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Monitoring channel dynamics of Burhi Dihing River using multi-temporal satellite data

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ABSTRACT

River channel is considered as a dynamic entity in the fluvial system. The Burhi Dihing river is an important south bank tributary of the river Brahmaputra, characterized by highly dynamic and unstable channel variations. The present study deals with the channel dynamics of river Burhi Dihing from Miau, Arunachal Pradesh to Dihingmukh, Assam using remote sensing techniques. Study of channel area, channel length, braiding index, sandbars and fill and erosion has been carried out for the period 1989-1999,1999-2008 and 2008- 2018 by dividing the study area into 6 grid at 15' longitudinal interval. The river is witnessing more progression changes then regression changes as in last three decade the total amount of deposition done by the river is 3935.964 hectares whereas the total amount of erosion done by the river is only 1552.961 hectares. The area of the channel is decreasing from 102.78 sq km in the year 1989 to 78.949 sq km in the year 2018. During the last three decade, i.e. from 1989 to 2018 the river have has become more braided as in the year 1989 the B.I was 1.76 which have increased to 1.96 in the year 2018 as well as the total number of sandbars have also increased from 208 in the 1989 to 405 in 2018. The outcome of the study is obtained by using the Toposheet, LANDSET ETM image and Google earth images in QGIS 2.14 software.

Key words : *Channel Dynamics, River flow, Sandbars, Remote Sensing, Burhi Dihing*

Introduction

Rivers are a dynamic and increasingly important part of the physical environment. Channel dynamics describes the capability of geomorphic processes to modify the channel form, gradient and pattern of the river (Miller *et al.,* 2009). A large part of the earth surface is composed of fluvial system of all sizes (Schumm, 1977) in which fluvial processes are acting to meet the complex responses. In this complex system processes are active in different magnitude. Schumm has rightly pointed out that an idealized fluvial system is composed of geomorphic and dynamic process component zone. The sediment and water producer comprises of (Zone1), the transfer component (Zone 2), and the deposition area (zone 3). Studying river channel dynamics is an important way to know and understand better about the different mechanisms that rule the functioning of the fluvial systems and also helps in forecasting its future evolution to be made and appropriate adaptation measures to be taken by society in front of the risks related to the fluvial dynamics (Zaharia *et al.,* 2011). Vegetation also exert a significant influence over fluvial process and controls the river channel dynamics (Hickin, 1984). Natural changes such as imperceptible precipitation variations, are likely to have contributed to the changes in a channel dynamics of a

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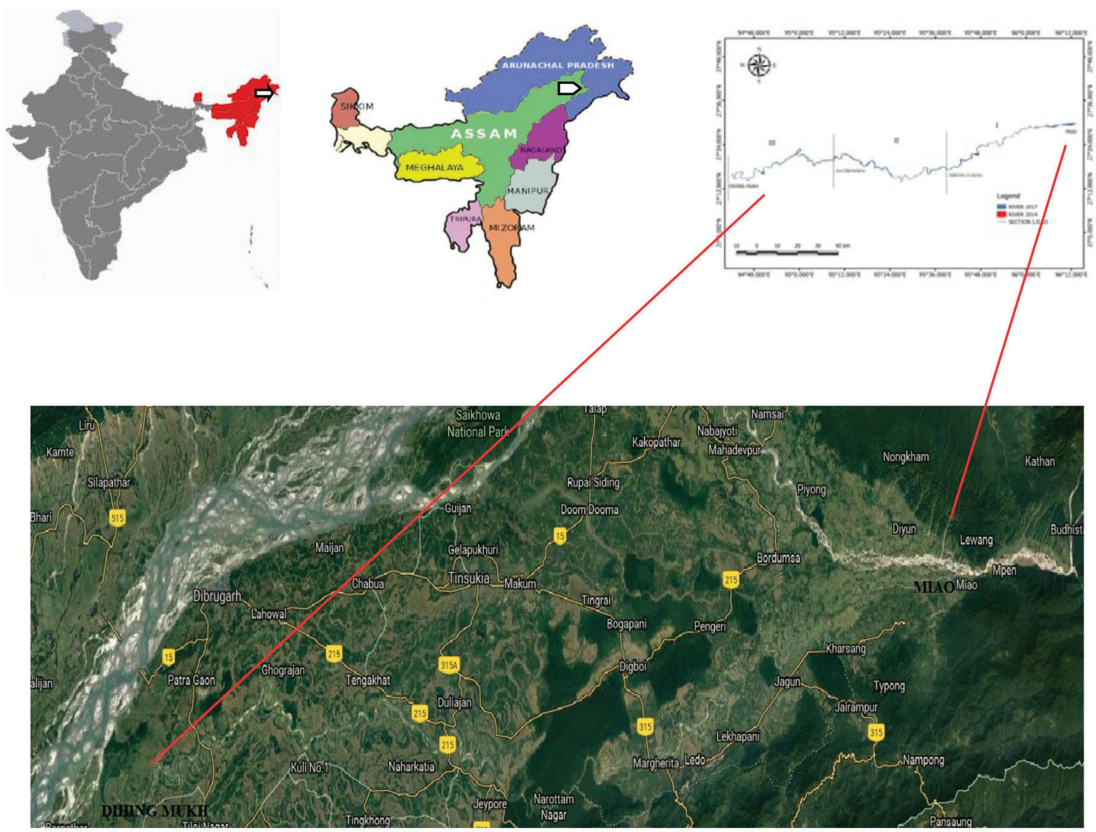
river but the role and signifance of human activities have been far greater (Billi *et al.*, 1997). Fluvial processes perform erosion, transportation and deposition functions. These processes transport much of the material produced by mass- movement from higher places and deposit it in lower places in order to level the land. Understanding of how rivers have developed in the past and are developing and changing in the present is an essential condition to understand how rivers can change in the future. Due to the dynamic nature of the river, its bank line changes, morphology of its bed changes through erosion and the deposition of various sizes of sediment load depending on the competency and capacity of the flow and different types of bars are formed. Riverbank erosion and channel shifting studies by various researchers are done in the last few years. However research on spatio temporal changes on channel dynamics by using GIS technology on the river Burhi Dihing after Noa Dihing joining the Brahmaputra are very few. Monitoring such changes forms an important part especially in an agro-based economy, which will lead to a better management of the riverine resources for future planning and development. Therefore, in this paper an attempt has been made to investigate the dynamic nature of the river Burhi Dihing of North east India from 1989 to 2018 with geospatial techniques.

This multidisciplinary study of the river is expected to be helpful for hydrologists as well as to the geomorphologists.. The better understanding of the river will also help the planners for better use and management of riverine resources.The main objectives are:

1. To analyse the channel dynamics of river Burhi Dihing from Miao, Arunachal Pradesh to Dihingmukh, Assam.
2. To calculate channel area, braiding index, channel length and fill and erosion.
3. To evaluate the amount of fill and erosion done by the river.

Study Area

The river Burhi Dihing is one of the biggest south bank tributaries of the Brahmaputra River in the North east India. The Burhi Dihing originates in the Patkai hills at the elevation of 2375 m. After flowing for about 80 km it meet the plains and runs through



Map 1. Showing the study area at a glance.

the alluvium of Assam valley for about another 300 km in a meandering pattern before joining the Brahmaputra at Dihingmukh. Its drainage basin lies in the states of Assam and Arunachal Pradesh. The Burhi Dihing basin occupies an area of about 8730 sq.km. (Bhagawati *at el.,* 2007) and receives an annual rainfall varying from 2100 mm to 3880 mm. Within its catchment area there are wide contrast of relief, slope, lithology, vegetation, and land use. There are two sources of Burhi Dihing river, a small stream from Na Dihing river bifurcated at Miao and came down to form this wide river. Another source of Burhi Dihing came from the deep forest of patkai range of Nagaland and nearby hills of Arunachal Pradesh.The present study is conducted on Burhi Dihing river from Miao, in Arunachal Pradesh to Dihing Mukh of Sibsagar district. The river Burhi Dihing basin is located between 27 ^{0} 15′ 55′′ N Latitude to 27^0 20′ 00" N Latitude and 94^0 42′0′′ E longitude to 95^{0}42′20′′ E longitude. The location of the study area from Miau to Dihing Mukh is from 27^0 15 ′ 43.59 ″ N to 27 ^{0}29 ′ 39.11 ″ N and 94^0 42' 12.85 ″ E to 96^0 12 ′ 53.63 ″ E

Materials and Methods

The spatio-temporal analyses carried out in this study are based on the changes of the Burhi Dihing River using Topographic maps, Google earth images and multi-temporal Landsat satellite images from 1989 to 2018 through Remote Sensing (RS) and Geographic Information System (GIS). In this study, georeferenced Toposheet no. 83 I/15, 83 I/16, 83 I/ 11,83 M/3, 83 M/7, 83 M/11, 83 M/15,92 A/2, 83 M/4,83 M/8, 83 M/12 and 92 A/3 at 1: 250,000 scale published by Survey of India (SOI) havev been subset and mosaic and LANDSET-8 OLI (Path/Row 134/41,135/41)for the year 2018, LANDSET-5 ETM (Path/Row 134/41,135/41)for the year 2008,1999 and 1989 have been freely downloaded from United States Geological Survey (USGS) earth explorer and Google earth images were used for identifying the dynamics of the river using the QGIS 2.18 softwere.

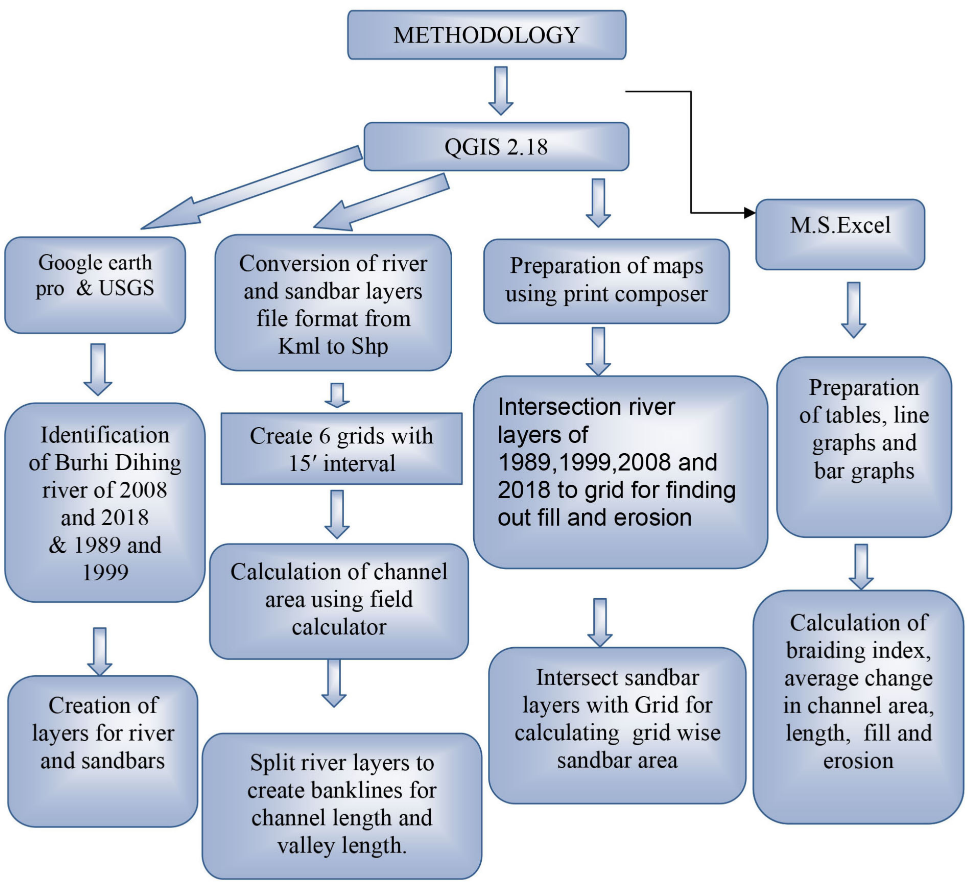


Fig. 1. Map of the Study Area

Results and Discussion

Channel Length

Channel length of a river refers to the curvilinear distance measurement along the centre of the channel (T. Endreny). The length of a stream is the distance measured along the stream channel from the source to a given point or to the outlet, a distance that may be measured on a map or from aerial photographs.

The result obtained after calculation shows that the curvilinear distance of Burhi Dihing from Miau to Dihing mukh in the year 1989 was 257.487 km but after that it has decrease to 239.083 km in the year 1999 (Table 1). This is because the river Na Dihing which is is a important tributary of Burhi Dihing have joined the mighty Brahmaputra in the year 1993 which have resulted in the decrease of the dicharge of the river. Again in the year 2008 the length of the river was 245.92km which have decreased to 242.53 in the year 2018 because the amount of rainfall have decreased in the year 2018 which have resulted in the decrease of the river discharge

Channel Area

Channel is a type of landform consisting of the outline of a path of relatively shallow and narrow body of fluid, most commonly the confine of a river, delta or strait. Channel can be either natural or human made. A channel is typically outlined in terms of its bed and banks. Natural channels are formed by fluvial processes and are found across the earth. These are mostly formed by flowing water of the hydrological cycle. Channel area refers to the amount of land which is drained by a river confining to their banks.

Table 1. Channel Length of Burhi Dihing (Grid wise)

Grids	Channel Length (km) 1989	Channel Length (km) 1999	Channel Length (km) 2008	Channel Length (Km) 2018
1	57.324	50.596	51.559	51.497
2	40.965	43.856	47.029	45.019
3	52.774	48.301	49.095	46.206
4	46.703	44.981	49.583	45.742
5	39.853	39.291	44.074	42.399
6	10.816	10.531	11.555	11.664
Total Cummulative Length	257.487	239.083	245.92	242.53

Source: Data collected by researcher

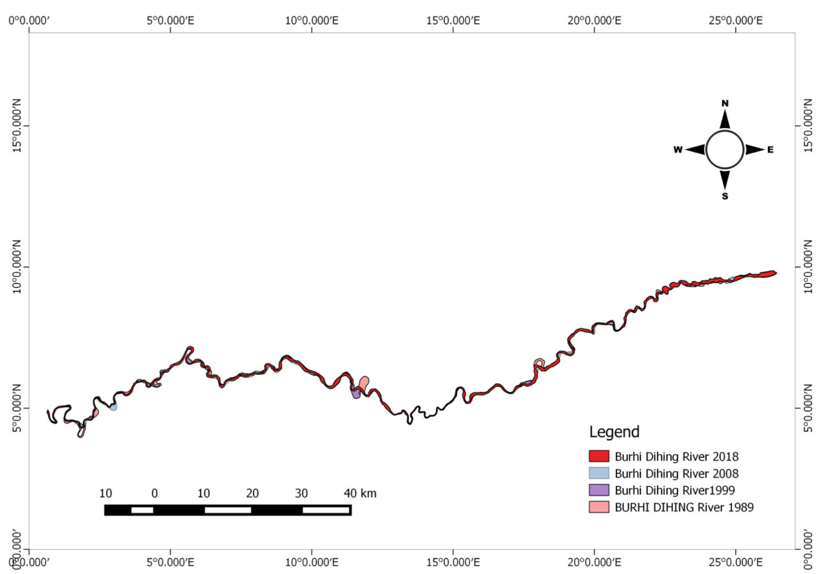


Fig. 2. River Burhi Dihing for the period (1989-2018)

The channel area of Burhi Dihing river is measured by using GIS software from Miau to Dihing mukh for the year 1989, 1999, 2008 and 2018. The study area is divided into six grids and then the total area is calculated.The result so obtained reveals that there is immense variation in channel area both spatially which is indicated in the sectional difference in channel area in the six grids and also temporarally which is indicated from the temporal difference in the channel area. (Table 2). And when

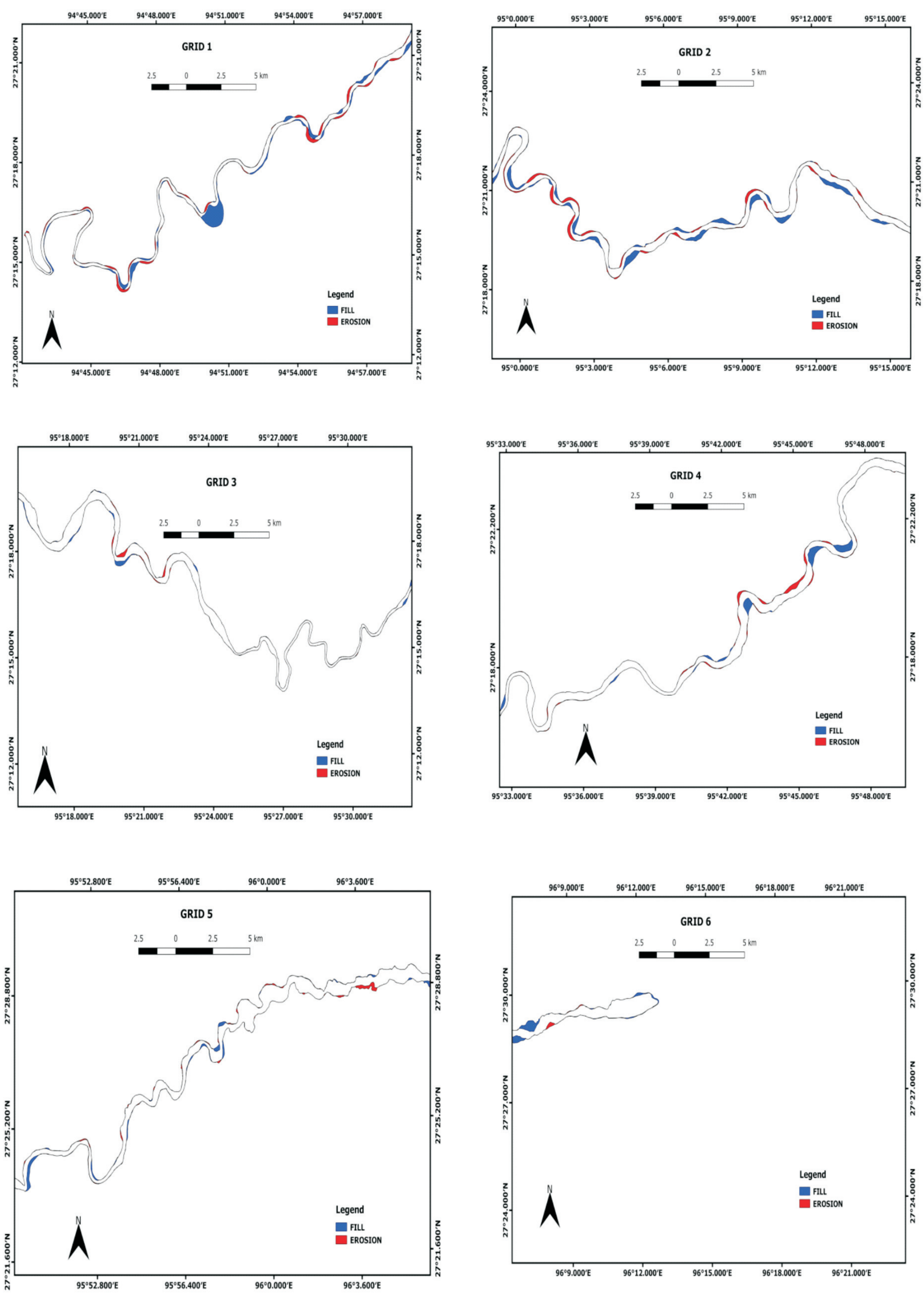


Fig. 3. Amount of fill and erosion for the period 1989-2018 (Grid wise)

Table 2. Channel Area of Burhi Dihing grid wise)

Grids	Channel Area 1989 (in sq km)	Channel Area 1999 (in sq km)	Channel Area 2008 (in sq km)	Channel Area 2018(in sq km)
1	17.981	14.847	12.478	10.755
2	17.974	17.085	16.361	14.996
3	19.772	17.787	13.274	13.264
4	20.176	17.901	17.903	17.428
5	19.910	13.228	16.641	16.365
6	6.967	6.796	6.922	6.141
TOTAL	102.78	87.644	83.579	78.949

Source: Data collected by researcher

we consider the channel area as a whole for the years 1989 we observe that in 1989 the channel area was 102.78 sqkm which have decreased to 87.644 sq.km in the year 1999. Again in the year 2008 the area was 83.579 sq.km which have further decreased to 78.949 sq.km in the year 2018. This clearly shows a decreasing pattern in the channel area. Which is maily because the river is doing more deposition then the accretional activity.

Fill and Erosion

The rivers are system in dynamic equilibrium. It balances water flow and sediment transport. Free flowing rivers tend to reach a state of equilibrium by a process of erosion and deposition. Erosion at one location is roughly balanced by deposition at another.

The amount of fill and erosion for the period 1989-2018 has been calculated by diving the study area in six grids. The amount of fill and erosion for period 1989 to 1999 is given in Table 3. The result so obtain after calculation shows that the amount of deposition or progessional change done by the river is 2970.407 hectare whereas the amount of erosion or regressional change done by the river by is 1456.837 hectare.

The amount of fill and erosion done by the river in study area for the period 1999-2008 is given below in Table 4. The result so obtain reveals that during the decade from 1999 to 2008 the river "Burhi Dihing" have done deposition more than erosion which is 1783.198 hectare compared to 1376.786 hectare of erosion.

The amount of fill and erosion done by the river in study area for the period 2008-2018 is given below in Table 5. The results so obtained after calculation shows that even in the period 2008 to 2018 the river have done more deposition which is 1132.913 hectare compared to 692.598 hectare of erosion done by the river.

Table 3. Amount of fill and erosion for the period 1989-1999

Grids	Fill (in hectares)	Erosion (in hectares)
1	657.63	344.25
2	411.953	323.051
3	528.39	329.933
4	473.591	246.094
5	789.82	121.548
6	109.023	91.961
TOTAL	2970.407	1456.837

Source: Data collected by researcher

Table 4. Amount of fill and erosion for the period 1999-2008

Grids	Fill (in hectares)	Erosion (in hectares)
1	370.432	133.593
2	307.172	234.748
3	506.242	54.915
4	266.042	266.299
5	257.187	598.511
6	76.123	88.72
Total	1783.198	1376.786

Source: Data collected by researcher

The amount of fill and erosion done by the river in study area for the period 1989-2018 is given below in Table 6.

The result so obtain after calculation reveals that as a whole for the entire period from 1989-2018 the river Burhi Dihing have done more deposition which is 3935.964 hectare compared to erosion which is 1552.961 hectare which is mainly because one of the major tributary of Burhi Dihing, the river Nao Dihing have joined the river Brahmaputra re-

Table 6. Amount of fill and erosion for the entire period 1989-2018

Grids	Fill (in hectares)	Erosion (in hectares)
1	1087.796	365.206
2	808.81	510.936
3	827.584	176.816
4	565.803	291.071
5	504.861	150.337
6	141.11	58.595
Total	3935.964	1552.961

Source: Data collected by researcher

Table 6. Amount of fill and erosion for the entire period 1989-2018

Grids	Fill (in hectares)	Erosion (in hectares)
1	366.87	194.5
2	345.5	208.451
3	65.435	64.451
4	174.627	127.135
5	109.356	81.78
6	71.125	15.183
Total	1132.913	692. 598

Source: Data collected by researcher

sulting in the decrease of the discharge of the river Burhi Dihing which is main power of the river to carry out its erosional activities.

Sandbars

A bar in a river is an elevated region of sediment (such as sand or gravel) that has been deposited by the flow. The term bar is used for any major element in the river bed which is either exposed or slightly submerged (Sarma, 2005). Different types of bar includes longitudinal bars, lateral bars and transverse bars etc. Among all the bars the most important bar for the river Burhi Dihing is the lateral bars along with some small mid channel bars. The result so obtained (Table 7) after analysis reveals that the number of sandbars formed by the river varies very year. In the year 1989 the number of sandbar formed by the river was 208 which have decreased to 165 in the year 1999. Again in the year 2008 the number of sandbars formed by the river was 288 which almost doubled in the year 2018. This variation are mainly because river is a dynamic entity which mainly do three main work erosion, transportation and depositions and the amount of erosion and deposition done by the river varies very year so is the number

Table 7. Total number of sandbars for the period 1989-2018

Grids	Sandbars (1989)	Sandbars (1999)	Sandbars (2008)	Sandbars (2018)
1	38	38	43	48
2	32	27	53	54
3	40	31	74	84
4	37	39	72	98
5	45	22	41	105
6	16	8	5	16
Total	208	165	288	405

Source: Data collected by researcher

of sandbars which is mainly a depositional feature.

Braiding Index

The most used parameter to study the channel pattern variation is the Braiding index. The braiding index depends on the water discharge flowing in the river and the amount of deposition done by the river.

Brice (1964) devised a braiding index based on the length of bars and islands in sand bed braided rivers. Brice's (1964) braiding index (BI) is defined as follows:

$BI=2(\Sigma Li)/Lr$

Where ΣLi is the total length of bars and (or) islands in the reach, and Lr is the length of the reach measured mid way between the banks. A total braiding index of 1.50 was selected by Brice to differentiate braided from non braided reaches.

The braidiong index of the river Burhi Dihing shows a varition. In ther year 1989 the braiding index of the river was 1.76 which have decreased to 1.68 in the year 1999 again in the year 2008 the braiding was 1.51 which have increased to 1.96. Overall the river Burhi Dihing is a braided river because in the all years the braiding index was above 1.50 which clearly indicates the river to be a braided one.

The results from various studies and factor analysis in this study reveals that rivers plays a significant a role in the prosperity of the economic development of India which is mainly dominated by agrarian economy. But at present day most of the rivers and riverine ecosystem are dwindling because of anthropogenic and natural causes. Burhi Dihing river is one of the important monsoon dominated river of North east India which carries out almost all the geomorphic works of erosion, transportation and deposition during the monsoon season. The

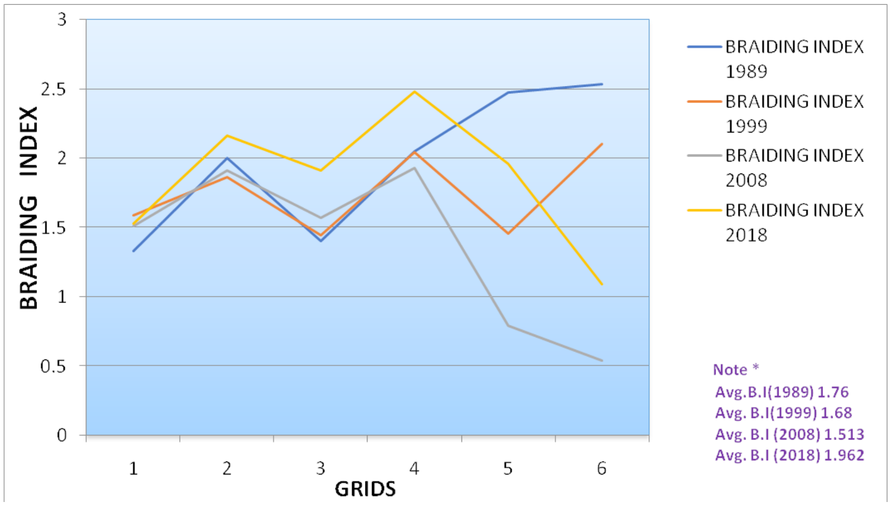


Fig. 4. Graph showing the braiding index for the period (1989-2018)

river is highly dynamic and it also represents a unique example of highly unstable drainage system. For this reason it is necessary to understand the topographical and hydrological characteristics of the Burhi Dihing river and its processes through geospatial approaches. This multidisciplinary study of the river is expected to be helpful for hydrologists as well as to the geomorphologists. The better understanding of the river will also help the planners for better use and management of riverine resources.

Conflict of interest (Previous works)

Several researcher and organisation have examined on the various aspect of channel dynamics on a global scale. Billi and Rinaldi (1997) investigated the human impact on sediment yield and channel dynamics in the Arno river basin of Italy. Hickin (1984) had considered the impact of vegetations in the channel dynamics of a river. Miller and Kochel (2009) had made an assessment of the channel dynamics in stream structuring and steam restoration on 26 various streams of North Carolina. Langat *et al.* (2019) had studied on the channel dynamics of the Kenya's longest river Tana river using Remote sensing and GIS techniques. Aisuebeogun and Ezekwe (2014) studied on channel dynamics and hydraulic geometry of two tropical deltaic catchment in Southern Nigeria at 10 different stations. Sarma, *et al.* (2022) explored the changes in river channel dynamics using geospatial approaches of the Satluj river. Vercruysse and Grabowshi studied on the impact of human on channel dynamics of Beas and Sutlej river. Geological Survey of India carried out geomorphological study of the Brahmaputra basin in India from time to time of which Burhi Dihing in an important south bank tributary. Goswami (1985) have made a study on the physigraphy, basin denudation and channel aggradation of the Brahmaputra river. Dhar (2000) studied on the flood problem of the Brahmaputra River. Sarma (2005) had made a study on the fluvial process and morphology of the Brahmaputa River in Assam. Sarma (2005) studied on Bank erosion and Bankline migration of the Brahmaputra river during the twentieth century. Lahiri (2012) studied on the Tectonic controls on the Morphodynamic of the Brahmaputra river. Sarma and Basumallick (1984) carried out a detail study on the Bankline migration of the Burhi Dihing river in india. Sarma and Basumallick (1986) studied on the channel form and process of the Burhi Dihing river. Sarma(1986) carried out a detailed study on the transportation of the sediment by Burhi Dihing river for the period 1972-1982. Sarma (2007) studied on Changes of river channel and Bank Erosion for the period 1934-2004.A detailed study on channel dynamics of Burhi Dihing is very much essential because rivers are very dynamic and changes both spatially and temporally and study on channel dynamic of the Burhi Dihing is not much done after 1993 when Noa Dihing one of the important tributary of Burhi Dihing joined the mighty Brahmaputra which made a significant change in the morphometrical characteristics of the Burhi Dihing river.

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