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Coastal Geomorphology of the Persian Gulf in Kangan Harbor Using High Resolution Images

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Abstract

With a revolution in different sciences, especially during the last decades of 20th century, the range of quantitative coastal geomorphologic studies has exceeded the descriptive and theoretical debates. These studies have a critical contribution in designing structures and establishments related to sea, handling and protecting the coasts, managing and engineering and planning of coastlines. Kangan harbor is one of the littoral towns in Boushehr province located in southern Iran near the Persian Gulf. This harbor is an economic fishing quay throughout the country of Iran where several varieties of edible and commercial fish are caught. Therefore, a survey on the geomorphology of the coasts of this region and its transformations in the course of time has a significant importance in the future development of this region. In this study, in order to investigate coastal geomorphology of Kangan harbor, IRS LISS IV satellite images with a resolution of 5.8 m in Envi4.8 software were used and the accuracy of these data were reviewed with field studies. Units of geomorphology of coastal sand dunes, estuaries, high and low tidal flats, sabkha and Mangrove forests were identified in this harbor.

Keywords: Coastal geomorphology; Satellite image; Kangan harbor; Persian Gulf

Introduction

The science of geomorphology has a critical importance in the field of studying coastline transformations, sedimentation, coastal erosion and destruction, alterations, floods, protecting lagoons and estuaries and managing coastal region. Therefore, recognizing geomorphologic phenomena is a great help for the management of coastal areas. Coastal area refers to a wide area of land and sea where different phenomena with marine and land origins interact. This region is changing due to the actions of geological phenomena, ecological and hydrodynamic processes on the one hand and human constructions on the other hand. The use of RS and GIS data in differentiating sedimentary environments and morphological evidence of coastal areas is growing during recent years [1].

Coastal zone monitoring is an important task in environmental protection, while coastline detection is fundamental for coastal management [2].

Attributes were identified according to the field experiments and visual observations of important geomorphologic phenomena. Also, Khodabakhsh et al. [1] classified coastal sedimentary areas in Khouzestan province by combining digital and visual methods. Using aerial photos, satellite images and GIS, studied the displacement of mud flats formed following a period of erosion and sedimentation along the coastlines of Iran. They found out that mud flats displacements occurred with erosion and sedimentation and temporal-spatial differences in its pattern. The impact of mud flats in morphological stability and coastal behavior were identified with statistical analysis. The position of coastlines in Chabahar gulf was investigated by satellite data for 13 years, using GIS and field surveys. 21 old coastlines were determined in Chabahar [3].

Ahlin and Niemeyer [4] studied the coastal monitoring of Gaza using remote sensing and a Geographic Information System (GIS), detailing the processes of sedimentation and erosion around the region. A coastline is defined as the line that forms the boundary between the land and the sea; the detection of a coastline in high resolution includes recognizing several discontinuities [5]. The main purpose of this study is delimitation of geomorphologic units in coastal harbor in order to give information about coastal management infrastructure to local governors in Kangan harbor.

Materials and Methods

In this study, IRS LISS IV satellite images with spatial resolution of 5.8 m were used. Firstly, the bands of this image were georeferenced in Envi4.8 software using 1:25000 topographical maps and geometrical modifications were performed on this image. In this classification, the area of the study was classified into 13 units in the form of supervised. The classified units were then reviewed using field surveys and the necessary corrections were done. These data were then transferred to ARC/GIS software on which polygonised process was performed and the area of these units was determined. The data were reclassified by Shepherd's 1973 classification method and the existent configurations along coastal area were divided into primary coasts (resulting from land erosion) and secondary coasts (resulting from marine phenomena).

Study Area

Kangan is a town located in the southeastern part of Bushehr province in the Persian Gulf, 200 km from the capital of this province (Bushehr) and its altitude from sea level is 20 m (Figure 1).

The weather of this region is arid, sub-tropical climate (boundary

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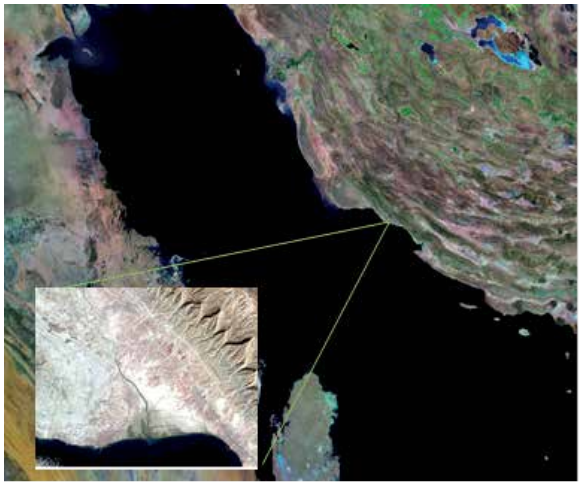

Figure 1: Study area of Kangan and Dayyer harbor.

of the tropical and mid-latitude weather systems) due to southern deserts, which surrounded it. The seasonal shifting of the tropical and mid-latitude systems leads to seasonal changes in the meteorological conditions [6]. During summers, seasonal winds called the wind of 120 days, torrid and dry. The average annual rainfall is 215 mm during December to March. There is only one river near Kangan forming a delta as well as a narrow gulf called Bouhmir across its estuary. The most significant weather phenomenon in the Persian Gulf is northwesterly Shomal wind, which occurs during the year [7]. Winds in the Gulf of Oman are influenced by the Indian Ocean monsoon system, reversed seasonally between northwest southeast in winter and summer, respectively [6].

Results and Discussion

Kangan coastlines geomorphology: Effective processes in the morphogenesis of the coastline

Movement of marine surface water is an important factor in generation of coastal features such as reliefs, flats, barriers and coastal erosive platforms, and contributes in expansion of different types of developing submarine configurations and formation of sedimentation and erosion surfaces. The relative changes of coastline along the south of the Persian Gulf was also studied.

Marine flows in the Persian Gulf are counterclockwise [8]. The clarifications of satellite images with a movement direction in ETM+satellite image with a band of 421 show the clockwise west-east direction of aquatic flows in Kangan harbor (Figure 2). So, these flows in the west-east direction across Bouhmir river estuary cause a diversion in its inlet at the point of joining the sea and its continuation is clearly visible under water and below the coastline.

The extension of this flow joining Kangan coastlines with a north-south direction deviates toward the south and turns to north-south direction. Suspensions and sedimentations at the bottom of the river also move in the direction of these flows. Another factor for morphogenesis over the south plateaus is wind process. The hot weather of the surrounding lands such as Saudi Arabia and Gang valley is attracted to this area and leads to strong winds during the summer regarding the tropical high-pressure climate over this area and the torrid low-pressure system on the earth's surface. So, the quick air circulation often results in dusty air [9].

Although sandy hills in Chabahar area usually have marine origin, the wind transfer in this region provides sea and land breeze and strong winds with simultaneous seasonal winds which result in the movement of sandy hills and erosion of the coastal areas.

Forms of the coastline

Tidal environments: Within the coastline skirts especially the area between Dayyer harbor to Kangan harbor, tide has a strong effect and has caused the formation of sedimentary at the junction of Delvar river to the sea due to low steep and geomorphologic environments. These regions are 1235 km^2 and cover 68% of the whole area. Tidal environments are divided into four regions which from land to sea include salt marshes, high tidal flats, low tidal flats and tidal channels.

Salt marsh: Salt marshes are in high tidal flats and exist only during stormy events when the sea level rises and covers this area. This is the last part of the tidal environment toward the land. The sediments of this area mostly include silt and clay. In salt marshes, it is possible that small sedimentary channels in the form of branches be formed. This area is covered in grassy vegetation and sometimes marine animals can be seen there [10] (Figure 3).

High tidal flats: The sediments in these areas are mostly grits and clay and main features are small separated channels. Grassy vegetation is small in this area and is locally observed but marine animals are remarkably increasing [10] (Figures 4 and 5).

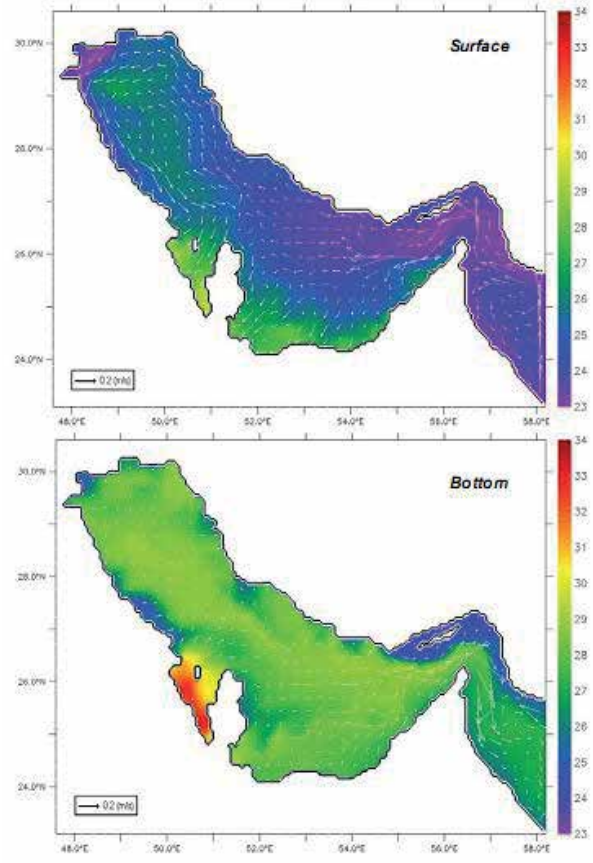

Figure 2: Surface and bottom current flows in the Persian Gulf.

Low tidal flat or intertidal zone: The sediments in this area mostly include grits, these sedimentary channels are in meandrous forms and are called tidal meanders. These meanders may change their direction laterally towards the direction of water movement. The residues of marine animals are observed at the bottom of these meanders in the form of residual sediments at the bottom of channels. Beyond the tidal channels of the area under study, the flats are directly affected by tides which have most of their fluctuations around Delvar River (Figure 6).

Tidal channels: These channels are the extension of tidal meanders toward the sea which are filled with water even when the tide is diminished. The remnants of marine animal shells in the sediments of this region are found in large amounts. Mixed diagonal stratification, which is caused by tide, is remarkably observed in these sediments [10]. These channels are found on the estuaries of most rivers joining the sea. On the estuary of Delvar River, Bouhmir estuary, Harras have the most distribution. Along Delvar River, the tide is up to 10 km to land (Figure 7).

Barriers: Barrier coasts were formed about 13% of the current coasts of the world. Barrier coasts have been formed in study areas with slight slope and low accumulation degree and environments with abundant discontinuous (separated) sediments [11]. It seems that those surface waves coming from long distances facilitate the formation of these barrier islands with slight slopes, but these kinds of barriers are generally formed by stormy waves. It also appears that small tidal waves help in the formation of these barriers, but they cannot be the basis for their formation. Barrier coasts are destructed by wave attacks and after shaping, destruction materials recede towards the land. These sediments are the materials formed and accumulated as underwater fan-like cones across the swamps of the posterior parts of barriers. Barrier islands are formed because of accumulation of grits with the same size with crossing stratification and the grits blown by winds cover them. These sediments towards the sea have a size between silt and grit and then turn to coastal mud among current ripples. In these

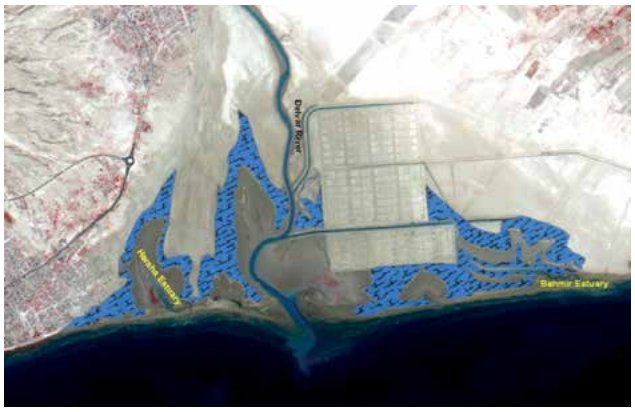

Figure 3: Sabkha area.

Figure 4: High tidal flats in Delvar.

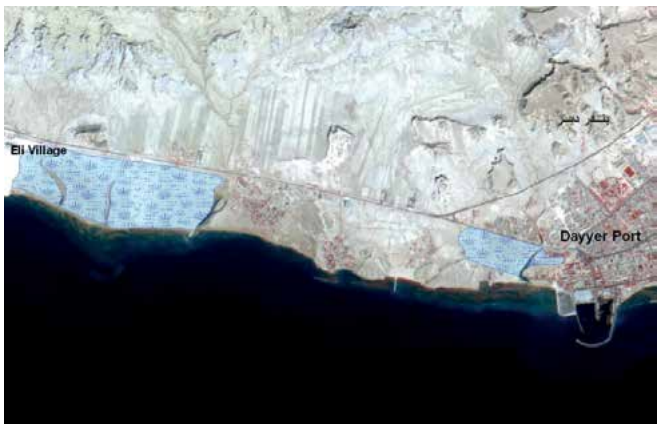

Figure 5: High tidal flats in Dayyer.

Figure 6: Low tidal flat.

Figure 7: Tidal channels.

barriers towards the land and consecutively may see swamp, tidal silt and clay structures and organic materials and probably flood plain sediments [11]. Across some regions of the coastline, we can observe coastal barriers, the western coastline of Dayyer harbor, and southern Eli village and between northern Eli village and Kheira hill. The coastal barriers between Dayyer harbor and southern Eli village are in the form of Mangrove stability (Mangrove settlement) and construction of fishing harbor and a decrease in carrying strength of sediments are formed in long shore current direction of these barriers. The direction of waves contact with the coasts also contributes in the formation of sandy barriers. In the area between northern Eli village and Kheira hill, the formation of these barriers may be observed and their extension is in the direction of marine currents. If this phenomenon continues in the future, we will see the formation of sandy (grit) hills and lines (Figures 8 and 9).

Rubble stone and sandy (grit) coasts: Along the coastline of the study area, we can observe sandy hills from Kangan harbor to Bouhmir estuary which locally placed behind the rubble stone and sandy coasts (Figures 10-13).

Geomorphologic research on grit grains across different sandy hills show that the constituent grits of these hills are locally the result of the destruction of present attributes in surrounding areas and the tides which are distributed during strong wind and aquatic phenomena as well as travelling through the coastal plain to the coastline. It means that after destruction of attributes, the resulting materials are carried

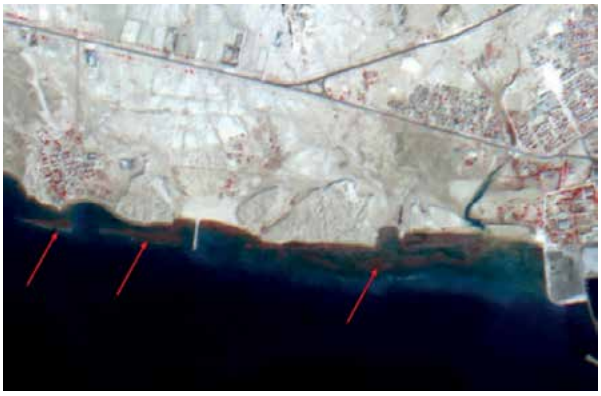

Figure 8: Construction of Barrier on west coast of Dayyer Port.

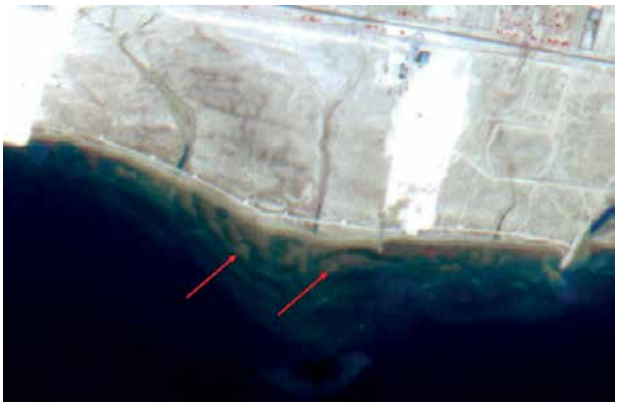

Figure 9: Barrier between northern Eli village and Kheira.

Figure 10: Deposition of sand in Dayyer Port.

Figure 11: Sand dunes and shingle beach of Kangan.

Figure 12: The coastline of the rubble stone area.

Figure 13: Shingle Beach on Kangan Coast.

by rivers along the surface of plains (plateaus) and after settling, they are transferred by winds and contribute in the formation of sandy hills.

From Dayyer harbor toward the west, the coasts transform to rubble stone coasts which their presence is the result of erosion from surrounding highlands and their components include Bakhtiari conglomerates (Figure 14), also indicates the algal beds on the sediments of Bakhtiari conglomerates along Kangan shores.

Mangrove forest: Mangroves are salty which are exposed to the tide in estuary beds and distributed in mud flat areas across heavy silt earth. These plants float in water when the tide is in and when the tide is out, they are apparent as beautiful islands. Habitats in Mangrove jungles are among the most attractive life landscapes in variety and sort of this habitat environment. Due to producing high amounts of carbon and its attraction, shallow water, sunshine, and low detrimental effects, calmness of the sea, abundance of nutrients, suitable oxygen supply and the presence of aquatic creatures profiting from different respiratory stems and roots of these plants during overflows, these habitats have become a suitable place for living of some creatures [12]. Because of very little dispersion in the surrounding region, these regions are unclear on ETM+and TM images but with combining the measure infrared band IRS LISS IV and its high spatial resolution, Mangrove area was determined. Areas with the most dispersion are: Harras estuary in the west of Delvar River and the western coastline of Dayyer harbor especially in southern Eli village where Harra jungles are formed as littoral barriers. Areas with the most dispersion are: Harras estuary in the west of Delvar River and the western coastline of Dayyer harbor (Figure 15) especially in southern Eli village where Harra jungles are formed as littoral barriers. Table 1 illustrates the area and area percent of existing forms of primary coasts and (Figure 16) shows the coastal geomorphologic units of study area.

Figure 14: Algal matter on shingle coast of Kangan coast.

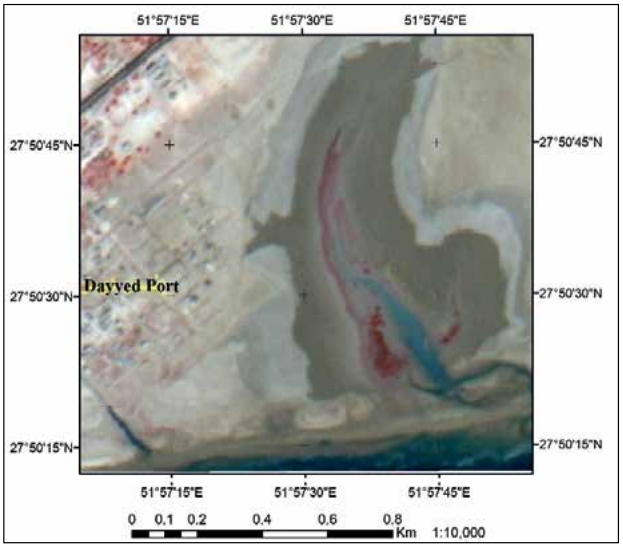

Figure 15: Dispersal of Harras forests in Dayyer harbor.

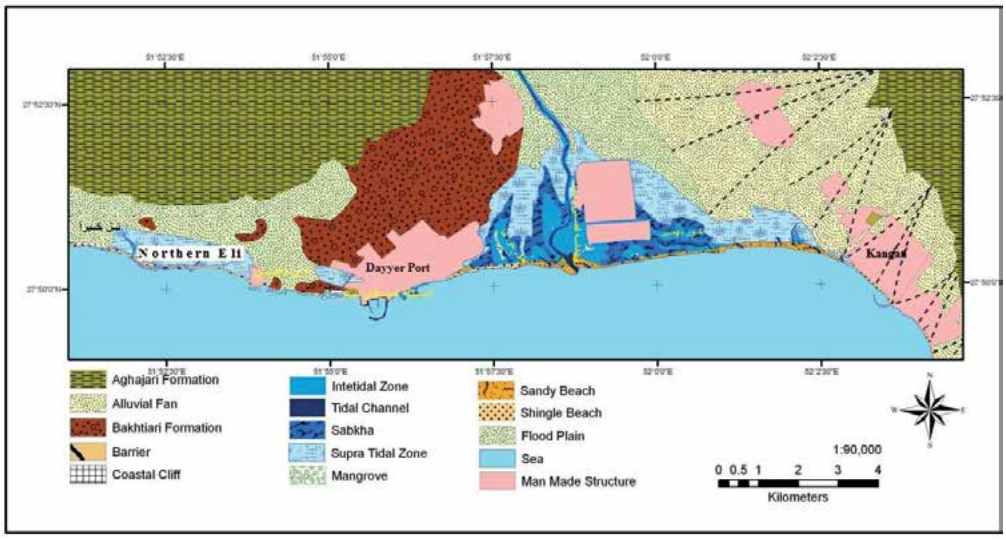

Figure 16: Coastal Geomorphology units' map of study area.

Primary coasts resulting from land phenomena	Space km²	Coverage percent
Alluvium fan	25.38	13.93
Alluvium plain	18.06	9.9
Total	43.44	23.83
Secondary coasts resulting from marine phenomena	**Space km²**	**Coverage percent**
Mud and tidal flats	12.35	6.78
Sandy tongues and mounds	0.2	0.15
Sabkha/Sandy and rubble stone coasts	2.5	1.37
Mangrove	0.3	0.17
Total	16.77	9.2
Other areas	**Space km²**	**Coverage percent**
Heights and highlands	54.51	29.91
Cities and harbors	14.93	8.19
Total	69.44	38.1

Table 1: Area and area percent of existing forms in littoral flats.

Conclusion

Marine currents and their direction have a great role in the formation of the coastlines, transformation and morphogenesis of the study area in Persian Gulf. About the clarifications on satellite images in aquatic boundaries of Kangan and Dayyer in the far shore, indications of formation of island barriers were observed. With development and evolution of these barriers, we will observe the formation of sandy (grit) longitudinal lines (ranges) in this region in the future and its effect can be attributed to new morphogenesis of coastlines and changes in the degree of the effectiveness of influential processes on the coastline from the sea direction and has negative effects on shipping affairs. Investigation and analysis of the formation trend of this attribute and characterization of its real nature, the manner of formation and its future development and its effect on erosion trend of the region coasts can guide us in accessing the patterns of changes in the coastlines and seabed in Dayyer harbor. Since Dayyer coast is affected by the tide, marine currents and littoral storms, it has been facing some problems such as destruction of some parts of littoral and urban constructions. One of these problems is the progression of water over sandy (grit) coasts during the events of hurricanes. Investigation of this problem in littoral regions should be conducted with studies about the returning periods of the hurricanes. The limits of water seepage also should be examined. Sedimentation processes because of marine currents, waves and hurricanes have caused very large sedimentation near the littoral establishments of Dayyer harbor. If this process continues, it will lead to the early filling of the quay basins and many damages to these establishments.

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