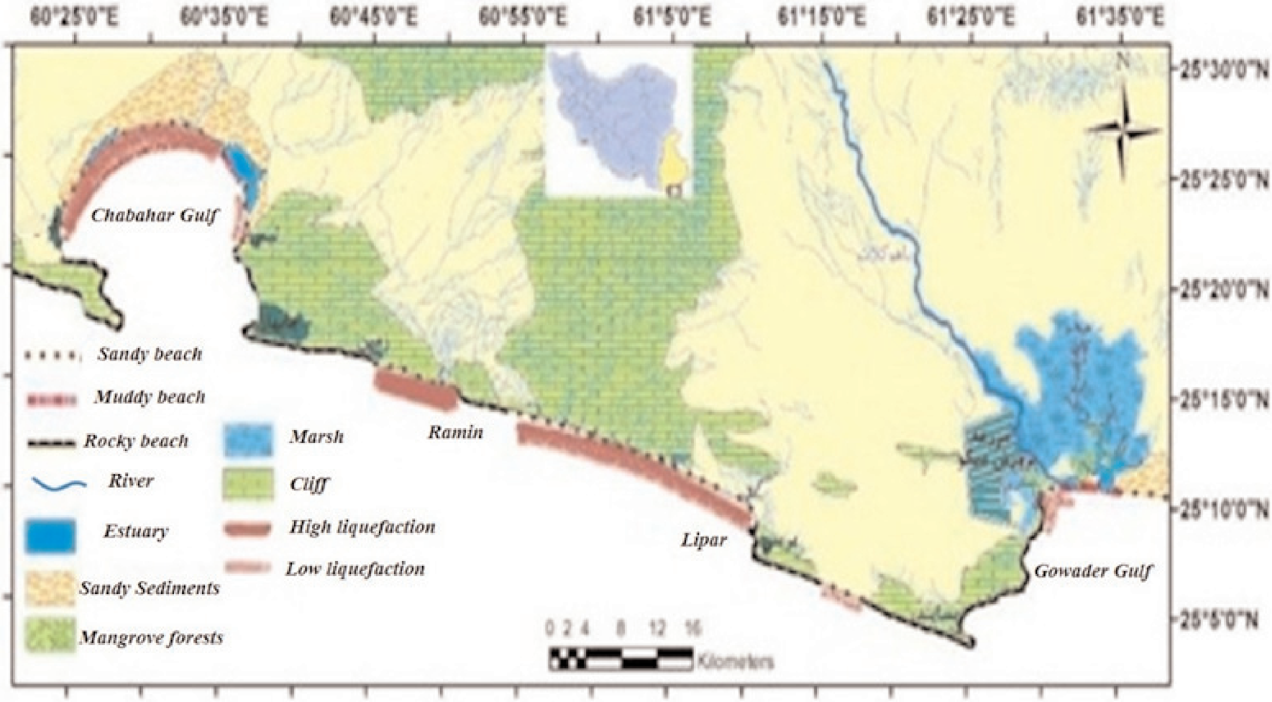

Figure 17. Zone of areas with liquefaction capacity in the Makran coast

Figure 18. Fractures, slump and landslide in Makran coasts

Figure 19. Zoning landslide and slump in Makran coasts

hazards are stronger on the east coast.

6- According to the flooding in coastal areas, the eastern part of the city of Chabahar, Lipar to Beris, Bay Gowader, and part after the Martian mountains are areas prone to flooding but Free Zone areas, Ramin, great sea have less potential.

7- According to liquefaction, coastal areas of Chabahar Bay, Tis, part of between Ramin and Lipar that sandy and soft texture and Martian mountains that are marl and in the spread areas of liquefaction is more probability.

8- In the areas of marine terraces because materials of Conglomerate are more rocky and hard the liquefaction is low.

9- In the city of Chabahar, Ramin, Lipar, Beris, Pasabandar, around the Gulf Pozm and then west (near the Estuaries) due to the active sand dunes is the highest of liquefaction. Chabahar Free Zone due to high altitude and difficult it is low probability of liquefaction.

10- Slip and slump on the study area depends on the tectonic, Eustasy and erosion of region. Landslides are more in coastal areas includes Konarak, Pozm, Chabahar city, the beaches between the Beris and Pasabandar and Lipar also due to slope instability and erosion by waves and faults.

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