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Adel Jassim AL-Fartusi; Mutasim Ibrahim Malik; Hameed Majeed Abduljabbar

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Spatial-temporal of Iraqi Coastline Changes Utilizing Remote Sensing

Adel Jassim AL-Fartusi [1,a)], Mutasim Ibrahim Malik [2,b)], Hameed Majeed Abduljabbar [3,c)]

[1] *Physics Department, Marine Science Center, Basrah University, Basrah, Iraq*
[2] *Physics Department, Science College, Wasit University, Wasit, Iraq*
[3] *Department of Physics, College of Education for pure science Ibn Alhaitham, University of Baghdad, Baghdad, Iraq*

[a)] Corresponding author: adel.mohammed@uobasrah.edu.iq
[b)] mutasim@uowasit.edu.iq
[c)] hameed.m.aj@ihcoedu.uobaghdad.edu.iq

Abstract. Assessment of human-ecosystem interactions in coastal environments is carried out by monitoring the change in the coastal line. In this study, we give an analysis of shoreline alterations along the Iraqi coast over the last five decades, during the period from (1973 to 2021), data series of Landsat (MSS, TM, ETM+, and OLI) were used and incorporated into GIS (Geographical Information System) for executing a temporal-spatial analysis for alterations in the coastline by applying (DSAS 5.1) Digital Shoreline Analysis System approach. Linear regression rate and endpoint rate quantified the high accretion at rates of more than 50 m /year also the net shoreline movement analysis identified about 2500 m toward the sea. The findings of this paper demonstrate an understanding of shoreline evolution and the ability to forecast future variations to support decision-makers in developing long-term management to safeguard our marine environment.

Keywords: Coastline change, DSAS, Remote sensing, Landsat.

PREFACE

The riverine load is made up of Total Dissolve Solid (TDS), Total Suspended Solid (TSS), and Bed Load as the concentration of each is measured by (mg l^{-1}). The classification was deduced through a study conducted on the Flinders River in Australia, where the last two loads are called sediments transport [1]. The sediments transporting are part of the flowing water mass and one of the basic determinants of water quality. Therefore, they gain special importance in physical and hydrological studies, as well as in geomorphology studies, because of their relationship to the formation of many aspects of the earth's surface, it is considered one of the necessities because of their wide impact on the economic and environmental aspects. TSS in surface water has a strong link to the environment and climate change. The sunlight passing through the water column is absorbed or scattered by organic and inorganic particles, which leads to turbidity and discoloration of the water [2]. Pollutants can also cling to suspended particles and disseminate outmost with them [3]. Suspended solids (TSS) were considered a traditional water quality criterion used by government-led environmental agencies like the US Environmental Protection Agency (EPA) [4]. Sediments from river discharge, coastline corrosion, and bed load are transported by currents or resting down the water column at land-ocean interface zones. This leads to erosion in one place and sedimentation in another.

INTRODUCTION

The transition zone between land and water is known as the coastal area, and it is an extremely valuable natural and economic resource [5], even though it is continuously unsteady. Furthermore, this microworld is a very complex ecosystem in which erosion and accretion phenomena are influenced by a variety of physical, climatic, biological, and anthropogenic factors [6], causing the coastline to recede or advance. Both a raise in sediment equipping and a reduction in wave energy indicate long-term natural coastline advancement. A natural fallback of the coastal site, on the other hand, denotes a reduction in sediment equipping and a raise in wave energy [7]. Observation of the coastal area is vital for a variety of reasons, including prospective development, cartography, safe navigation, resource management, and environmental protection [8]. Global forecasts of climate change consequences show that rising sea levels will exacerbate erosion processes along low-lying coasts [9]. Given the serious threat that coastal erosion and accretion pose to the marine environment, as well as the pressing need to restrain this risk in the face of global climate change, understanding the spatial and temporal evolution of Iraq's shoreline is critical. At regional and global scales. Remotely sensed data is critical for identifying, observing, and delineating shoreline change [10]. Thanks to the availability of pictures that are multi-band, multi-temporal, and multi-sensor, scientists have been able to acquire data on spatial and temporal variation caused to natural and human activities, as well as developments in digital treatment and analysis. Landsat satellite data from 1973, 1990, 2006, and 2021 were used in this study to look at how the shoreline has changed in the coastal zone over the last 50 years, where the period between one satellite image and another was divided into approximately seventeen years .The study's goals are to (a) look at how the shoreline has changed along the coast over the last 50 years, and (b) illustrate what caused these alterations.

DESCRIBE THE RESEARCH ZONE

Where land meets the Arabian Gulf's marine waters in faraway south Iraq the investigated region is located, which can be described by:

The Geographical Location

Geographically, the research region (the Iraqi coast) for a distance of 64 km is located in the Arabian/Persian Gulf's northwest portion [11]. It is located between latitudes 30 00'25"–29 59'26" north and longitudes 48 51'38"–48 42'38" east. As seen on the map, the region is bordered on the west by Khor Al-Zubair and east by two estuaries, Shatt Al-Arab and Bahmshir, (Figure 1).

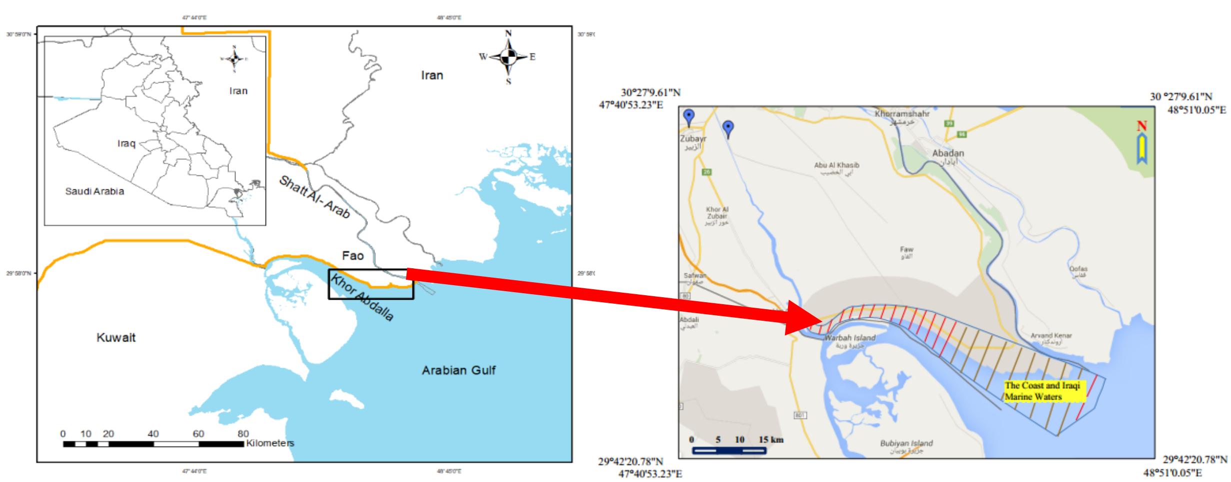


FIGURE 1. The study area's location

Hydrologic Context

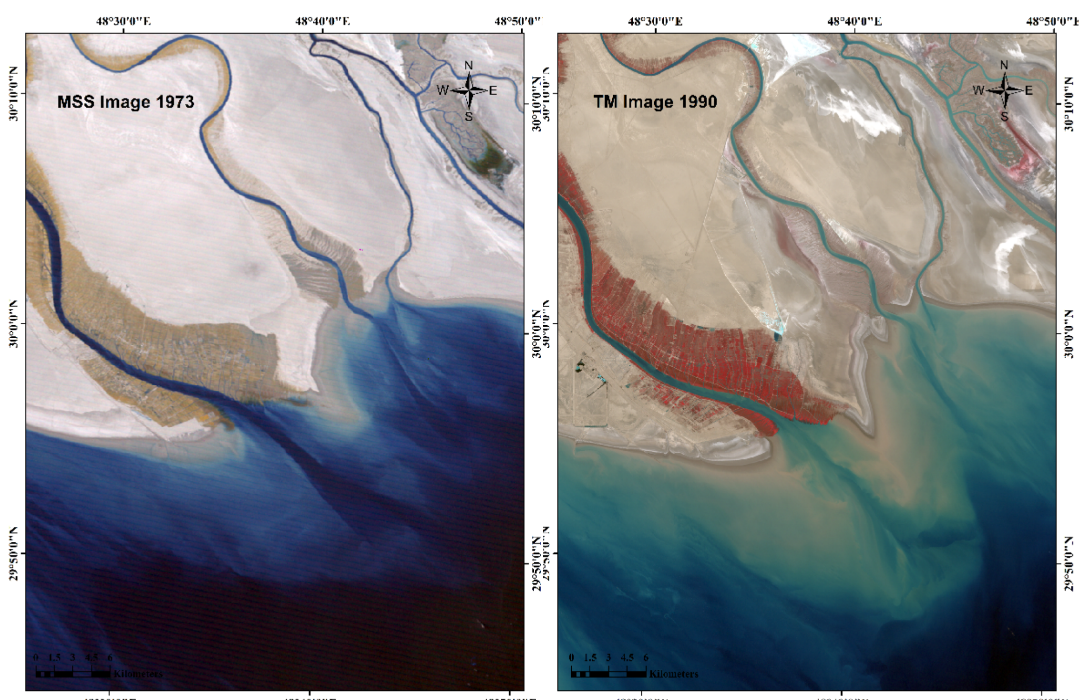
In general, the hydrological regime of the studied region is influenced by the hydrology of the surrounding region represented by the estuaries Shatt Al-Arab and Bahmshir, in addition to the water of the Arabian Gulf. Tidal phenomena have an impact on the studied area, which is from a mixed kind between diurnal to semi-diurnal, semi-diurnal is the most prominent kind, characterized by the presence of two tides and two ebbs in per day unequable extent [12]. Every year, the Shatt Al-Arab discharges approximately 30 million tons of dissolved load to the Gulf, whilst north of the meeting of the Karun River, the suspended load is reached 0.22 million tons annually. [13]. Suspended load is roughly 20 million tons/year down the conflux with the Karun River, and 9.5 million tons/year at Faw [14]. The ebb period for the river is longer than those of the tide [15]. The bed load is estimated at 85 thousand tons per year at Shatt Al-Arab, it is relatively low [14]. After 2004 [16], the course of the Karun River changed to flow into Bahmshir, and thus these quantities of sediments are drained to it and then to the Arabian Gulf. This contributed to changing the motion and allocation of sediments and thus increasing the sedimentation process along the Iranian coastline (Maraqat Abadan), which led to the inlet to the Shatt Al-Arab was deviated to the right side (Iraqi's side) [17]. Hydrological research indicates the discharge of water Shatt AL-Arab significantly reduced in the last quarter of the twentieth century when it reached (1500 m^3/s) [18] and continued to drop until (724-815 m^3/s) at the end of the 1990s from the past century [14], the river discharge after the twenty-first century reached very small values (50-70 m^3/s) [19,20]. The characteristic remarkable for tracking Shatt Al-Arab closely from the Outer Bar area is the presence of the sediment bars. The Coriolis phenomenon causes transportation and redistribution of the sediment load which leads to its impact on the coast of Iraq [21], movement of water in the Arabian Gulf is counterclockwise, as it passes in a northwest direction along the Iranian coast, and the water recedes to the southeast along the Arab coast [22].

METHODS AND MATERIALS

The methods in this project are based on satellite remote sensing techniques and GIS to Mapping coastal changes, at regular periods.

Source of Data

Detect changes in the shoreline, remote sensing data is a precious instrument for this purpose. As long as waters absorb infrared wavelengths, soil and vegetation reflect them robustly, which is crucial in the explanation and mapping of data, Multispectral pictures are a superior mix to map the spatial apportionment of waters and land. In this case, in the world of remote sensing datum, the longest archive of satellite images that are constantly obtained are the Landsat satellite images. (Figure 2) exhibits set for Landsat images from (1973 - 2021) MSS (Multispectral Scanner), TM (Thematic Mapper), ETM+ (Enhanced Thematic Mapper Plus), and OLI (Operational Land Imager) were used to detect shoreline alterations in the research zone, details in (Table1). The United States Geological Survey (USGS) website was used to obtain these multispectral images.



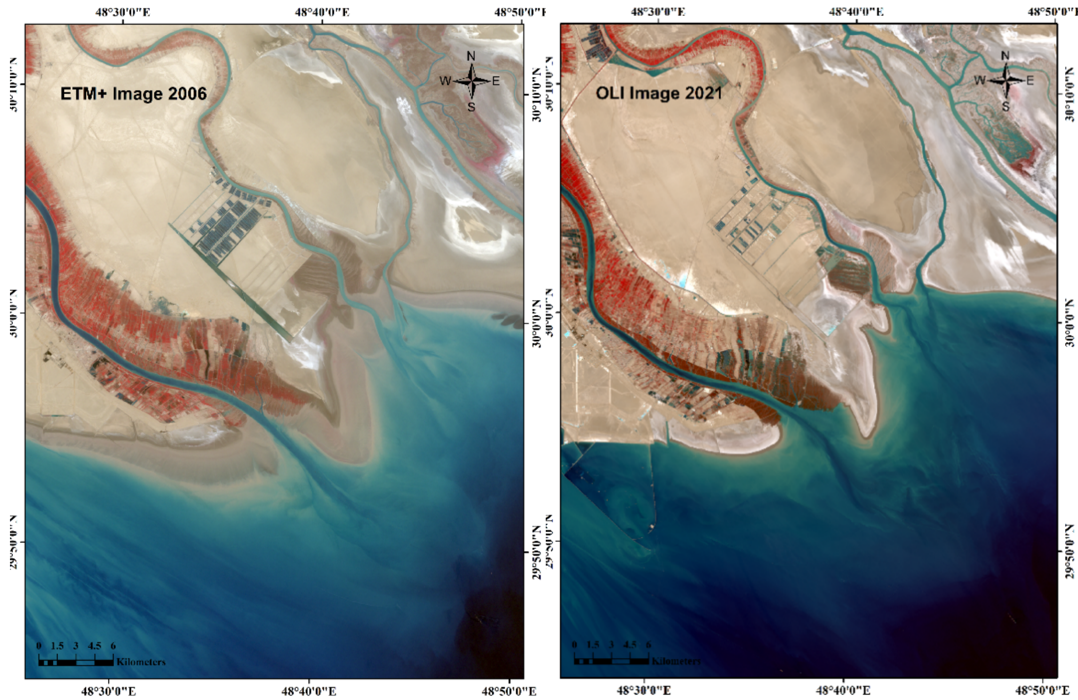


FIGURE 2. Landsat Satellite Image (1973-2021)

have been using the combinations (4,3,2) in all sensors, MSS, TM, ETM+, and the OLI sensor, which represents the bands (NIR, RED, and GREEN) respectively are Examples of band combinations (color). [23]. RGB color space representation is frequently used to simplify color mixing and highlight important aspects of an image [24].

TABLE 1. Shows the Landsat image collection that was used to alter the shoreline in southern Iraq.

Satellite Name	Sensor Type	Path _Row	Date Acquired	Scene Center Time (AM)	Spatial Resolution (m)
LANDSAT 1	MSS	177_39	1973-07-26	6:45:24	60
LANDSAT 5	TM	165_39	1990-06-20	6:36:02	30
LANDSAT 7	ETM+	165_39	2006-07-25	6: 52:27	30
LANDSAT 8	OLI	165_39	2021-06-09	7:15:40	30

Image Processing

The downloaded Landsat images are in UTM projection, zone 39, and WGS 84 datum. A scheme has been developed to analyze changes along the coastline of Iraq. After the images have been preprocessed (radiative calibration) and (atmospheric adjustment) utilizing Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) and Quick Atmospheric Correction (QUAC) where these functions are in the ENVI toolbox.

Shoreline Extraction

Using ArcGIS (10.8.1) software and ENVI (5.3), all satellite images were digitized to extract coastlines at various intervals as shape files, later it was utilized as input at Digital Shoreline Analysis System DSAS (5.1) tool, which was an instrument to count the average of altering of the coastline from a time series of numerous coastal sites. The DSAS application program needs an arbitrary baseline to construct cross-sections (Transects), where the buffer method was created to draw the baseline and Transects analysis, as in (Figure3).

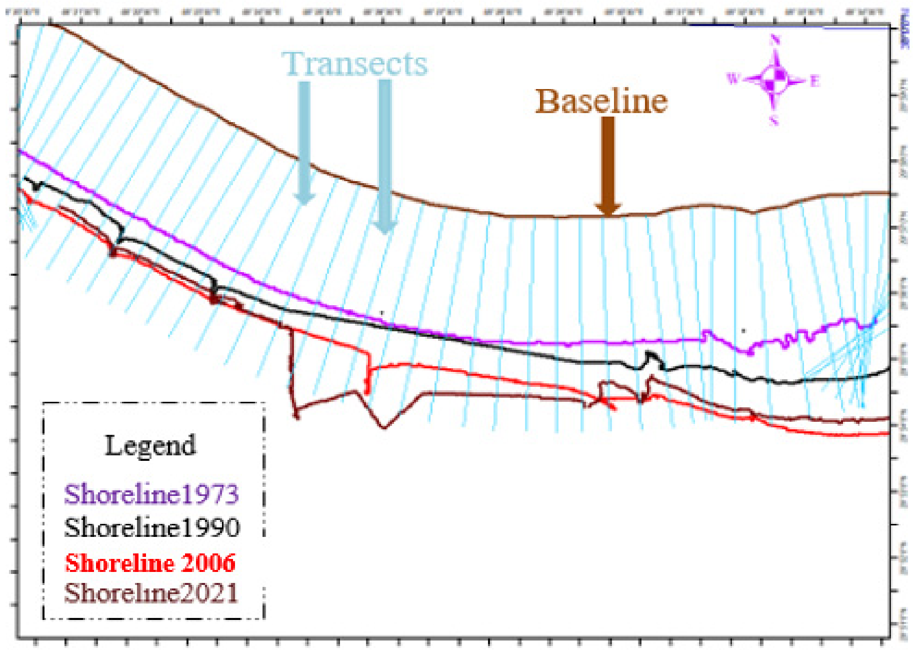


FIGURE 3. Shoreline change during the study period and DSAS transect

Statistics on shoreline alteration were determined in the format of shoreline change envelope (SCE), net shoreline movement (NSM), and Linear Regression Rate (LRR). LRR is counted by fitting a least-squares regression line to all coastline sites of a specified cross-section, and End Point Rate (EPR). EPR is a straightforward method for counting rates of alteration by dividing the span between the oldest and newest shoreline on the period between them. The schematic diagram of operations is shown in (Figure 4).

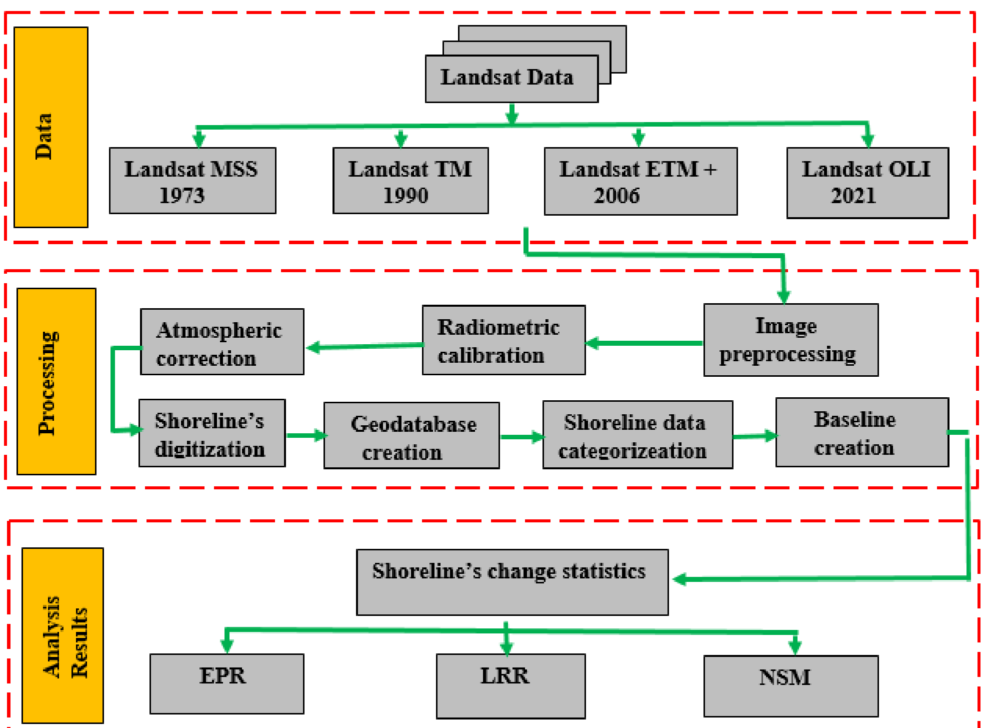


FIGURE 4. Schematic diagram of the coastline extraction procedure

RESULTS AND DISCUSSION

+2Depending on shoreline alteration analysis, the long-term (1973-2021) has been calculated using DSAS (5.1). It was observed that the rate of accretion is continuous.
DSAS transects have been used to calculate the shoreline dynamics. Positive values of the EPR (endpoint rate) indicate shoreline expansion towards the sea (increase).
According to the study, the value of (SCE & NSM) was found equal and therefore we will depend on one of them. The statistical parameter (NSM), for each transect, put perpendicular to the shorelines, measured the actual distance between the oldest and youngest shorelines. It can be calculated as:

$$NSM = \{d2021 - d1973\}m \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where: d represents a distance
The value of (NSM) was found to be more than 2500 meters, and this indicates that the coastline has progressed toward the sea since 1973 until now. Figure (5), shows that during a period of (50 years) the maximum progress of the coast was a distance of (2500 meters) towards the sea, depending on the sedimentary nature and environmental conditions during this period and the tidal phenomenon in the region and the shape of the coast as sediments move from Shatt Al-Arab river towards Khor Abdullah then to Khor Al-Zubair, the wind direction leads to mixing the waters and an increase in the speed of water currents, thus different levels of sedimentation along the coast. The linear regression rate (LRR) calculates the average variation, by fitting the least-squares regression line to each of the transect's shoreline points, it was found that its value is close to (EPR) (Figure 6). To compute the endpoint rate (EPR), NSM was divided by the period elapsed between the oldest and newest coastline. It necessitates the input of two shoreline dates, as well as supplementary data such as erosion and accretion rates, if available. The following formula is used to compute it:

$$EPR = \{d2021 - d1973) / (t2021 - t1973\} m/year \ldots\ldots\ldots\ldots(2)$$

Where: t represents the time
The value of (EPR) was found to be around 50 m/year, and this indicates that the coastline has progressed towards the sea since 1973 until now. (Figure 7) It shows that there are sections in which sedimentation occurs greater than in other sections along the coast, and the largest progress of the coast towards the sea is (50 m/y), and this is due to the environmental conditions in the area and the shape of the coast, this indicates that the coast is not exposed to erosion, but rather to sediment.

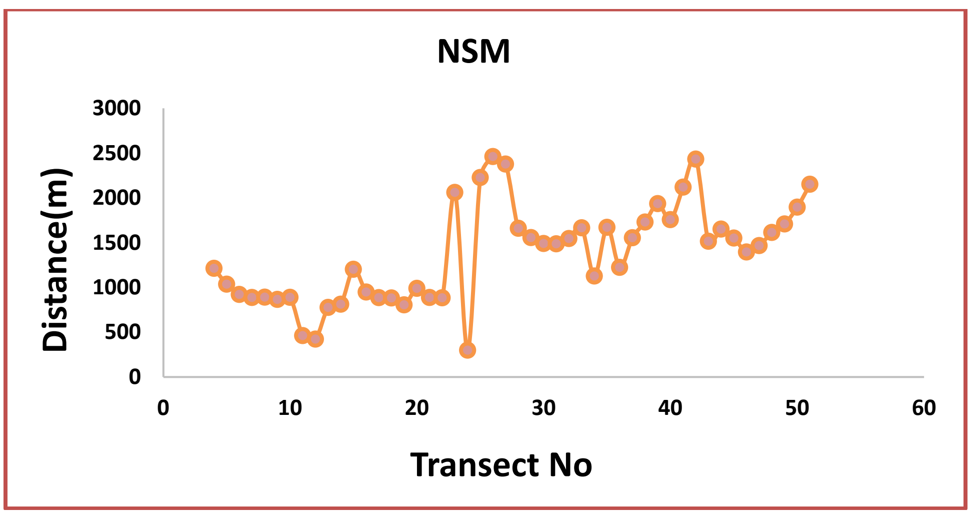


FIGURE 5. Net shoreline movement in the study period

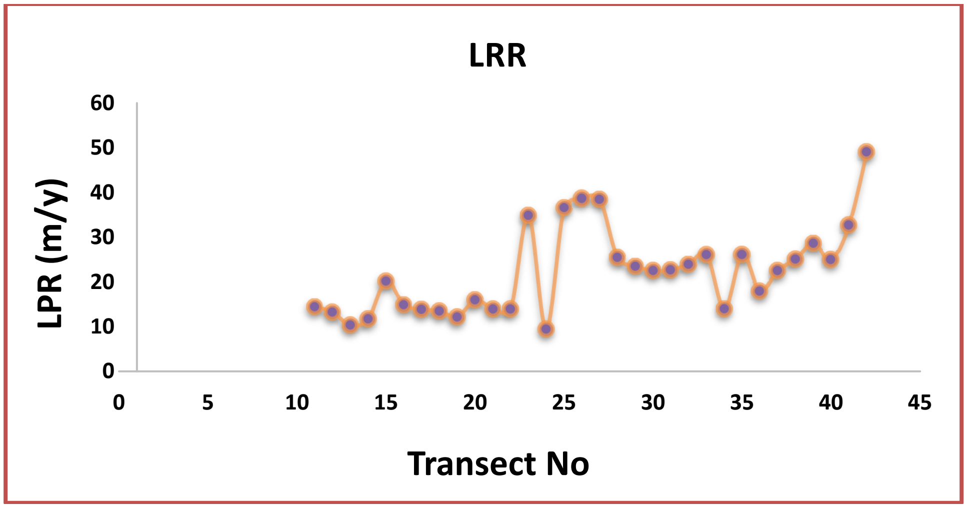


FIGURE 6. Variations in LRR values obtained using the DSAS

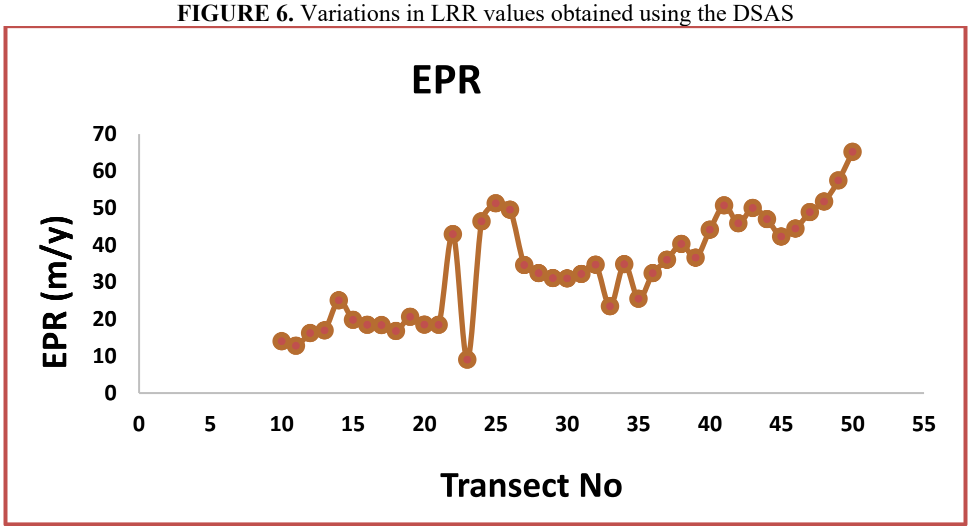


FIGURE 7. Variations in EPR values obtained using the DSAS

We note from the graphs (5,6,7) that in the previous years to the nineties, when the discharge of the Shatt Al-Arab river was high (1500 m^3/sec), the sedimentation rates were lower than it is at present, and thus the progress of the coast would be slow because the discharge is high and the length of the ebb hours is greater than in the case of the tide, which This leads to the rush of sediments away from the coast. While the period after the nineties, when the Shatt Al-Arab river discharge reached low levels of less than (50 m^3/sec) due to the dam's construction on the river's upstreams and tributaries by Turkey, Iran, and Iraq. We note that sedimentation along the coast has become larger and that there is continuous progress toward the Gulf.

CONCLUSION

To classify and delineate shorelines along the Iraqi shore were employed Landsat series images (MSS, TM, ETM+, and OLI) were during the elapsed period (1973 - 2021) at the Digital Shoreline Analysis System, an outstanding strategy for shoreline region planning, observation, and development of sustainable. During the previous decades, significant changes in the shoreline have occurred (50 years), according to our findings. They have advanced toward the sea distance of approximately 2500 meters from 1973 to 2021 at an average of 50 meters per year. Found through study, both anthropogenic, and natural factors such as the movement of tides, waves, and the kind prevailing winds in the region. Contributed to increasing the extent of the Iraq coastal area.

RECOMMENDATIONS

The outputs of the study can form an applied database for future projects if there is an intention to develop and manage the coastal environment and invest in the waterfront and develop it in an optimal way to keep pace with coastal investments in other parts of the world where conditions are similar to those in the Iraqi coastal environment.
The study can provide basic information for government officials and decision-makers to make sound decisions for the sustainable development of coastal areas.

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