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ORIGINAL ARTICLE **OPEN ACCESS**

Identification of Changes in Tidal Creeks in Kalubhar Island, Gulf of Kachchh, Gujarat Using Landsat Satellite Data

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ABSTRACT

Tidal creeks are one of the prominent features in tide dominated coastal areas such as Gulf of Kachchh. Changes in creeks depends on vegetation and size of the channel and it may vary from unnoticeable to few centimetres per year. In this study changes in tidal creeks in Kalubhar island during the period of 1990 and 2020 were identified with the help of remote sensing and GIS as it has potential to monitor changes due to its synoptic coverage. Result of this study indicates towards increase in length and number of creeks. It is also been observed that stability of higher order creeks also increased due to increase in vegetation cover in the area. Changes in such morphometric parameters may lead to change in geomorphology of the area.

Keywords- *Tidal creeks, Landsat, Kalubhar island, Gulf of Kachchh, Gujarat*

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INTRODUCTION

The Indian coastline is made up of a range of landforms, including sandy beaches, muddy shoreline, tidal flats and marshes.[1]The exchange of water and sediment between the outer and inner parts of a coastal environment is facilitated by channels, which allow tidal waves to travel through tidally dominated coastal landscapes.[2,3]Both erosive and depositional processes are responsible for the initiation of channels and the development of networks. Sediment erosion, sea level rise, headward erosion, bank erosion, and channel migration are some of the processes that control the initiation and evolution of channels.[4]Channel initiation will happen more readily on sandy tidal flats due to the higher erodibility of cohesive versus non-cohesive sediment and unvegetated against vegetated soils.[5]Because of the scale of the area that each author considered, there are overlaps and differences between the classifications of tidal channel network morphologies made by various authors. In a variety of coastal settings, including estuaries, back-barrier systems, open coast tidal flats, and marshes, Eisma(1998) studies intertidal channels on a variety of scales.[5] His classification is more extensive, recognizing ten different channels in three groups: (a) single channels: straight, sinuous, and meandering (when sinuosity ratio is more than 1.5) (b) channel systems: parallel channels, dendritic and elongate dendritic, distributary, braided, and interconnected; (c) few or no channels. Seven types of networks are identified by Pye and French (1993) in marsh systems.[6]These complement or add to those proposed by Eisma(1998)[5]: Reticulate, complicated, superimposed, linear single, dendritic and linear dendritic and meandering dendritic.

This research work is aimed to study changes in tidal channels/ creeks present on Kalubhar island between year 1990 and 2020 with the help of remote sensing and GIS. Due to its synoptical range, remote sensing is the best approach to monitor these areas due to the difficulty of performing fieldwork in coastal muddy areas.[7,8] To analyse changes taken place various parameters such as tidal network patterns, creek length, creek order, bifurcation ratio has been calculatedin GIS platform. Observation on these parameters is discussed in result and discussion section.

MATERIAL AND METHODS

STUDY AREA

Kalubhar island is an island in the central part of southern fringe of Gulf of Kachchh having an area of around 67 Km^2 .One of India's macrotidal sites, the Gulf of Kachchh, has a depth that varies from about 60 metres at the mouth to less than 20 metres at the head[9], while the depth near the centre is between 30-

35 metres.[10]Mixed semi-diurnal tides with a tidal range of 4 metres at the mouth to about 7 metres at the head are present in this region.[11]Geographically it extended from 22°23' to 22°29' N; 69°35' to 69°40E(Figure-1). Extensive mudflats, islands, and numerous dead coral reefs are located along the southern part of the Gulf. At low tide, these mudflats get exposed. Kalubhar island is a coral island and classified as platform reef.[12,13] Northern and western parts of Kalubhar reef have sparse algae on sanded and muddy reef flats, while the southern and eastern portions possess muddy reef flat. Geologically, Deccan traps are disconformably deposited on Mesozoic sediments, in south of the Gulf; which are then overlaid by disconformable Palaeocene volcanoclastic deposits[14](Figure-2). Kalubhar island comprises calcareous clay and silty marl [15].

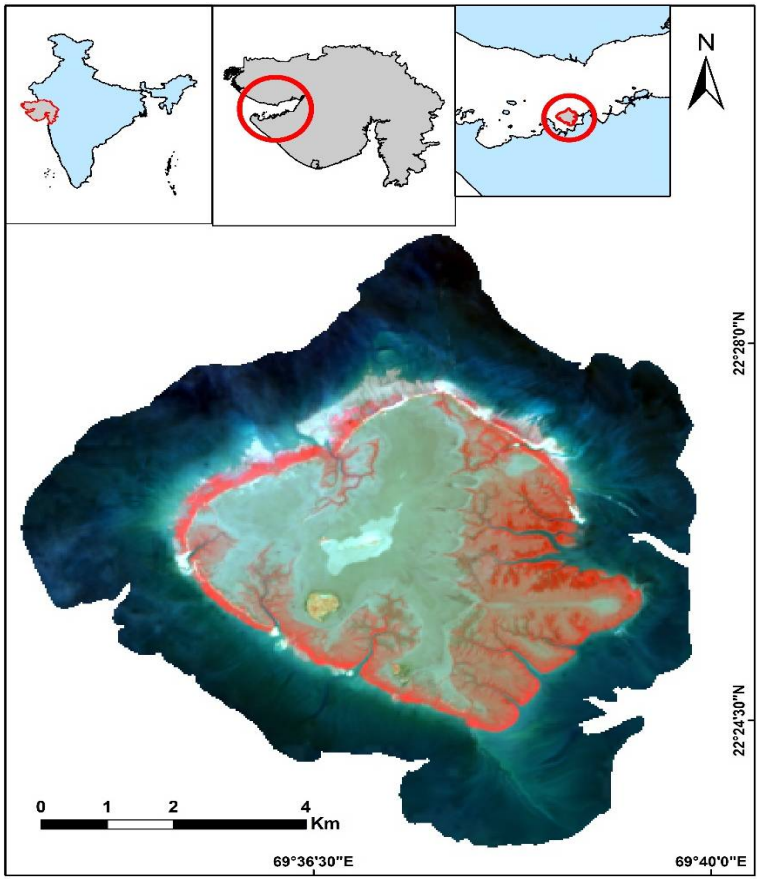

Figure 1: FCC of Kalubhar island generated from Landsat-8 data

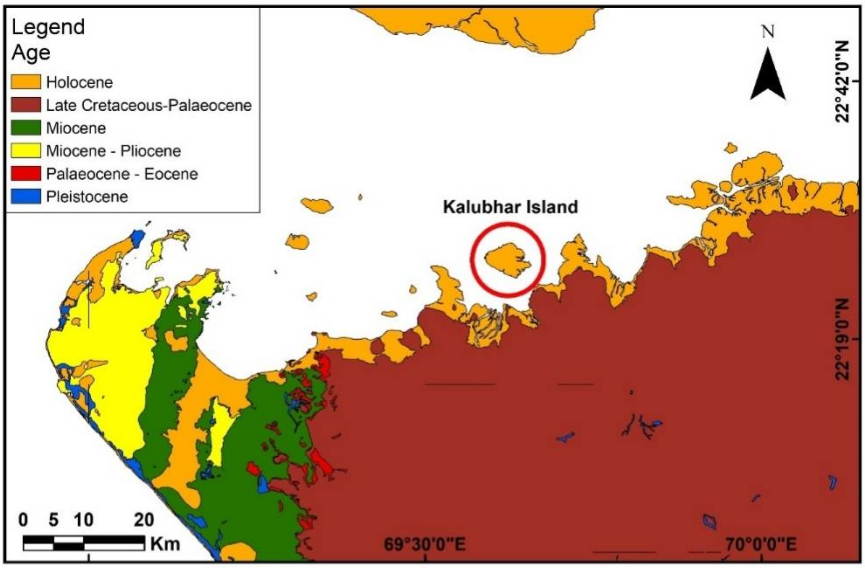

FIGURE 2: GEOLOGICAL MAP OF SOUTHERN GULF OF KACHCHH

METHODOLOGY

Landsat satellite imageries of year 1990 and 2020 of high tide condition and having low cloud cover was downloaded from USGS Earth Explorer data portal. These data were pre-processed and tidal networks/ creeks were extracted manually in GIS platform. To analyse the changes in tidal creeks different parameters such as network pattern, channel length, creek order and bifurcation ration was calculated after the extraction. For identification of different types of channels pattern present on the island classification given by Eisma(1998) was followed.[5]For ordering creeks method given by Strahler (1964) has been used and from the creek order bifurcation ration has also calculated.[16]

RESULT AND DISCUSSION

Based on the visual image interpretation and calculation of morphometric parameters it is observed that tidal creeks have changed during the period of 1990 and 2020. In the following subsection changes observed in different parameters is discussed.

a) Tidal network pattern

Tidal creeks having higher width are easily identified in Landsat satellite datahaving spatial resolution of 30m; while creeks of narrow width are identified based on vegetation and moisture content. Based on the extraction and visualization it has been observed that four different types of network pattern are present on island. Types of network pattern identified on island are straight, dendritic, sinuous and meandering. These patterns were identified based on the classification given by Eisma(1998) as it is more detailed classification.[5]This classification may vary based on the scale and resolution of data.

b) Creek length

The length of the creek was measured from the mouth of the creek to the end of the extension on land.Total length of all the channels in Kalubhar island in 1990 was ~24.37 km which increased to ~32.70 km in 2020.This length increased as a result of the expansion of earlier channels and the creation of additional channels.In the eastern part of the island growth and development of channels are relatively higher in comparison to western part of the island due to presence of higher mangroves, larger extension and better connectivity of creeks to gulf, which is not prominent on western side of the island. Higher order creeks may extend seawards which can be detected in low tide condition as the portion of island which is normally submerged under water get exposed during low or ebb tide. Hence, length of channels extracted in low tide condition may vary from channel length extracted in high tide condition.

c) Creek order

The Strahler (1964) method has been used in the present work to assign order to the identified creeks.[16]This approach calls for the convergence of two or more streams to create the subsequent higher-level stream. It is observed from the creek order that creeks of highestthird order are present in Kalubhar island(Figure-3 and 4). On the island 77 first order creeks were identified during the period of 1990 which increased to 123 in 2020. While second order creek increased from 22 in 1990 to 30 in 2020 and number of third order creeks was increased from 5 in 1990 to 9 in 2020(Table-1).It can be analysed from the data that new channels are developed due to which number of higher order channels also changed.

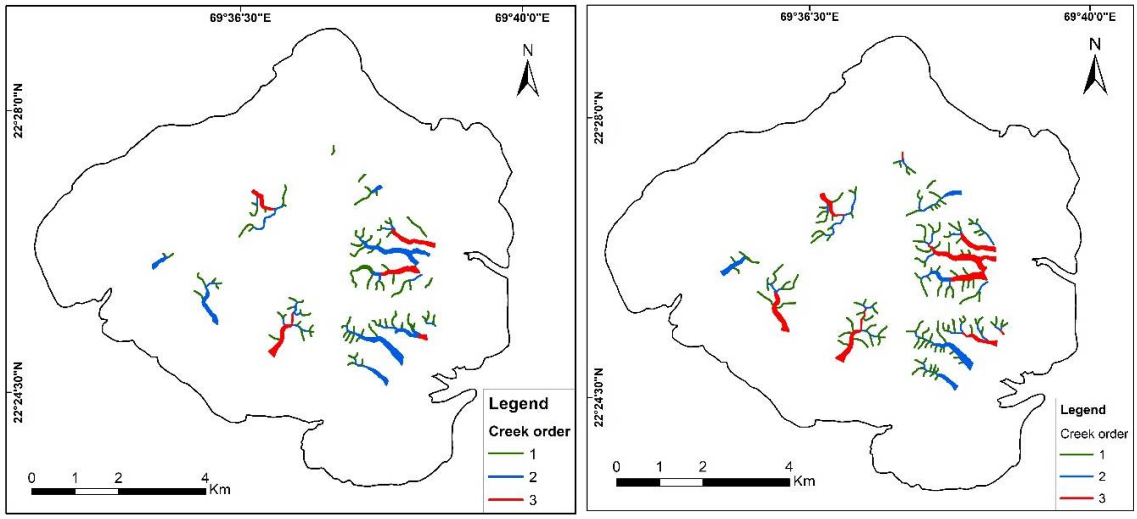

Figure 3: Map showing tidal creeks in Kalubhar island during 1990(left) and 2020 (right)

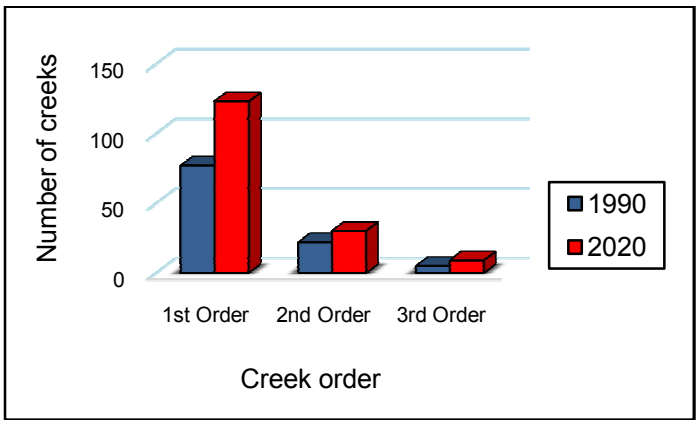

Figure 4: Bar graph representing creek order and their number in year1990 and 2020

d) Bifurcation ratio

The bifurcation ratio is defined as the sum of all streams in a particular order divided by the sum of all streams in the next higher order. Results of bifurcation ratio shows increase in the ratio of first to second order creeks in 2020 from 1990, while ratio of second to third order creeks are reducedduring this time period; which indicates towards more stability of higher order creeks in comparison to lower order creeks. The increase in stability is due to increase in mangrove vegetation from 1990 to 2020 as growth of vegetation reduces erosion and promotes deposition of sediments.

Table-1: Numbers of creeks of different order and their bifurcation ration in 1990 and 2020

Order	Number of creeks in 1990	Bifurcation ratio (1990)	Number of creeks in 2020	Bifurcation ratio (2020)
1st Order	77		123	
2nd Order	22	3.5	30	4.1
3rd Order	5	4.4	9	3.33

CONCLUSION

This study was conducted to study the changes in Kalubhar Island's tidal networks between 1990 and 2020. Based on the analysis, the following conclusions were made:

1. From Landsat satellite imageries having 30m resolution, four different types of network patterns were found. They are sinuous, straight, dendritic, and meandering. Depending on the scale and spatial resolution of the satellite data, this classification might change.
2. Between 1990 and 2020, a number of new creeks were created, leading to a greater increase in the number of first order creeks. The quantity of higher order creeks has also changed as a result of the growth in lower order creeks.
3. Due to the expansion of existing channels and the creation of new creeks, the overall length of creeks also grew.
4. As mangrove flourishes, higher order channels become much more stable. The eastern part of the island has more advancement of the channel since there is more vegetation and the channel extends more seaward.
5. To comprehend the general morphometry of the area, it might be useful to study places that are often submerged under water and only exposed at ebb tide.

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