

# Shoreline management Plan for Yanbu coast, Western coast of Saudi Arabia

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**Abstract**— *A comprehensive study was carried out on the Yanbu coast to evaluate the potential for erosion and accretion patterns. From 2004 to 2019, the Google Earth engine was used to collect satellite-imaging data, considering changes in the coastal zone caused by natural or human-induced events. At five-year intervals, the image was analyzed with Q-GIS, and the delimited shoreline shapefile was compared to a recent image to show the Yanbu coast's erosion and accretion behavior during the previous two decades. Shoreline changes were computed and assessed, followed by the implementation of a recommended shoreline management plan for the entire coast.*

**Keywords:** *Shoreline management plan, Yanbu, Erosion, Accretion*

## 1. INTRODUCTION

Exposure to studies on various concepts and definitions of coastal areas on a global or local level, with their various names and forms, aids in project management of coastal development. Such exposure also assists in evaluating methods of conscious coastal area development done globally and locally as the conceptualization of the coastal zone for each experiment directly affects the methods implemented.

Coastal erosion is caused by natural causes such as wind and waves, and it has become a major coastal zone problem in the Yanbu coast, the western coast of Saudi Arabia. Yanbu is a major port city on the eastern Red Sea littoral, and is one of the Kingdom's largest and oldest marine ports (Figure 1). The region's population is rapidly increasing, resulting in fast urbanization and high-value land. In 2016, the city's population was estimated to be approximately 76,000 people. Meanwhile, the Yanbu shoreline has been eroding and accumulating for decades. The dynamic

behavior of the shoreline along the coastline is visible in satellite images. The dynamic nature of the coast, which is known for industrial and port operations, necessitates a thorough shoreline management plan for the future. As a result, a study was conducted to identify possible erosion and accretion sites along the Yanbu coast, as well as to develop a coastal zone management plan based on the coast's erosion/accretion characteristics.

A coastal zone management plan can be used to address this problem by analyzing the erosion/accretion problem and formulating a management plan. The temporal changes of the shoreline from 2003 to 2020 show that the dynamics of this coastline are mainly controlled by human activities, which have led to the accretion of land towards the sea. The present study focuses on identifying potential erosion and accretion zones in the Yanbu coast using satellite images and making a coastal zone management plan based on the erosion/accretion characteristics of the coast. Because the Yanbu coastline is critical for its industrial and port activities, the dynamic nature of the coast requires a detailed shoreline management plan for the future.

## **2. MATERIALS AND METHODS**

### **2.1. STUDY AREA**

Yanbu is an important port city located on the eastern Red Sea littoral at about 160 km west of Al Madinah and 300 km northwest of Jeddah (Figure 1). This region, largely a level plain, is nearly 80 km long and incorporates both Yanbu Al-Balad or Al-Bahr (Old Yanbu) and Yanbu Al-Sinaiyah (Industrial Yanbu – Figure 1).



Fig. 1 Study Area

The consequence of this is that the region has a sharply rising population, resulting in rapid urbanization and land of high monetary value. The residential population of the city in 2016 was approximately 76,000 (RCJY, 2016). A growing destination for tourists, the city is mainly known for its industrial activities. The industrial city was established in the south of the old city of Yanbu in 1975. Recently, the city attracted several development and urban expansion projects. This young city has become a centre for modern industries and plays a major role in the Kingdom's gross national income. Yanbu Industrial City represents the last station for the raw oil and liquid natural gas pipelines (Niang et. al, 2020).

## 2.2 DATA COLLECTION AND ANALYSIS

From 2004 to 2019, satellite-imaging data was obtained using Google Earth, examining changes in the coastal zone caused by natural or human-caused factors. The analysis of this area is based on the aforementioned 5-year period of satellite photos, as well as the erosion and accretion components, as shown in the following figure.



Fig. 2. Accretion pattern of Yanbu coast

QGIS software was used to dereference and delineate the shoreline at regular intervals and identify the potential erosion and accretion zone in this region. Radical changes have occurred in the Yanbu coast and these changes can be observed by comparing the images captured through Google Earth.

### 3. RESULTS & DISCUSSION

The images were analyzed using Q-GIS at five-year intervals, and the delineated shoreline shapefile was compared to a recent image to determine the Yanbu coast's erosion and accretion nature during the last two decades. The Yanbu coast's potential and erosion zones are depicted in this coastline analysis (Fig. 3) (Nofal and Abboud, 2019). The map depicts changes in the shoreline from 2014 to 2019. The map depicts changes in the shoreline from 2014 to 2019. Because the coast is longer, several section analyses were required to completely comprehend the shoreline change. The shoreline change map has been divided into three sections as below.

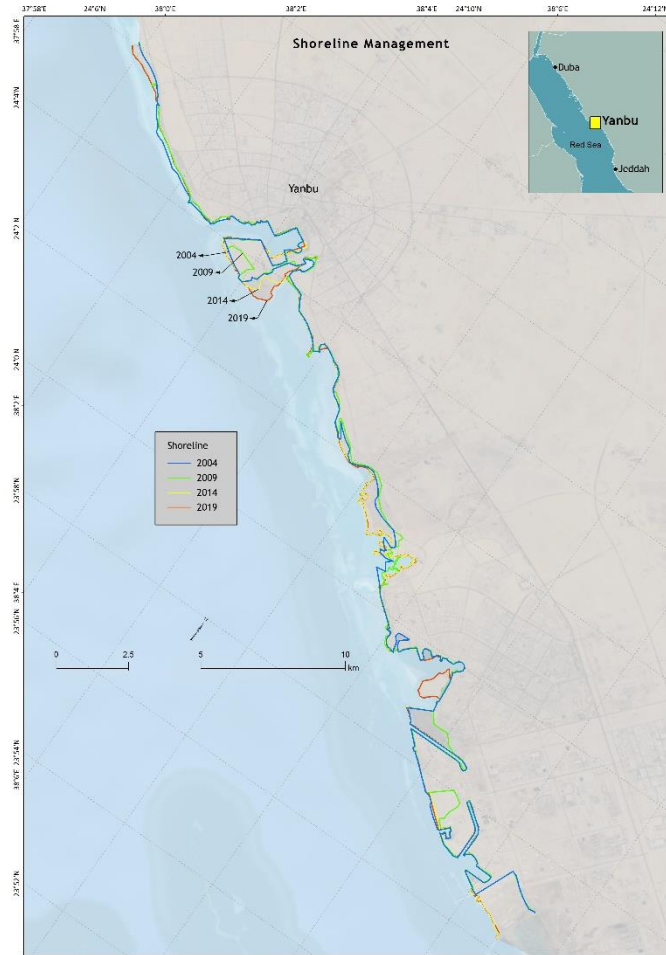


Fig.3. Shoreline change (2014-2019) map of Yanbu coast

### 3.1 NORTH SECTION

From 2004 to 2019, the northern portion of the Yanbu shoreline experienced rapid accretion (Fig. 4). Environmental activities have caused natural accretion. An extensive environmental study was necessary to determine the sediment transport directions. The sediment dynamics are more prominent in this area since there is a Sharm (creek) on the north



side of the location.

Fig. 4. Yanbu coast northern region, erosion and accretion pattern

### 3.2 YANBU COMMERCIAL PORT REGION

From 2004 through 2019, this region showed clear erosion/accretion trends. The pattern depicts man-made accretions on the commercial port's southern side (Fig.4). The shoreline on the southern side of the Yanbu commercial port accreted substantially after 2014, and the pattern of accretion indicates artificial activities such as land filling as part of the port expansion (Spalding et al., 2014, Hariri, 2012).

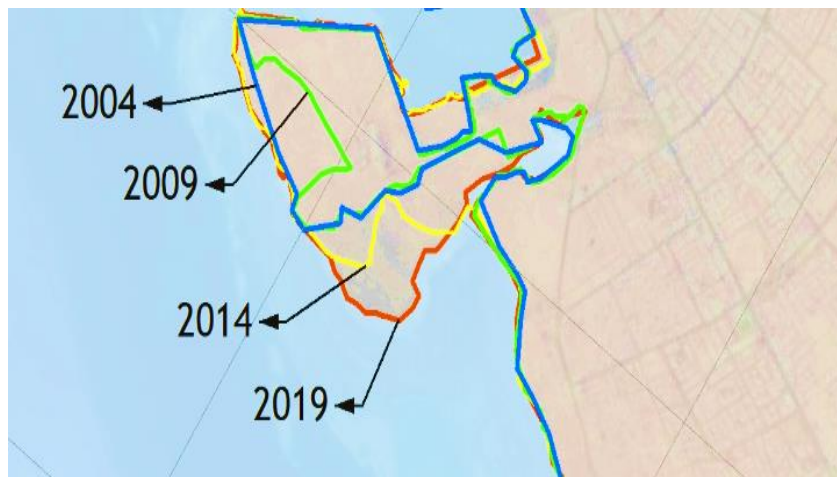


Fig. 5. Yanbu commercial Port region erosion and accretion pattern

### 3.3 YANBU COMMERCIAL PORT SOUTHERN REGION

Due to natural and intense human activity, the southern coastline zone of the Yanbu commercial port has a high rate of erosion and accretion (Fig. 4). The northern half of the image shows substantial accretion between 2014 and 2019. However, because of human activity, the geomorphology in the southern section of the region has changed significantly. There was no inland waterbody in this region in 2014 and there was none until 2019, when human activities such as

dredging resulted in the construction of an inland waterbody. As a result, the erosion and accretion pattern in this region is a combination of natural and manmade activity.



Fig. 6. Yanbu coast region erosion and accretion pattern

### 3.4 SHORELINE MANAGEMENT PLAN FOR YANBU COAST (SMP)

The assets and infrastructure that provide a wide range of social and economic advantages to the region are the focus of the short-term risk management strategy for this area. The suggested strategy can be executed once modifications are made based on a thorough analysis of an environmental impact assessment (EIA). The proposed concept was realized by constructing defensive structures along the natural erosion/accretion sector. In areas where anthropogenic activities predominate, certain changes to beach filling and dune management are necessary. The below table shows the proposed shoreline management plan.

Table. 1. Shoreline management plan for Yanbu coast

Sl. No.	Location	Policy and Approach
1.	North section:	<ul style="list-style-type: none"> <li>• This region's sand dunes must be managed.</li> <li>• Coastal defense is not advised in this area.</li> <li>• Sand mining at a medium level is recommended.</li> <li>• Because a coral barrier protects the shore, no SMP is</li> </ul>

		necessary.
2.	Yanbu commercial Port region:	<ul style="list-style-type: none"> <li>• Develop a long-term beach management strategy to deal with the anthropogenic activities</li> <li>• Manage beach filling in the southern side of the Yanbu port</li> <li>• Detailed study of Environmental Impact Assessment (EIA) required for beach filling</li> </ul>
3.	Yanbu commercial Port southern region (I)	<ul style="list-style-type: none"> <li>• An increase in the rate of accretion is proposed by adding more coastal defense systems.</li> <li>• To address the long-term trend in beach accretion, develop a long-term shore management strategy.</li> <li>• Increase the effectiveness of existing fortifications and undertake shoreline management</li> </ul>
4.	Yanbu commercial Port southern region (II)	<ul style="list-style-type: none"> <li>• Keep sand filling processes to a minimum.</li> <li>• Beach filling requires a comprehensive Environmental Impact Assessment (EIA).</li> <li>• Develop a long-term shoreline management strategy to address the long-term trend of beach filling caused by anthropogenic activities.</li> </ul>

#### 4. CONCLUSION

This research examines the shoreline change along the Saudi Arabian coast at Yanbu, utilizing images at various years (2014 to 2019) to analyze temporal changes using GIS methods. Shoreline changes were analyzed along with a proposed shoreline management plan to be executed for the entire coast. The study also highlights the complexities of the Yanbu coast's shoreline dynamics, which are complicated by uneven seasonal changes and anthropogenic activity, both of which significantly modify the shoreline. The study was undertaken with restricted resources and time constraints, and the objectives were defined and fully analyzed. The research has a broad scope, allowing it to examine all environmental factors that impact shoreline and coastal zone changes. This study will allow the development of a comprehensive shoreline management plan as well as a coastal zone management plan for this area.

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