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# A GIS-BASED STUDY ON THE CHANGING COURSE OF THE RIVER JIADHAL IN THE DHEMAJI DISTRICT, INDIA

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**Abstract**
River bank-erosion, deposition and channel-shifting are considered most dynamic and significant geomorphological processes formed by complex geological, hydrological, and anthropogenic factors. In the present study, river Jiadhal is one of the main sub-tributary of the River Brahmaputra in the Dhemaji district of Assam that changes its channel course frequently due to bank-erosion and sediment-deposition in the intermediate part and lower course of the channel. A study on the changing course of the river Jiadhal was carried out using satellite imageries for the years 1987, 1997, 2007 and 2017. The study found that the changes in the river vary from time to time and the bank-erosion and sediment-deposition fluctuate from place to place. The total area of bank-erosion is 13.34 km2 from 1987 to 2017 and the total area of sediment-deposition is 14.59 km2 from 1987 to 2017. This paper evaluates how the shape, size and position of the Jiadhal River have changed from the years 1987 to 2017 using remote sensing and GIS techniques. The study is also necessary for effective management along the side of the river Jiadhal to control bank erosion and to mitigate the adverse impact of erosion and channel-shifting.

***Keywords:*** Bank Erosion, Sediment Deposition, Channel Shifting, Jiadhal River, Remote Sensing

## 1. Introduction

The major focus while studying fluvial geomorphology (He et.al. 2019) includes the shifting nature of the river, bank-erosion, transportation, and sediment-deposition (Alam et al. 2023; Ibitoye, 2021; Schumm, 1977) that results in the changes in river planform (Saikia et al., 2023). Likewise, river bank-erosion, sediment-deposition (Mondal and Satpati, 2012) and shifting of the river channel is a geomorphic progression that occurs in all river channels to adjust the shape and size of the river (Bhunia et al., 2016). The self-adjustment of the rivers also triggers the formation of many new geomorphic features (Bera et al., 2012) through the process of bank-erosion and deposition (Gogoi and Patnaik, 2022) and the shift in the river course has also become one of the major concerns (Sarif et al., 2021) among the dwellers of the river catchment. The shape of the channel varies due to the excessive amount of water-discharge and sediment load (Mandal, 2017) that gets deposited at different phases of the river (Abidin et al., 2017). The continuous erosional process and accretion (Debnath et al., 2023; Hasanuzzaman et al., 2023; Kummu et al., 2008) reduce the water-carrying capacity (Ibitoye, 2021; Surian, 1999) of the river and the bed of the river rises rapidly.

Subsequently, channel aggradational (Mitra et al., 2005) and degradational processes (Chang, 2008) are enhancing the river bed causing instability (Haron et al., 2017; Moret et al., 2006) in river system.

Channel shifting (Jana, 2021) is a complex process with numerous factors that contribute to the changes. According to Lovric & Tosic, (2016) river bank-erosion plays a vital role in controlling the stability of a channel which later has a significant contribution to sediment-load. Moreover, extensive bank-erosion (Dragićević et al., 2017) led to various socio-economic consequences such as the destruction of floodplains, losses to habitable land and agricultural land (Handique et al., 2023) and caused damages to other government infrastructures (Das et al., 2014).

The river Jiadhal is regarded as one of the frequently changed channels (Boruah et al., 2020) in the Dhemaji district of Assam. Records reveal that after the earthquake of 1950, the river experienced a series of continuous floods with high magnitude and high frequency (Das, 2016). The major floods in the years 1969, 1973, 1984, 1988, 1989, 1992, 1994, 1997, 1998, 2002, 2007, 2009, 2011, 2014 and 2017 (Hazarika, 2010; Das, 2013a) have severely damaged the entire drainage basin. Moreover, due to high flood, the Jiadhal River has become unstable and changed its course after every high-magnitude of flood (Kakoty et al., 2018). Excessive erosion and subsequent deposition in the intermediate and lower course of the river have created a challenging environment. Many records and studies (Buragohain and Bhuyan, 2014) made it clear that continuous flood, lateral bank-erosion (Gogoi and Goswami, 2013) and deposition of sediment (Das, 2015) within the river bed and surrounding areas have made the river unstable forming a braided pattern (Gogoi, 2010) in the lower reach and the entire drainage system has collapsed (Das, 2013b). The river becomes braided due to the abundant supply of sediment-load (Wang et al., 2016) that exceeds the sediment-carrying capacity of the river (Baki and Gan, 2012). The braided channels (Maibangsa et al., 2015) later enhance the lateral erosion and widen the channel causing channel bank-line migration (Saur et al., 2022) in the river Jiadhal.

During the flood of 1969, the Jiadhal River catchment experienced the worst conditions as the river took a major shift in its course and many households were washed away by flood (Gogoi, 2023) leaving the people of Dhiri Chapori, Kekuri, Ratua and Jiadhal Tinigharia in jeopardy. In the year 1973, a destructive flood occurred and breached the left bank embankment (Das, 2018) that was once protecting the people of the eastern side of the district from severe floods. Siltation (Buragohain and Bhuyan, 2014) and sedimentation (Sonowal et al., 2017) with high water discharge led to bank shifting in the lower reach of the river.

A study on the changing course of the river Jiadhal is needed to understand the dynamic nature of the river. Moreover, studying about the shifting nature of the river helps us understand the impact of the river and bank-erosion on the environment and the risks associated with it. A detail study about the changing pattern of the river also helps in policy-making decisions so that the local people living nearby the river can enhance resilience to natural hazards.

Thus, the main idea of this paper is to – i) recognize the changes in the channel from the foothills to the lower-reach of the Jiadhal River from 1987 to 2017, ii) to quantify the shift in the river due to bank-erosion and deposition of sediment at different cross-sections and iii) to understand the reason behind the changes in the channel course. The result obtained will be of great importance for understanding channel migration and for better river basin management and planning within the Jiadhal River catchment.

## 2. Study Area

The Jiadhal River Basin extending from 94°15'19" E to 94°37'23" E longitude and 27°12'44" N to 27°45'2" N latitude has a catchment area of about 1053.20 sq. km of which 66.5 percentage and 33.5 percentage of the land come under Assam and Arunachal Pradesh respectively. The Jiadhal River is a sub-tributary of the river Brahmaputra in the state of Assam. The river originates in the West Siang district of Arunachal Pradesh by joining three rivers namely Siri, Sika and Sido (Bormudoi, 2015) in a place called Tinimukh (Borgohain et al., 2016). The river passes through a gorge called Jiadhalmukh before debouncing into the Brahmaputra plain of Assam. Due to the sudden loss of energy, most of the sediment carried by the river were deposited within a short distance in the plains. The Jiadhal River basin is bounded to the east of the basin by the Moridhal River (Gogoi, 2015) and to the west by the Subansiri River. Still, the demarcation of the boundary towards the lower-reach of the river is difficult as the river frequently changes its course and creates a braided-like pattern. As the nature of the river is unstable, it is known by different names in different places depending on the direction it flows.

The types of soil found in the Jiadhal River basin are of mixed type, in the hilly terrain of Arunachal Pradesh red loamy soils are found while in the foothills and the plain regions, old alluvium and new alluvium soils are found respectively. The basin falls under the tropical monsoon climate (Saur et al., 2022; Das, 2019) with mild dry winters with little rainfall and hot and humid summers with heavy rainfall. According to the Brahmaputra Board Master Plan, 2000 the basin is divided

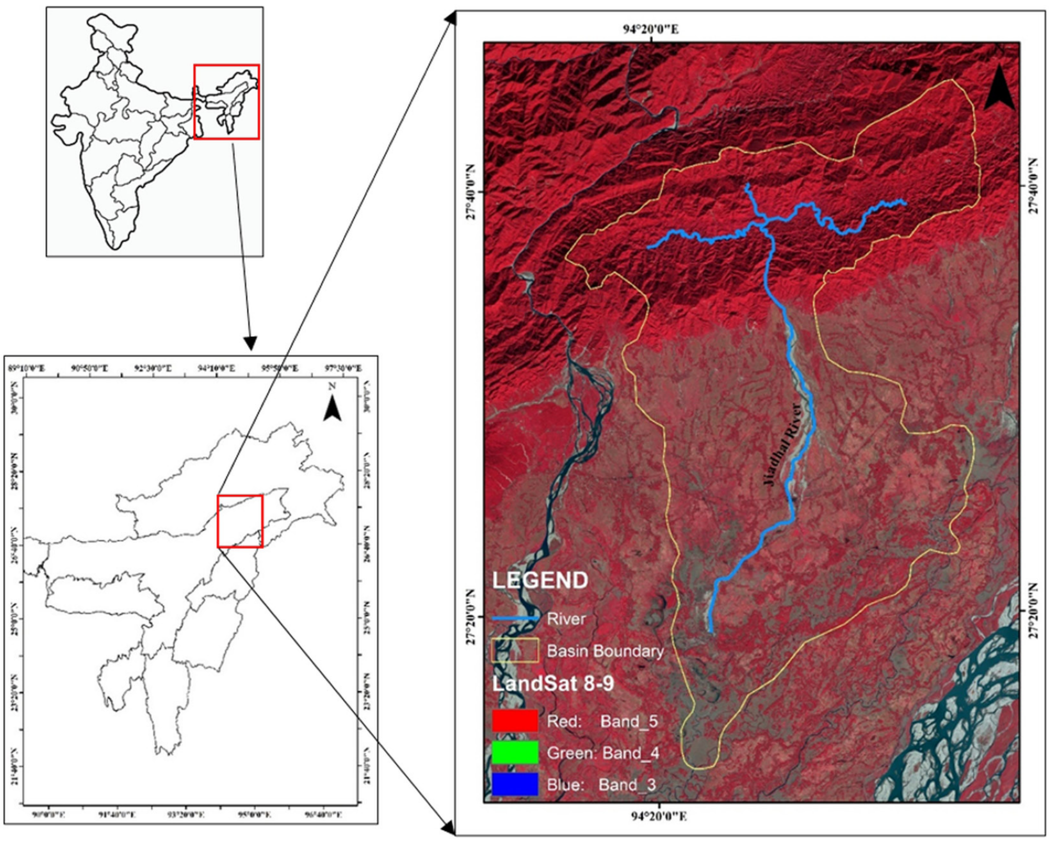



Fig. 1. Location map

into three parts: pre-monsoon (i.e. March – May), monsoon (i.e. June – October) and post-monsoon (i.e. November – February). June, July and August are considered as the month with maximum rainfall. The average annual rainfall of the catchment is 250 cm. Fig. 1 gives a clear detail about the location of the study area.

## 3. Materials and methods

The entire study was carried out using a secondary source of data to determine the changing channel pattern of the Jiadhal River. For the study, satellite images (Paul & Bhattacharji, 2022; Bordoloi et al., 2020) such as Landsat 4-5 (MSS & TM), Landsat 7 (ETM+) and Landsat 8 (OLT & TIRS) with a resolution of 30 m for the years 1987 to

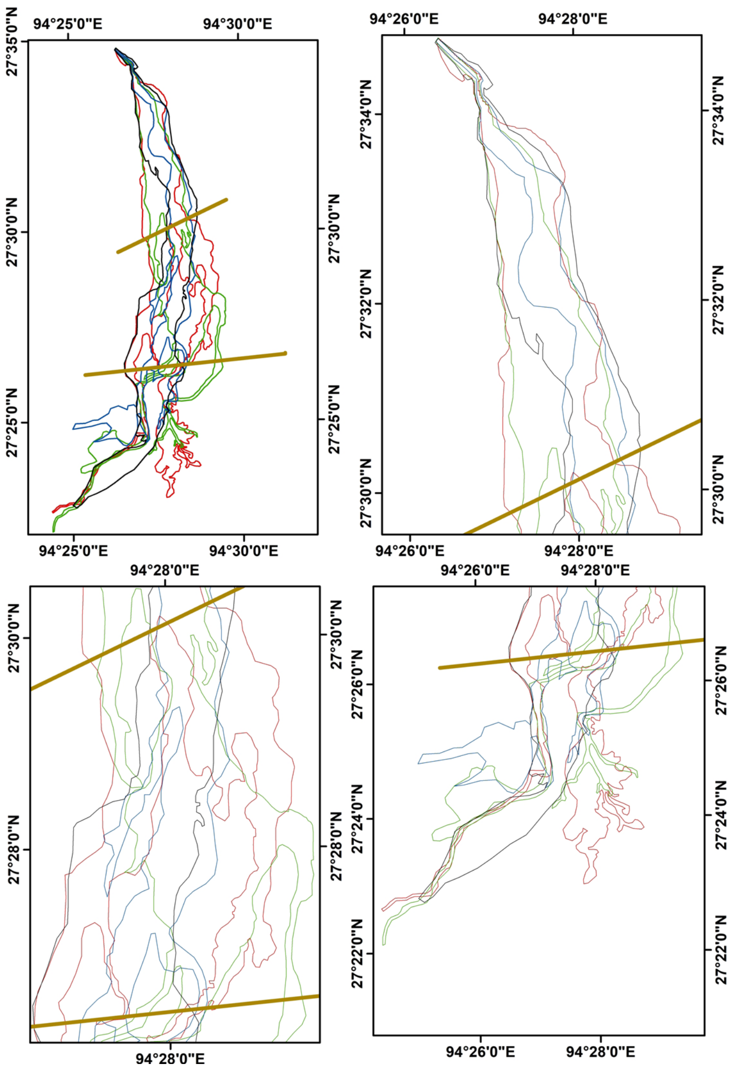



Fig. 2. Zoning of Jiadhal River in three sections

2017 were downloaded from Earth Explorer USGS (Momin et al., 2022). Table 1 gives a detailed description of the satellite images used during the study. The images that were taken from USGS were mostly of the winter season (Ibitoye, 2021) as during this period it was easy to detect the channel flow pattern compared to that of the flooding season or summer season. The satellite images (Saikia et al., 2019) were further compiled

Table 1. Details about the satellite imageries

| Satellite | Sensor | Date of Acquisition | Path/Row | Resolution (m) |
|---|---|---|---|---|
| LANDSAT 4-5 | MSS & TM | 03/12/1987 | 135/041 | 30 |
| LANDSAT 4-5 | MSS & TM | 27/10/1997 | 135/041 | 30 |
| LANDSAT 7 | ETM+ | 18/12/2007 | 135/041 | 30 |
| LANDSAT 8-9 | OLT & TIRS | 04/02/2017 | 135/041 | 30 |

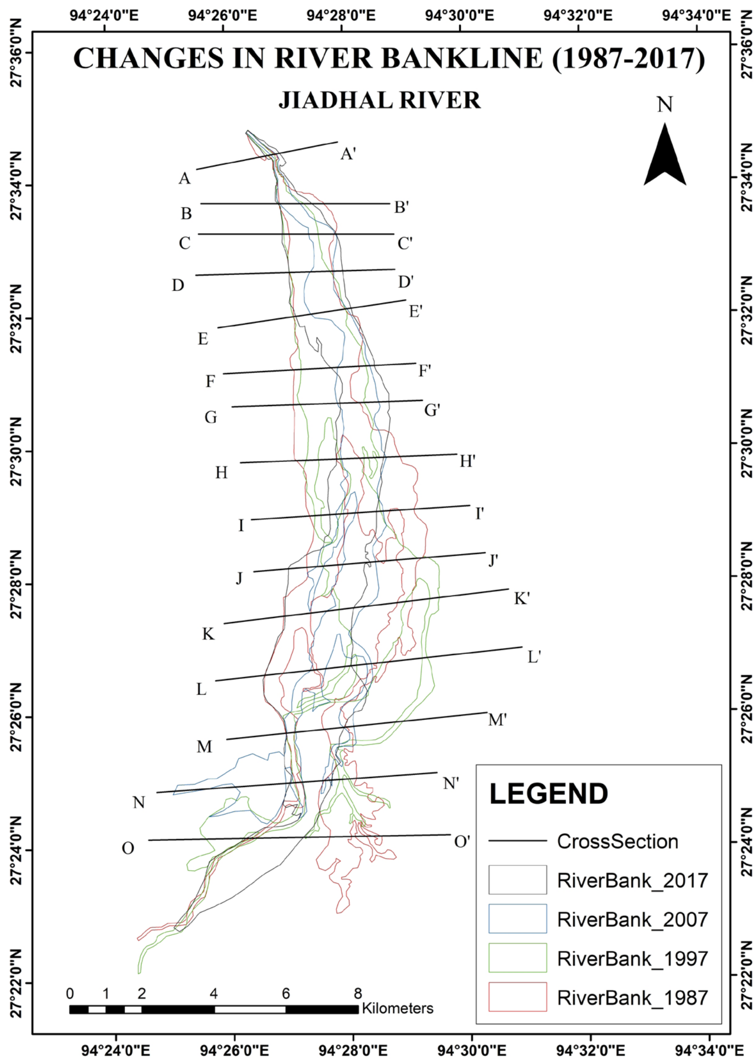



Fig. 3. River Bankline Changes from 1987-2017

and classified in ArcGIS 10.8 to identify the channel dynamics (Saikia et al., 2023) and morphological changes (Borgohain et al., 2016) of the river Jiadhal. Later, taking the interval for 10 years the Jiadhal River was digitized from each of the satellite imageries.

For the study, random cross-sections were plotted at random distances on the river to measure the changing variation of the river due to bank erosion (Dragićević et al., 2017; Mondal and Satpati, 2019) and sediment deposition. Further, the Jiadhal River was divided into three sections i.e., the foothill region, the intermediate and the lower-course of the river. The foothill region is between the upper-course of the river and the middle portion of the river (Fig. 2) where the river enters the floodplain region. The intermediate part is the middle-section of the river (Fig. 2), where the maximum amount of bank-erosion takes place. The lower course of the river (Fig. 2) is the part of the river where the maximum quantity of siltation process takes place due to the gradient of the river. Also, in this part of the river, channels are almost unrecognizable due to the high alluviation and braided pattern of the river.

## 4. Results and findings

The changes in the Jiadhal River channel are categorised into three groups taking an interval of 10 years i.e., from 1987 to 1997, 1997 to 2007 and 2007 to 2017. The details about the changing course of the river Jiadhal are discussed below-

### Changing of the river course between 1987 to 1997

During the period 1987-1997, in the foothills from cross-sections A-A' to G-G' the amount of deposition is more compared to the rate of erosion along the river channel. This is so as there is a decrease in gradient which slows down the water velocity and causes the deposition of sediment along the foothills. The river has eroded for 224.32 m on the right-bank (RB) and 424.68 m on the left-bank (LB) but the amount of deposition is 685.48 m and 1089.85 m on both the

Table 2. Changing course of the river Jiadhal along with direction (1987-1997)

| | Cross-Section | Right Bank (m) | Left Bank (m) | Shifting direction |
|---|---|---|---|---|
| Foothills | A-A' | 227.48 | 27.24 | - |
| | B-B' | -26.46 | 552.45 | West |
| | C-C' | -152.4 | 442.92 | West |
| | D-D' | 0 | 67.24 | - |
| | E-E' | -45.46 | -65.48 | East/West |
| | F-F' | 259.53 | -196.43 | East |
| | G-G' | 198.47 | -162.77 | East |
| Intermediate | H-H' | 966.57 | -502.7 | East |
| | I-I' | 0 | 0 | - |
| | J-J' | 438.36 | -1671.12 | East |
| | K-K' | 772.86 | -1893.68 | East |
| | L-L' | 760.17 | -916.25 | East |
| Lower course | M-M' | 602.47 | -241.41 | East |
| | N-N' | -145.52 | 623.39 | West |
| | O-O' | -1031.87 | 965.82 | West |

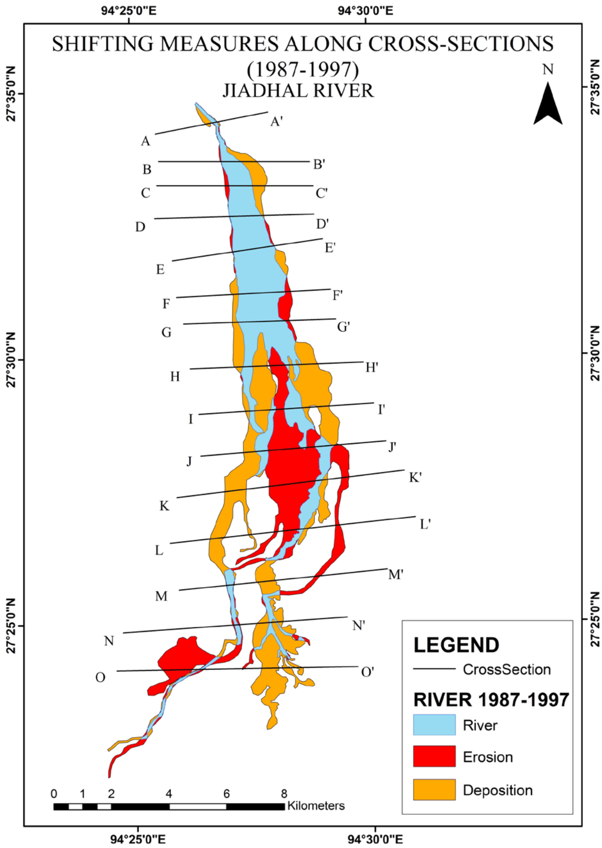



Fig. 4. Cross-section and segment of the river course (1987-1997)

right and left banks respectively due to the sudden changes in the river gradient. In the intermediate part, a major shift in the left bank of the river Jiadhal is seen along the cross-sections H-H', J-J', K-K', and L-L'. Along the cross-sections, J-J' and K-K', the river has eroded a total of 1671 m and 1893.68 m respectively towards the left bank. Similarly, erosion of 916.25 m and deposition of 760.17 m was measured along the cross-section L-L'. Towards the lower course of the river Jiadhal along the cross-sections M-M', N-N' and O-O', the erosion rate is higher on the RB and the deposition amount is higher on the LB.

In the period 1987-1997, during the entire course of the Jiadhal River, changes or shifts in the bankline are not the same between all the cross-sections. It is seen from Table 3 and Fig. 4 and Fig. 5 that the river mostly flows on the eastern side of the Dhemaji district where the rate of erosion is higher towards the LB as compared to the RB. After the floods of 1989 and 1992, the river maintained its course towards the eastern side of the district but the old Moridhal embankment once again collapsed during the flood of 1992 near the Jiadhal Kekuri village.

## Changing of the river course between 1997 to 2007

It can be understood from Fig 7 and Table 4 that during the period 1997-2007, there was more sediment-deposition than compared to bank-erosion in the foothills from cross-sections A-A' to G-G'. Moreover, during this period it can be observed that the river is gradually shifting towards the eastern part of the district with a slow rate of bank-erosion on the LB of the river. The total amount of land that was covered with sediment-deposition

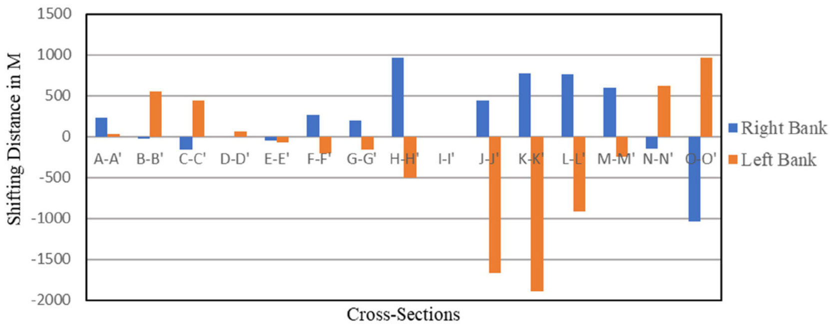



Fig. 5. Shows the shift in Left and Right Bank due to Bank-erosion and Sediment-Deposition

within the foothills was 3966.69 m. Within the intermediate part from cross-section H-H' to L-L' the Jiadhal River slowly started shifting towards the western side. While the river reaches the lower course the rate of bank-erosion increases rapidly and the entire river has shifted towards the western side in the lower course of the channel.

The major flood event recorded during the period 1997-2007 was in 1998, 2002 and 2007. The flood of 1998 breached the railway line near Samarajan, which was acting as a barrier and protecting the villages from bank erosion and flood. Later due to the breaching of the railway track, the entire Samarajan area faced a severe flood hazard which led to the loss of households, livestock, and lives. The floods of 2002 and 2007 had a severe impact on the lower course of the river Jiadhal. During this period the entire lower reach of the river shifted towards the western side of the district due to low gradient (Bormudoi and Nagai, 2016) and lack of protective measures. Moreover, the water from the river spread out in all directions resulting in a fan-like structure.

Table 3. Changing course of the river Jiadhal along with direction (1997-2007)

| | Cross-Section | Right Bank (m) | Left Bank (m) | Shifting Direction |
|---|---|---|---|---|
| Foothills | A-A’ | 85.96 | -67.87 | East |
| | B-B’ | 39.72 | 112.71 | - |
| | C-C’ | 697.84 | -476.26 | East |
| | D-D’ | 575.71 | -115.80 | East |
| | E-E’ | 501.40 | -48.15 | East |
| | F-F’ | 1017.61 | -95.25 | East |
| | G-G’ | 1048.45 | -413.19 | East |
| Intermediate | H-H’ | 425.64 | -425.45 | East |
| | I-I’ | 336.84 | -89.80 | East |
| | J-J’ | -177.80 | 1459.15 | West |
| | K-K’ | -346.64 | 1381.50 | West |
| | L-L’ | -453.70 | 722.28 | West |
| Lower course | M-M’ | -249.10 | 250.88 | West |
| | N-N’ | -3108.87 | 159.10 | West |
| | O-O’ | 1461.46 | 0.00 | - |

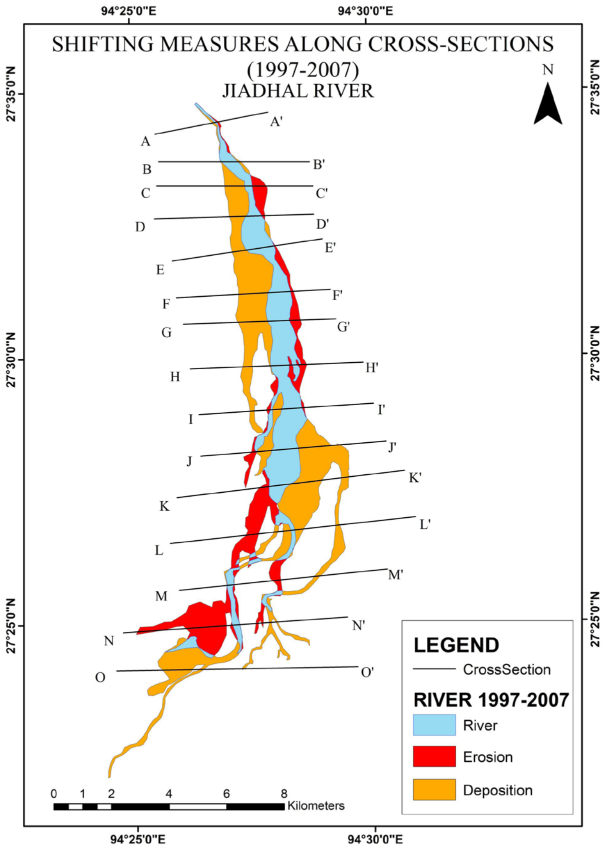



Fig. 6. Cross-section and segment of the river course (1997-2007)

## Changing of the river course between 2007 to 2017

It was during this period that the rate of erosion was higher in both LB and RB. In the foothills from cross-sections A-A' to F-F' the river has eroded both sides of the banks. From the intermediate part, the river Jiadhal gradually shifted towards the western side and the erosional process stopped in the RB. The highest shift of 1389.18 m was seen in the cross-section J-J' towards the LB. Later, the lower course of the river again shifted towards the eastern side creating a braided pattern. The major flood events that occurred in the period 2007-2017 were recorded in 2011, 2012 and 2014. It is seen from Table

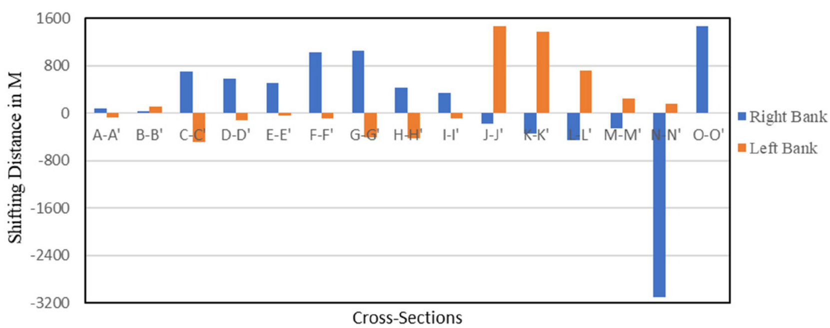



Fig. 7. Shows the shift in Left and Right Bank due to Bank-erosion and Sediment-deposition

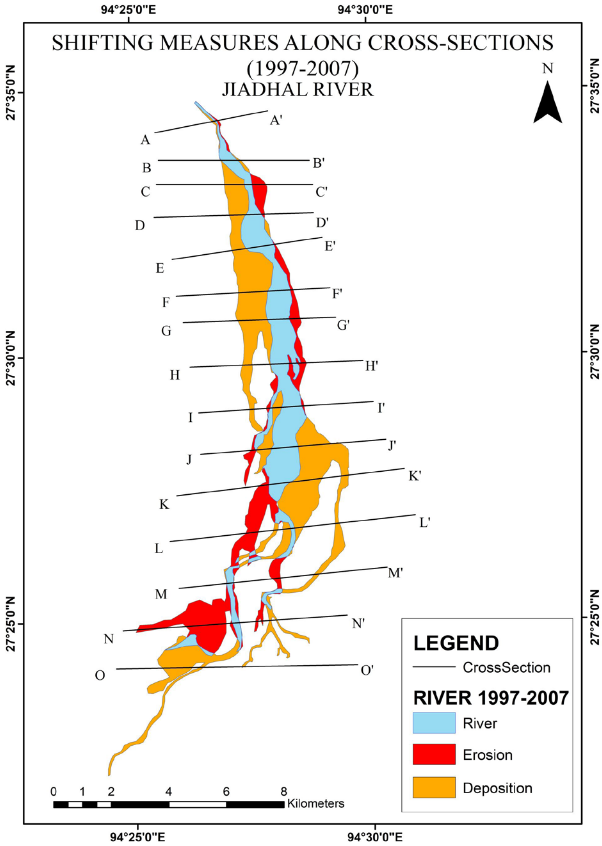



Fig. 8. Cross-section and segment of the river course (2007-2017)

Table 4. Changing course of the river Jiadhal along with direction (2007-2017)

| | Cross-Section | Right Bank (m) | Left Bank (m) | Shifting Direction |
|---|---|---|---|---|
| Foothills | A-A’ | -161.52 | -107.68 | East/West |
| | B-B’ | -59.89 | -330.73 | East/West |
| | C-C’ | -730.92 | -39.83 | East/West |
| | D-D’ | -589.15 | -235.03 | East/West |
| | E-E’ | -421.43 | -109.94 | East/West |
| | F-F’ | -182.02 | -129.15 | East/West |
| | G-G’ | 70.45 | -287.91 | East |
| Intermediate | H-H’ | -159.89 | 82.55 | West |
| | I-I’ | -484.1 | 196.95 | West |
| | J-J’ | -1389.18 | 179.6 | West |
| | K-K’ | -1175.98 | 326.08 | West |
| | L-L’ | -1270.02 | -690.02 | West |
| Lower course | M-M’ | 0 | -1366.06 | East |
| | N-N’ | 2336.57 | -662.87 | East |
| | O-O’ | 0 | -1600.41 | East |

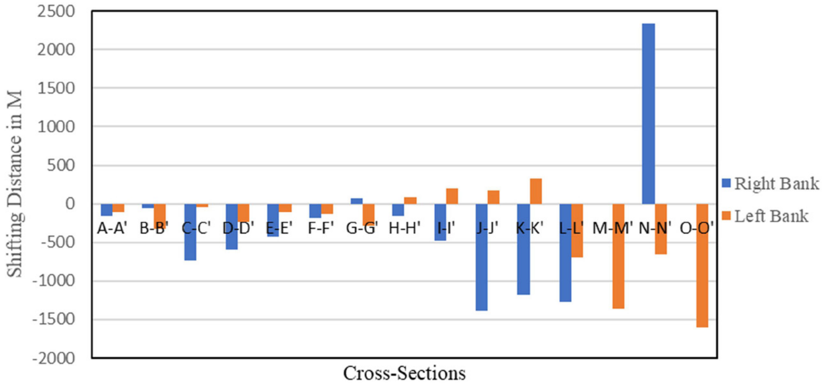
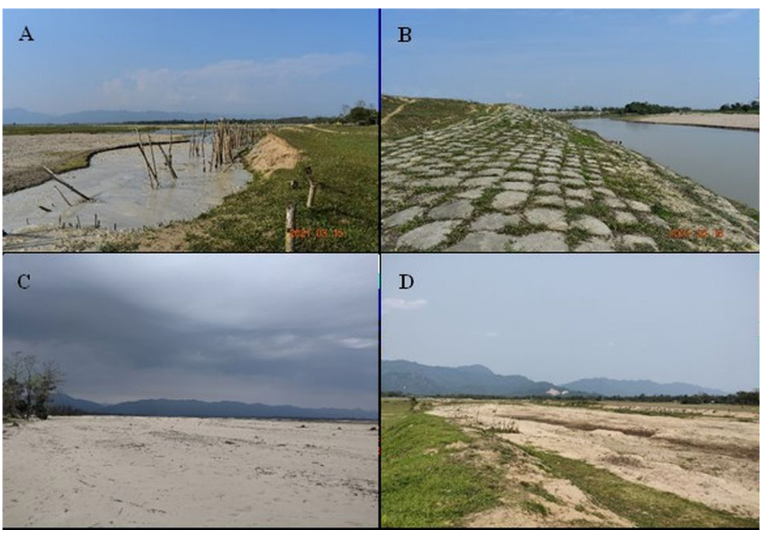



Fig. 9. Shows the shift in Left and Right Bank due to Bank-erosion and Sediment-deposition

5 and Fig. 9 that the RB erosional process was more compared to the LB. During the period from 2007 to 2017, the RB was more vulnerable to bank-erosion and channel shifting. After the flood of 2014, the river Jiadhal abandoned its older channel and created a new channel and the portion of the Jiadhal River water is carried by the Koran branch of the river. There are many other sites of bank-erosion near the Koran River that prove the shift in the river course.

## 5. Conclusion

The floodplain region of the Jiadhal River catchment is one of the most hazardous in the district of Dhemaji. Due to the high-water velocity in the river, the river gets eroded on both the sides of the banks and the bed of the river rises due to high alluviation. The channel-changing analysis provides area-wise variation in distances to directions the channel has been shifted. The intermediate part and the lower course of the Jiadhal River were mostly affected by bankline shifting, and sediment-deposition which later resulted in an immense loss of settlement and agricultural land use. The river usually becomes unstable during the flood period and causes a serious impact on the surrounding areas. Moreover, significant bank erosion and bankline migration are




A. Protecting the river bank using bamboo, B. Protecting the embankment using geotags
C. Sediment Deposition within the river bed, D. An abandoned channel of the river Jiadhal

also seen along the new course of the river Jiadhal. The erosion along the new channel is causing channel widening and the areas used for human settlement and crop cultivation are turned into wasteland.

In recent times, the LB of the Jiadhal River is more susceptible to bank-erosion and an unstable situation of the river is seen in the eastern side of the Dhemaji district. Moreover, embankments and barriers have also increased the rate of in-channel sediment-deposition.

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