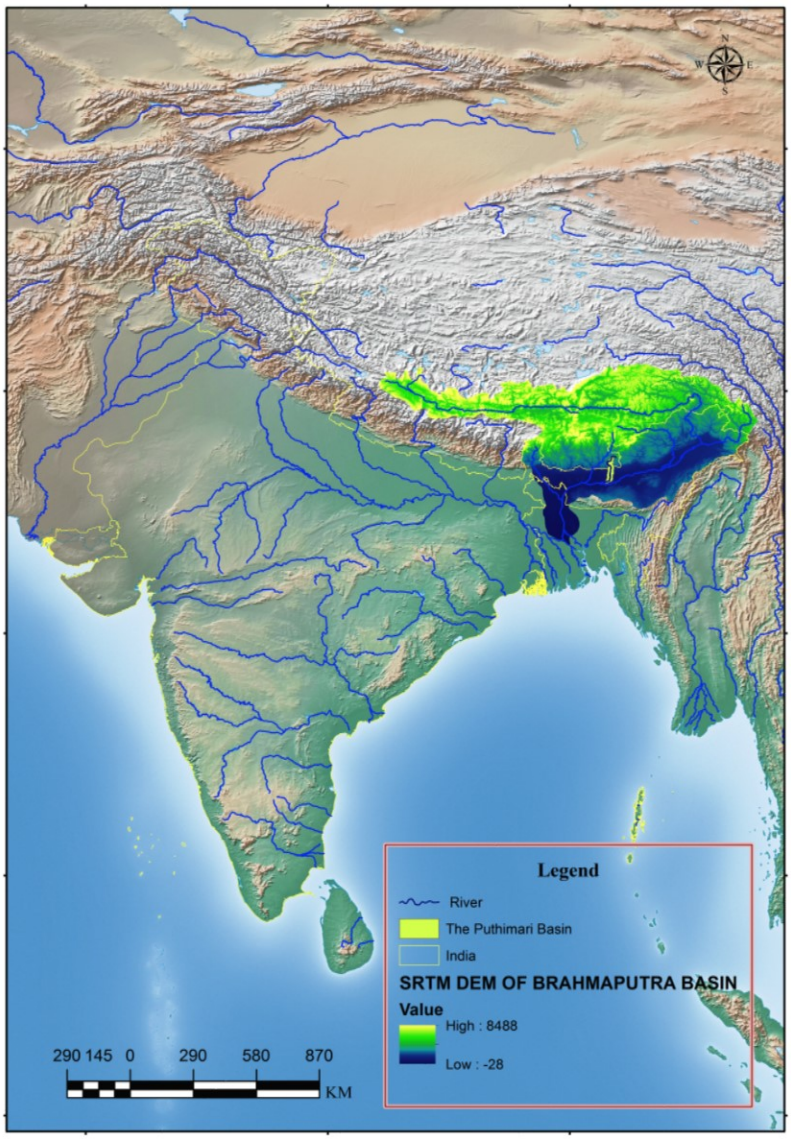
EFFECTS OF GRADATIONAL PROCESSES ON RIVER MORPHOLOGY: SOME EXAMPLES FROM BRAHMAPUTRA VALLEY

(LECTURE NOTES)



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DEPT. OF GEOGRAPHY
BHATTADEV UNIVERSITY, BAJALI

MA/MSc Fourth Semester
Course No. GGY 4214 (3)
Course Name: Fluvial Geomorphology
Unit I: Channel Form AND Processes (40 Marks)
4. Processes of Channel Erosion and Deposition, Channel Agradation & Degradation –Their Effects on River Morphology…
A Syllabus for CBCS Based PG Corse in Geography, 2017
Department of geography
Gauhati University
&
MA/MSc Fourth Semester
Paper Code: 4206 (3)
Course Name: Fluvial Geomorphology
Unit II: River Basin Management (40 marks)
2. Fluvial geomorphology of the Brahmaputra Valley…Geomorphology of Majuli Island
Department of geography
Gauhati University

Course Objectives:

1. To familiarize the students with the gradational processes of river,
2. To make the students understand about the effects of gradational processes on river morphology and
3. To acquainted the students with the relationships of gradational processes and river morphology taking examples from the Brahmaputra valley.

Course Outcomes:

1. The students will enrich themselves with the concept of river processes.
2. The students will learn about the acute problems of Brahmaputra River through fluvio-geomorphologic analysis.
3. The students will be able to realise the importance of fluvial-geomorphologic analyses and their applications in day to day life.

EFFECTS OF GRADATIONAL PROCESSES ON RIVER MORPHOLOGY: SOME EXAMPLES FROM BRAHMAPUTRA VALLEY

Dr. P. K. Roy

Introduction:

The Brahmaputra is a major transnational river covering a drainage area of 580,000 sq. km., 0.5 percent of which lie in China, 33.6 percent in India, 8.1 percent in Bangladesh and 7.8 percent in Bhutan. Its basin in India is shared by states of Arunachal Pradesh (41.88%), Assam (36.33%), Nagaland (5.57%), Meghalaya (6.10%), Sikkim (3.75%) and West Bengal (6.47%). Originating in a great glacier mass at an altitude of 5,300 m just south of the lake Konggyu Tso in the Kailas range about 63 km southeast of Manasarovar lake in southern Tibet, the Brahmaputra flows through China (Tibet), India and Bangladesh for a total distance of 2880 km before emptying itself into the Bay of Bengal through a joint channel with the Ganga. Its total length comprises of 1625 km in Tibet, 918 km in India and 354 km in Bangladesh. Records show that devastating floods occurred in 1954, 1962, 1966, 1972, 1973, 1977, 1978, 1983, 1984, 1987, 1988, 1991, 1993, 1995, 1996, 1998 and 2004. Upwards of 9600 km^2 land, that is 12.21% of the geographic area of Assam, is annually affected by floods. In 1998, the flood which came in four frightening waves, deluged 38,200 km^2 or 48.65% geographic area of the state, putting in peril the lives and properties of 12.5 million people (Goswami, 1998). The Brahmaputra River and its tributaries have been shown in Figure 1B and a Flow Diagram figure 2.

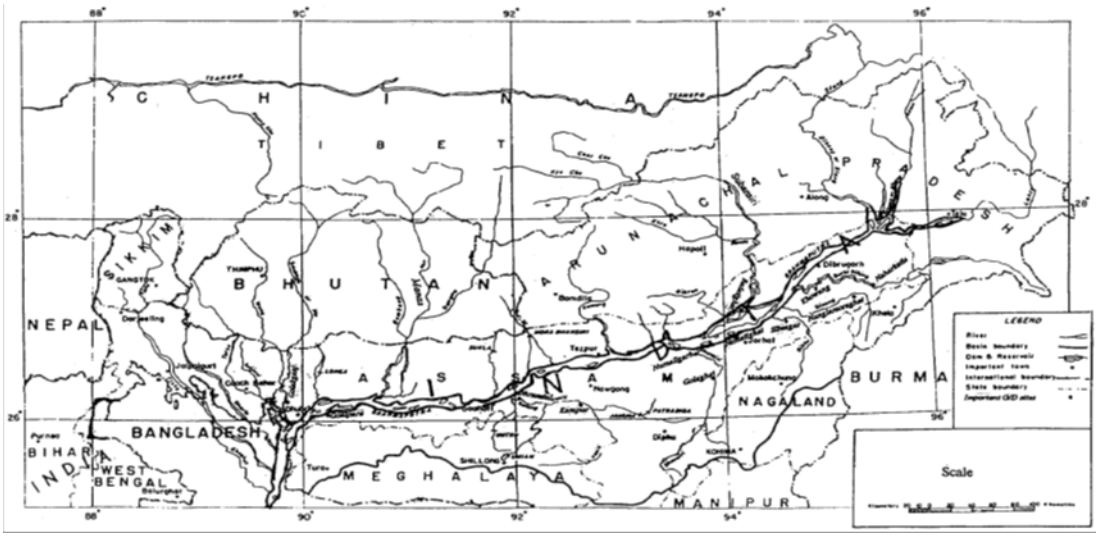

Figure 1A: The Brahmaputra Valley

The course of the Brahmaputra River can be divided into three reaches: upper, middle, and lower.

Upper Reach:

In its upper reach, the river flows 1,625 km from the source to the Indo-China border through Tibetan plateau with an elevation from 3,000m to 5,000 m, mainly in the east direction almost parallel to the Himalayan mountains and north thereof. Here, the river is known as Tsangpo, which means 'the purifier'. After flowing for 80 km in an easterly direction,

Tsangpo meets two big rivers, viz., Mayum Chu and Chema Yung Dung. The main river is about 160 km north of the Himalayas. The drainage area spreads to a maximum of 80 km to the south and 135 km to the north from the Tsangpo.

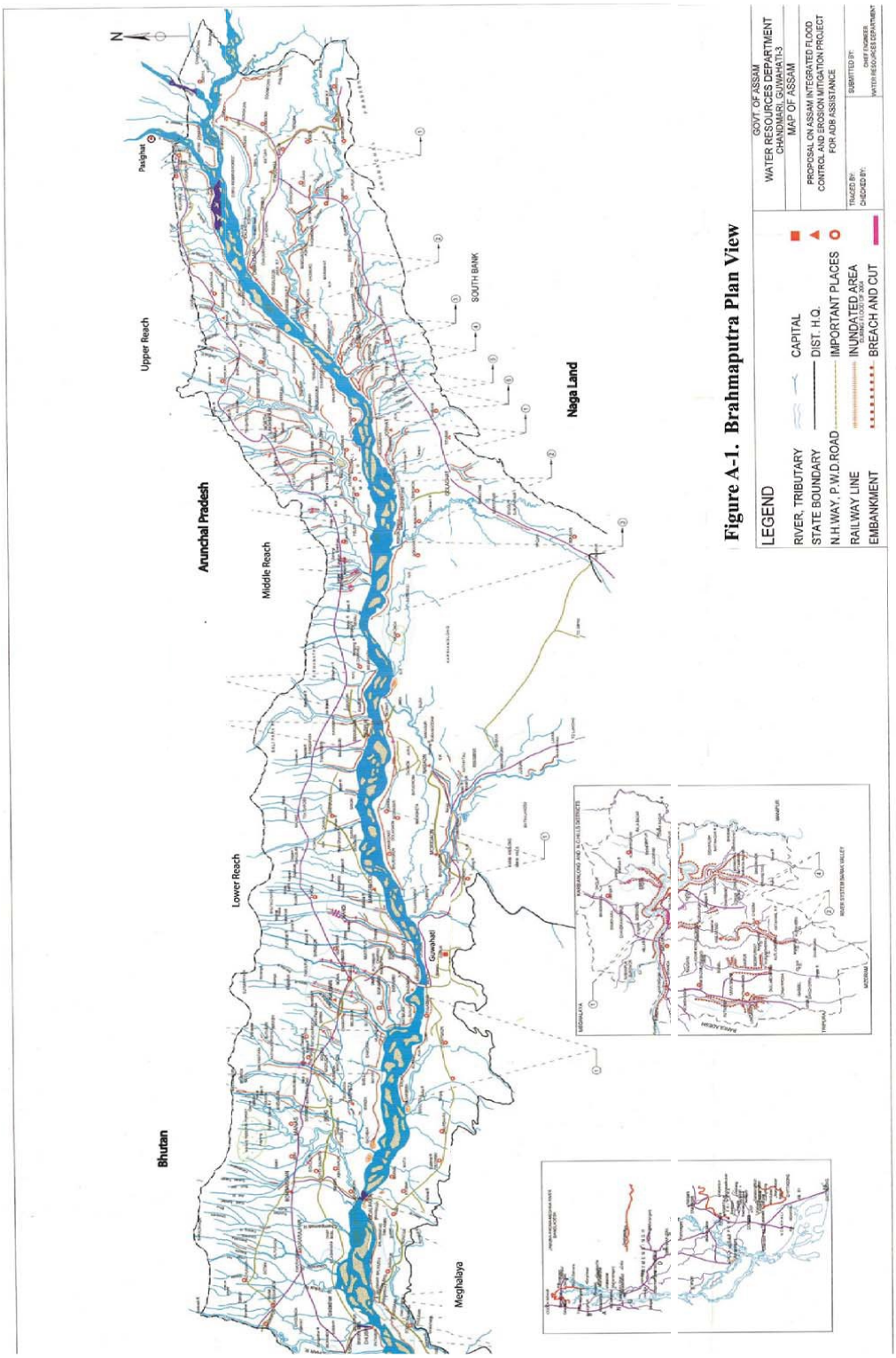

Figure 1B: North bank and south bank tributaries in Brahmaputra Valley

The catchment area of the Brahmaputra River up to the Indo-China border is 293,000 sq. km; this part of the catchment falling under high Tibetan plateau is 50.5% of the total catchment area. The basin here is long and narrow; the maximum length in the east-west direction is 1,540 km and the maximum width in the north-south direction is 310 km. This part of the basin is bounded in the south by Himalayan ranges and in the north-west side initially by the Kailash ranges of Himalayas and then by the Nyenchentanglha mountain ranges. The 650 km reach from Pindzoling to Gyatsa Dzong is one of the most remarkable inland navigable systems in the world where boats ply at an altitude of 3,659m and more. In this part, the average width of the river is more than 2 km. Along this reach, the major tributaries joining the Tsangpo are the Shap Chu, Nayang Chu, Rang Chu, Yarling Chu on the right bank and the Tong Chu, Shang Chu, Kyi Chu on the left bank. Of these, the Nayang Chu and Kyi Chu are much bigger. Nayang Chu, a snow fed river, passes east of the great trade centre of Shigatse to meet Tsangpo. The Kyi Chu or the Gya Chu is the largest tributary of the Tsangpo in Tibet which flows for about 300 km.

After 92° E longitude, the river flows through deep gorges till it comes near 93° E longitude where a major town, Gyatsa Dzong, is situated on the left bank. Near Gyala (Linzhi), it takes an abrupt turn towards northeast and flows through stupendous gorges between the huge mountains of Gyala Peri (7,150 m) and Namcha Barwa (7,755 m). Here the river flows through a series of cascades and rapids taking numerous hairpin bends. A major tributary, Po-Tsangpo, joins the river here from north. About 1.6 km before the Indo-China border is the only known fall of about 24.4m on the main river. Although Tsangpo has an easterly course throughout its run the north of the Himalayas, a large number of its small and large tributaries flow in the westerly direction. They meet Tsangpo by flowing from the opposite direction thereby developing a barbed type drainage pattern. This feature has led to the speculation that the Tsangpo might originally have flowed westwards.

In the eastern part of the Tibetan plateau, the Tsangpo River takes a hairpin bend around the Namcha Barwa mountain ranges. Tsangpo arrives at the Indo-China border near Monku at an elevation of 660m and flows for 5 km as the international boundary to arrive at Kobo in Arunachal Pradesh, India, at a chainage of 1,255 km from the mouth of the river. It enters India flowing south and is now known as the Siang River.

Middle Reach:

In the middle reach, from the Indo-China border to the Indo-Bangladesh border, Brahmaputra flows 918 km through India. Of this, 278 km is through the mountainous state of Arunachal Pradesh and the next 640 km is through the valley in the state of Assam. In Arunachal Pradesh, the river is known as Siang in the upper reach and Dihang in the lower reach. The river crosses Himalayas through deep gorges traversing 226 km from the Indo-China border up to the Pasighat town flowing mainly in the southern direction.

From Pasighat up to the Indo-Bangladesh border for a length of 692 km, the river passes through alluvial plains. All along its course in this region, the river flows in a braided form and the main course oscillates from one bank to the other, forming many islands and sand chars. Most of these sand chars are not habitable as they get submerged during high stage. During monsoon months, almost all the braided channels join to form one vast sheet of moving water. The average gradient of the river from the Indo-China border to Kobo within the state of Arunachal Pradesh is 1:515.

Dihang River enters into the plains of Assam at Kobo where it meets two major trans-Himalayan tributaries, Dibong and Lohit, coming from northeast and east, respectively. From here onwards, the combined river is known as Brahmaputra. At the tri-junction of the Dihang, Lohit and Debang, the contribution from the Dihang is about 31.63% of the total discharge. From

Table1: Reach wise distribution of length, catchment area, gradient of the Brahmaputra River and nature of topography through which the river flows

Location (Country the river flows through)	Name river and length (km) in that reach	Catchment area in that part (sq. km) and % of total area	Gradient		Topography of the area
			Reach with Elevation (m)	Average Gradient	
Tibet (China)-(Upper Reach)	Tsangpo (1,625)	293,000 (50.52%)	Source EL = 5, 300 m) to Indo-China Border (EL 660 m)	1:385	High Tibetan Plateau
India (Middle reach)		195,000 (33.62%)			
i) Arunachal Pradesh	Siang in 1st part & Dihang in 2nd part (278)		i) Indo-China border to Kobo (EL 120 m)	1:515	Himalayan mountain region
ii) Assam	Brahmaputra (640)		ii) Kobo to Indo-Bangladesh border (EL 28m)	1:690	Brahmaputra Valley
Bhutan	Main river does not flow here	45,000 (7.76%)	–	–	Himalayan mountain
Bangladesh	Brahmaputra, Jamuna, Padma and then Meghna (337 km up to mouth)	47,000 (up to confluence with Ganga (8.10%)	i) First 60 km. from India Border	1:1,140	Plains including coastal belt
			ii) Next 100 km	1:1,260	
			iii) Next 90 km	1:2,700	
			iv) Rest up to sea	1:3,700	

Kobo, the river flows first in the southwest direction and then in the west direction. The lengths of the river reaches from Kobo to its mouth and to Pasighat are 918 km and 226 km, respectively. The average gradient of the river in this reach is 1:515. River terraces are noticed along the river stretch between Yinkiong and Pasighat. Some of the terraces are 250m high above the river bed.

Further down, the river passes through towns of Tinsukia, Dibrugarh, North Lakhimpur, Sibsagar, Jorhat, and Golaghat. In this reach, the river is a highly braided channel, except at Pandu where it is constricted into a single channel of 1.2 km wide. This is the narrowest point in the entire reach. In this reach, the river is navigable throughout the year and has the important towns of

Tezpur, Naogaon, and Guwahati. Many tributaries meet the river here; the biggest amongst them is the Jia Bhareli which contributes about 4.9% of the total discharge of the Brahmaputra. Downstream of Pandu, many tributaries, notably, the Puthimari, Pagladia, Manas, Champamati, Saralbhang (Gaurang), and Sankosh join the Brahmaputra. Majuli Island (Latitude 26°53/ N and Longitude 94° E), the biggest river island of the world, is the most remarkable feature of the valley reach of the Brahmaputra. It is formed by bifurcation of the Brahmaputra into two branches: the Kherkatiya Suti on the north and the Brahmaputra (Dihing) on the south.

Table2: Topographic distribution of Brahmaputra basin area

S. N.	Nature of Topography	Basin Area under the Topography (sq. km)	Percentage of Total basin area	Geographical Location
1.	High Tibetan Plateau	293,000	50.5	Southern Part of the Tibet province of China.
2.	High Himalayan mountains	137,050	23.6	Part of Himalayan kingdom of Bhutan and of 3 states of India: Arunachal Pradesh, West Bengal and Sikkim.
3.	Brahmaputra Valley	56,200	9.7	Part of Assam State of India.
4.	Lower (Assam) Mountainous Region	37,200	6.4	Part of 3 states of India: Nagaland, Assam and Meghalaya.
5.	Plains	56,550	9.8	Part of the 2 plains districts of West Bengal (India) and part of Bangladesh.
6.	Coastal Region	Negligible		Coastal region of Bangladesh.

Lower Reach:

It covers the lower portion of the river for a length of 337 km from the Indo-Bangladesh border to its outfall into the Bay of Bengal. The whole portion of the lower reach of the river falls within Bangladesh. Near the Indo-Bangladesh border, the Brahmaputra River takes a turn towards south and flows mostly in the southern direction with a little eastward trend. The river flows 225 km from the Indo-Bangladesh border up to Goalundo.

In the reach from the confluence of the Tista River near Bahadurabad to Goalundo, the Brahmaputra River is known as Jamuna. At Goalundo, the Brahmaputra (Jamuna) joins another major river, Ganges-Padma, coming from west and the combined river flows as Ganga-Padma for 80 km. Near Rajabari, a little south of the tropic of cancer, another major tributary Meghna coming from north-east joins it and the combined river flows for 32 km as Meghna River. A little downstream, the Meghna River tri-furcates into three channels forming a delta. The three channels

are: Sandwip (the east channel), Shahbaz (the central), and Tutulia (the western channel). These channels ultimately outfall into the Bay of Bengal forming broad estuaries.

Practically, there is no notable tributary on its east (left) bank in this reach, except the Meghna River. Important tributaries on its west (right) bank are Raidak, Dharla, Tista, and Atrai. The river gradient in this reach varies from 1:11,340 near the Indo-Bangladesh border to 1:37,700 near its mouth.

Bank Erosion/Bank line Migration of Brahmaputra River:

River bank erosion is outcome of fluvial processes. Bank line migration results from gradual and longtime bank erosion or lateral erosion of river. Bank line migration pattern of Brahmaputra River has been the main attraction for the scholars of various disciplines such as Geography, Hydrology, Civil Engineering, water sciences and Geology and for the GIS analysts. Here, some multidisciplinary studies have been mentioned bellow:

Study carried out by Sarkar et al.:

The migration patterns of bank line of various years with respect to year 1990 are graphically represented in Figure 3 to 8. The positive values indicate that the stream bank has shifted northward from 1990 and negative values show vice-versa.

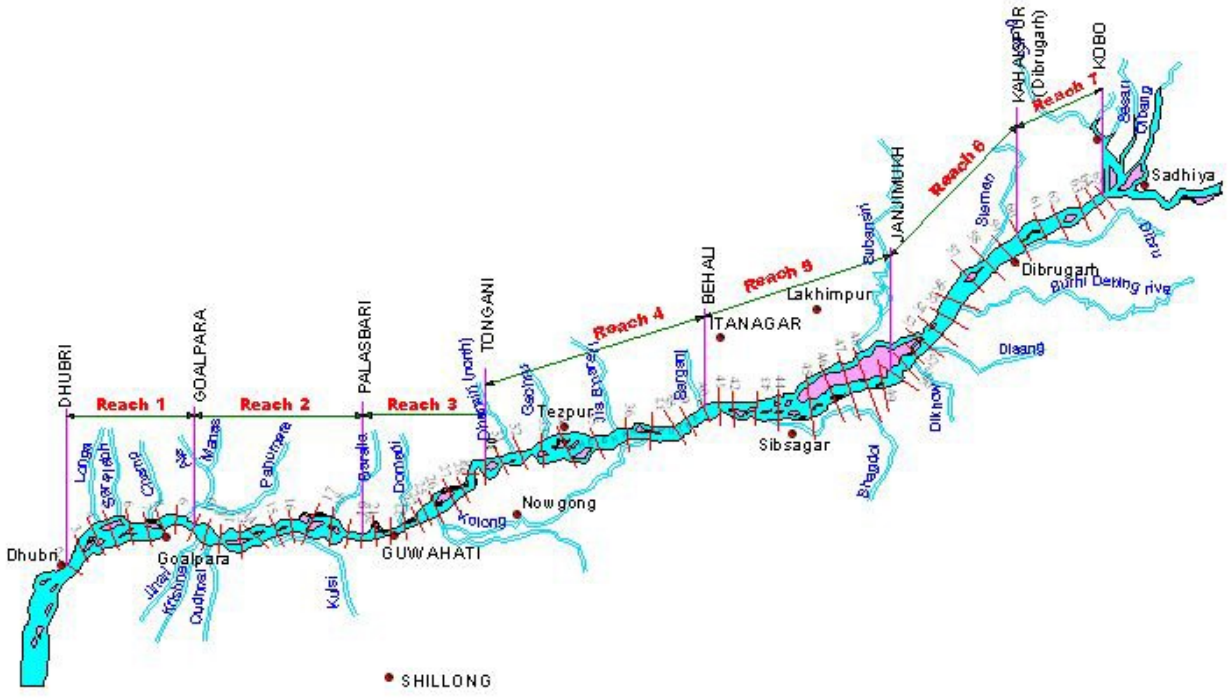

Figure2: Brahmaputra River- from Dhubri (cross section 2 at 17.34 km from Bangladesh border) to Kobo (cross section 65 at 640.07 km)

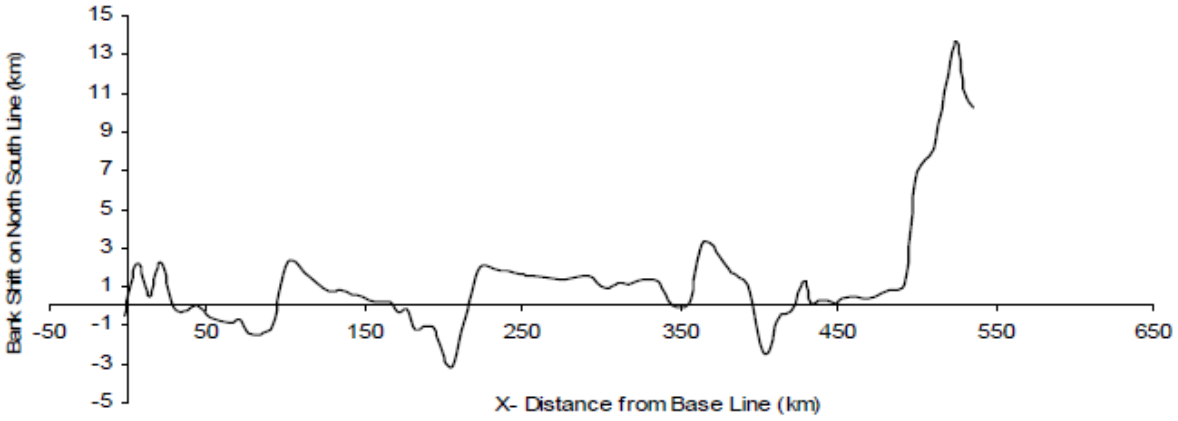

Figure 3 Shift of Left Bank Between 1990-1997

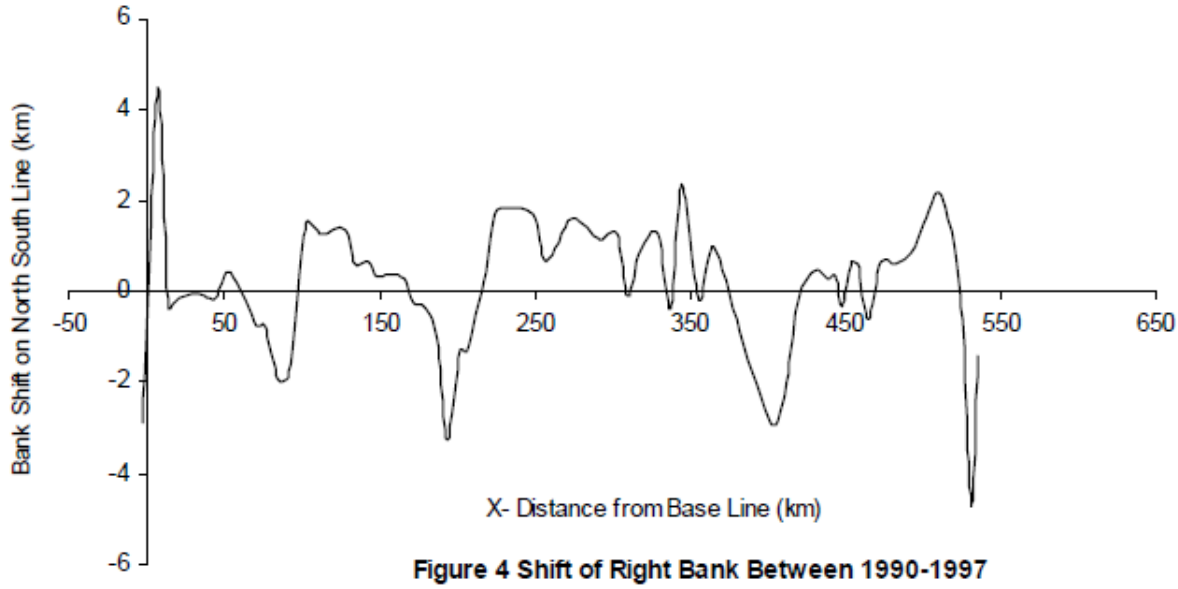

Figure 4 Shift of Right Bank Between 1990-1997

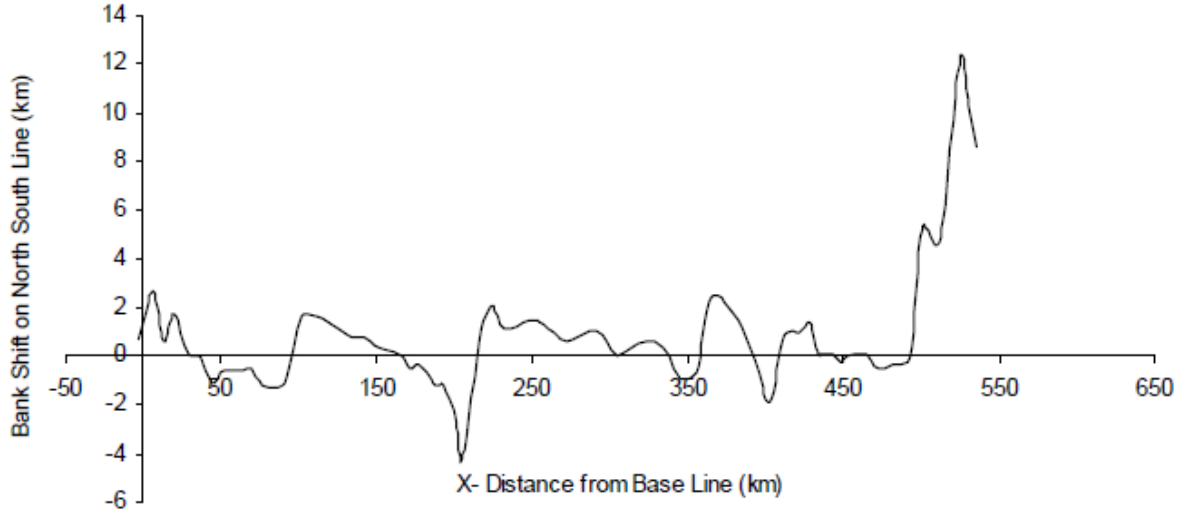

Figure 5 Shift of Left Bank Between 1990-2000

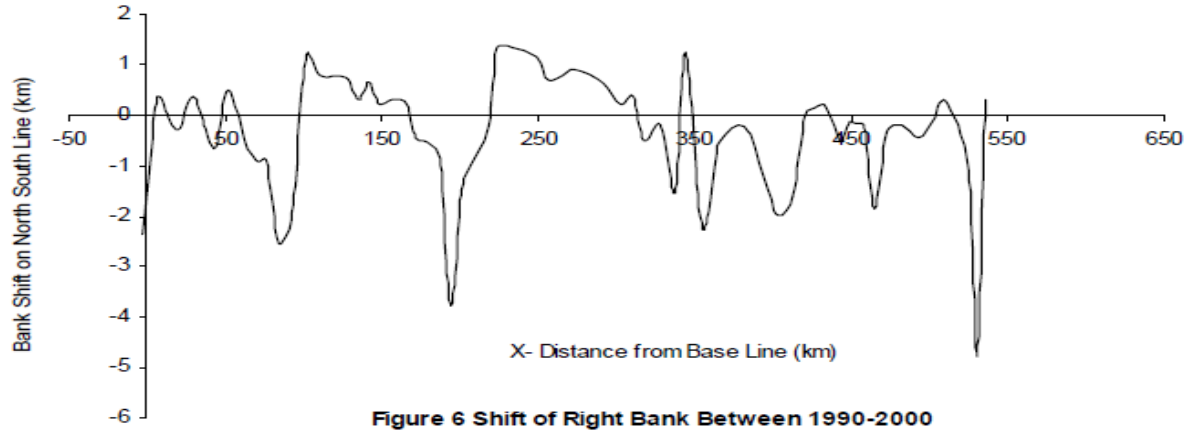

Figure 6 Shift of Right Bank Between 1990-2000

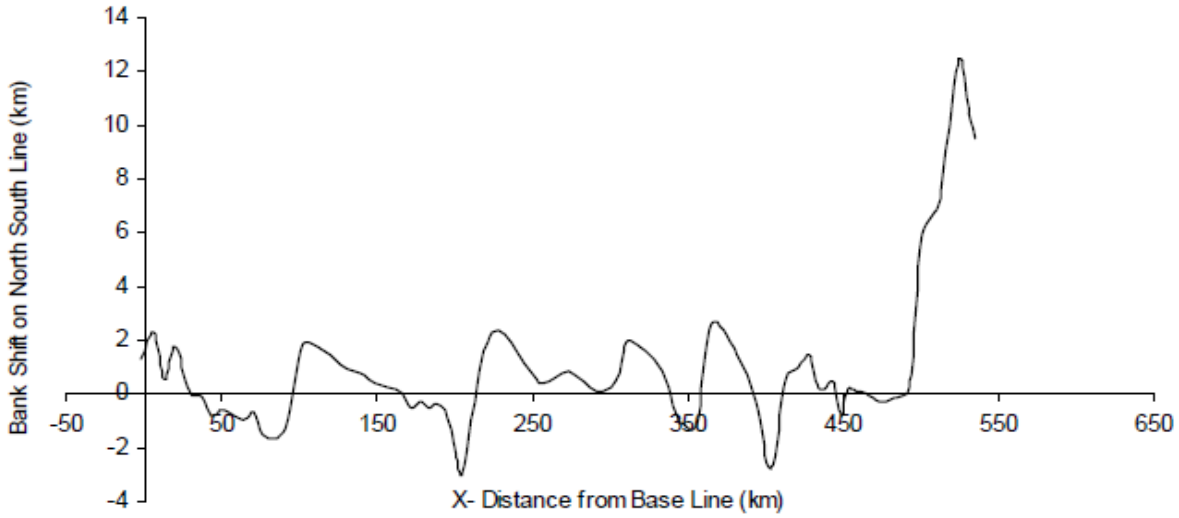

Figure 7 Shift of Left Bank Between 1990-2002

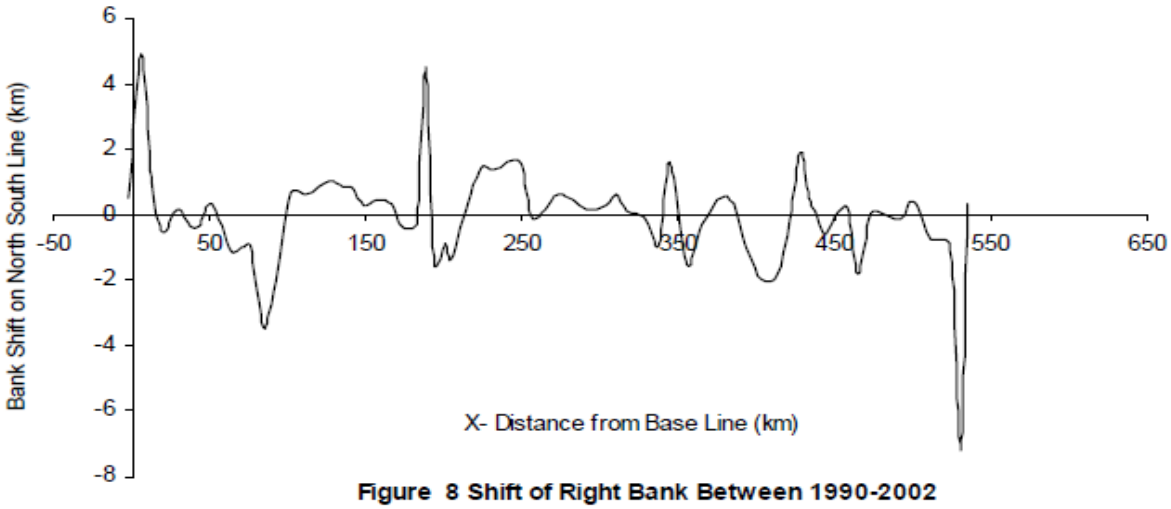

Figure 8 Shift of Right Bank Between 1990-2002

Analysis of bank line migration from Reach-1 to Reach-7:

The discussions of the results pertaining to various reaches are as detailed follows:

Reach – 1

During the years 1990, 1997, 2000 and 2002, there is a mixed trend of erosion and deposition occurrence along the left bank of this lowermost reach. From cross-section 2 to cross-section 6, it shows deposition, while from cross-section 7 to cross-section 10, erosion is observed. In the case of right bank, there is a trend of erosion between cross-section 2 to cross-section 4 and deposition in between cross-section 5 to cross-section 10.

Reach – 2

In this reach, left bank of river displayed migration towards North. It shows that it has deposition tendency. In the case of right bank also, deposition is observed. Thus the whole reach having the length of 89.76 km is influenced by deposition. River is changing its course towards North over this reach. However the width of the river is decreased.

Reach – 3

This reach has a length of 79.5 km. For the left bank, over 9 km length, there is deposition. The remaining 70 km length channel bank is affected by erosion tendency and it is migrating towards South. In the case of right bank, mixed trend of deposition and erosion has been observed. Maximum deposition occurs in between 224.91 km to 251.95 km i.e., from cross-section no 26 to cross-section no 29. River width also is varying. It varies at different cross-sections of this reach. However river width does not change significantly.

Reach – 4

In this reach, all cross-sections on left bank except at cross-section 37 and 40, shows trend of erosion and are migrating towards South. In the case of right bank, there is deposition tendency and it is migrating towards South. Thus left bank shows erosion while right bank shows deposition for the whole reach. River width is decreasing between cross-section 31 to cross-section 33 and where as it is increasing between cross-section 34 to cross-section no 36.

Reach - 5

During the period 1997, 2000 and 2002 the left bank has deposition tendency between cross-section 40 to cross-section 42 and also between cross-sections 46 to cross-section 49. Other remaining cross-sections show erosion along this bank. Similarly right bank has erosion tendency in between cross-section 40 to cross-section 43 and cross-section 45 to cross-section 47. Deposition also takes place along right bank in between cross-section 48 to cross-section 50. River width varies at different cross-sections.

Reach – 6

Deposition is observed along left bank during the period 1990 and 2000 while there is erosion on right bank. During the period 1997 and 2000, cross-section 51 to cross-section 52 and cross-section 55 to cross-section 56, show tendency of deposition whereas cross-section 53 to cross-section 54 and cross-section 57 to cross-section 60 show tendency of erosion along the left bank. On the right bank, cross-section 52 to cross-section 54 and cross-section 56 to cross-section 58, there is erosion. For the duration 1990, 1997, 2000 and 2002, the river width is increased at cross-section 51 to cross-section 53 and cross-section 55 to cross-section 56 while it is decreased at cross-section 54 and cross-section 58 to cross-section 59.

Reach – 7

During the period 1990 and 2000 left bank has displayed mixed nature of both deposition and erosion while along right boundary there is erosion. During the period 1997 and 2000

there is deposition along left bank and erosion along right bank. During the period 1990 to 2000, the width of the river has increased at some cross-sections while it has decreased at others but during the period 1997 to 2000, the river width has increased. The reachwise average width, maximum width and width at nodal points of the Brahmaputra River are furnished in Table 5.

The study reveals the following:

1. The river Brahmaputra has a trend of channel boundary migration towards north and south directions depending upon nature of riverbank and local flow pattern. However it is observed that the general tendency of river migration is somewhat towards south.

2. The average northing for right bank line of the Brahmaputra river moved about 0.47 km to the north between 1990 and 2002, while that for the left moved about 0.48 km to the south. The river has avulsed just upstream side of the Dibrugarh town and excised areas of floodplain to create new bars.

3. The river mean width has increased from 7.99 km to 8.94 km in the total length of the river; whereas the minimum width at Pandu is slightly constricted due to the presence of the bridge. The maximum width has marginally increased from 18.11 km in 1990 to 18.13 km in 2002 at downstream side of Pandu at cross section 18 near Gumi.

4. The satellite based study brought to the fore on the ongoing major avulsion processes of the confluence zone of mainstreams of the Brahmaputra near Sadiya. The total area within the stream bank was increased by 12.10% between 1990 and 2002 due to erosion process causing channel widening. Expansion of the river had taken place primarily through floodplain erosion and excision coupled with bar or island growth. Trends of expansion showed no sign of slacking and the expansion process appears to continue. The degree of braiding of individual reaches fluctuates in the short-term due to morphological response to the magnitude and duration of monsoon runoff events.

Study carried out by Kotoky et al. (2005):

Some selected stretch of the Brahmaputra river channel the erosion phenomenon as evidenced for a stretch of 270 km from Panidihing Reserve Forest to Haloukonda Bil during the period 1914–75, evidenced significant erosion on both the banks of the river. However, the 30 km region on the southern bank of the river experienced maximum deposition up to a land area of 28.15 km2 near Sikarighat and up to a maximum of 38.75 km2 near Bhomoraguri Hills. The activity of erosion is much more pronounced near Jorhat–Majuli areas, and continues for 50 km up to Kumargaon. In this area a total loss of land measuring 49.5 km2 is observed. Moreover, the area around Kaziranga National Park also witnessed major erosion activity near Sohola Bil up to Dipholumukh. In this area, a total of 83.23 km2 was eroded away from the main mass till 1975. Interestingly, the banks on both sides of the Brahmaputra from Orang Reserve Forest to Haloukonda Bil are subjected to significant erosion. However, the erosion was much more pronounced on the northern bank of the river than the southern bank for the period 1914–75. The situation during the period 1975–98 is somewhat different than the earlier period (1914–75) under study. A slight reduction in erosion activity around Majuli area is observed with a shift in

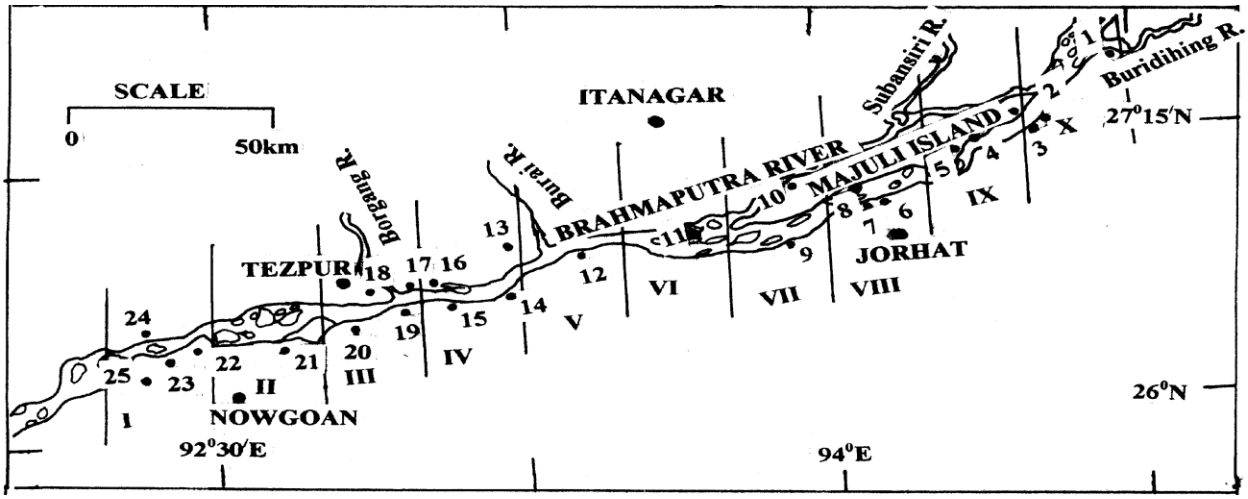

Figure9: Erosion prone reaches of Brahmaputra River

its position. On the southern bank, the river exhibited a depositional phase around Neemati–Jorhat and around Kaziranga National Park areas. Around Kaziranga, near the confluence of Burai River, an area of 17.65 km2 was added on the southern side of the Brahmaputra. The overall activity of the erosion–deposition processes spanning the period 1914–98 is presented in the figure 11 *a* and *b*.

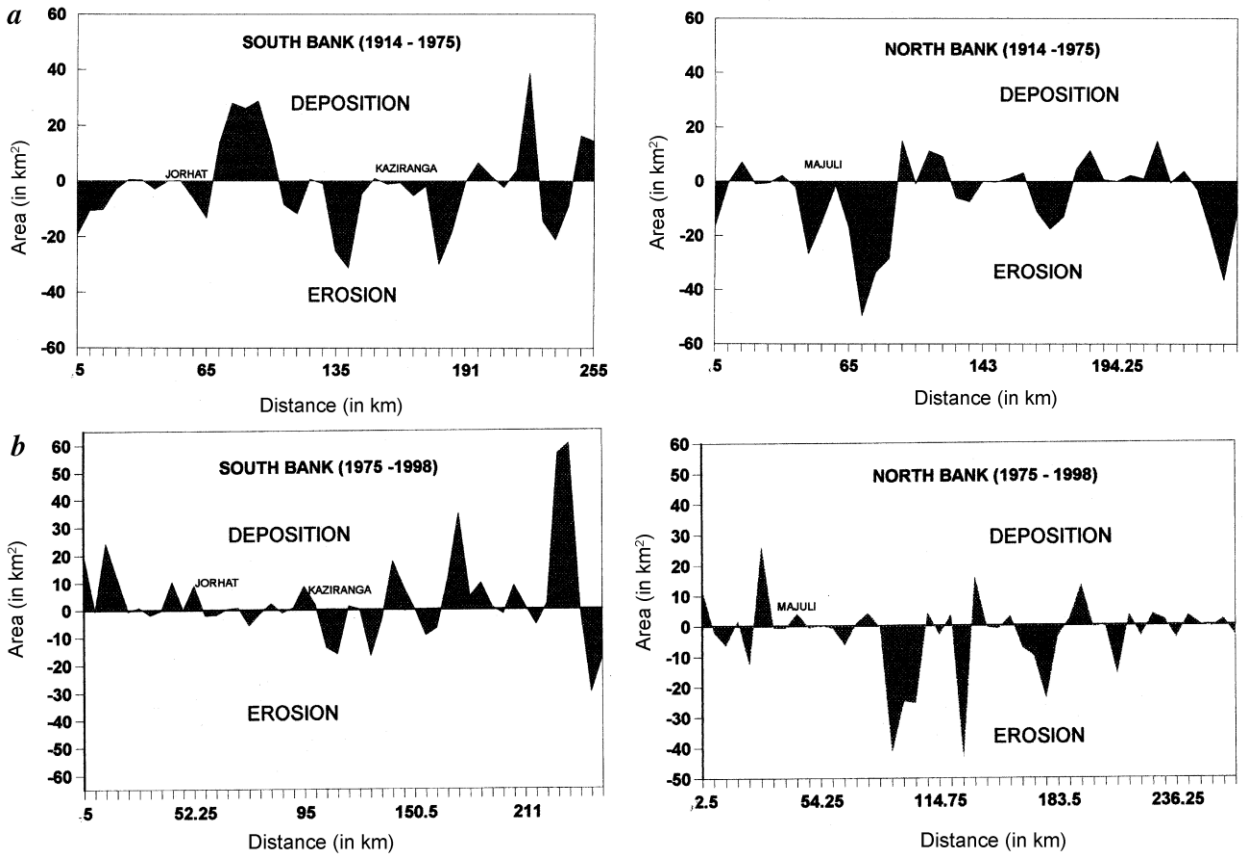

Figure10: Erosion and deposition by Brahmaputra River

A report by *NHC*:

It is stated by (NHC, 2006) that in the vicinity of Majuli Island, about 25 percent of the total river length from the upper end, the Brahmaputra has migrated southward by at least 25 kilometers since about 250 years ago. This location is believed to be a special case, and the actual period over which the shift took place is not stated. Other sources mention a present average rate of southward migration of 10 meters per year (or 1 kilometer per century). A general tendency to migrate southward is explained as being due to the larger quantities of bed sediment delivered by north bank tributaries. Individual channels of the multiple-channel system shift frequently and rapidly during flood events.

The report also revealed bank erosion and loss of floodplain land. Statistics on rates of bank erosion and accretion and on net loss of land are given in various sources. One source indicates that in a roughly 50-year period between about 1920 and 1970, approximate total areas of (outer) bank erosion amounted to 780 square kilometers on the north bank and 750 square kilometers on the south bank, over a length of 630 kilometers. Corresponding rates of bank erosion, averaged over time and space, work out to roughly 25 meters per year on each side, or 50 meters per year counting both sides. In an alluvial river in a state of long-term equilibrium, bank erosion at some locations is generally balanced at other locations by bank accretion – that is, inward growth of banks through deposition of sediment and colonization by vegetation. For the Brahmaputra, however, rates of new bank formation quoted by the same source are much less than rates of bank loss by erosion, such that net loss of land is estimated as 980 square kilometers between about 1920 and 1970. This seems to indicate an average net widening over the 50-year period of around 30meters per year, which is quite similar to a previously quoted value of about 20 meters per year for average widening over about 70. The figures quoted above are averaged over nearly the whole length of the Brahmaputra in Assam. Locally, some lengths exhibit virtually zero erosion (due to presence of nodes), whereas others exhibit considerably higher rates. Lengths immediately downstream of nodes appear to have especially large widths and lateral erosion rates.

Reach Specific Bank Erosion:

Bank Erosion at Dhola:

The bank line migration study of Brahmaputra River at Dhola pointed out some significant shifting of its course. The river Dehang, Debang and Lohit join near Kobu and acquires the name of Brahmaputra has a high gradient and characterized by frequent shifting of channels. Originally the Debang and Lohit river flow together and fall into Dihang River at 25 km downstream of Soikhowa reserve forest. Evalsion of Lohit River took place in 1991 which increases the discharge in Dhola, Dangri and Dibru River. It worsens the problem of river Dibang from north. This created intensified bank erosion at Tinsukia nad Dibrugarh districts.

The combined main channel of river Debang and Lohit is bifurcated, forming a qiute wide channel, flowing southward direction for 4 km and taking southwestern turn around Dibru forest and finally meeting the Brahmaputra at its confluence with Dibru River. This cannel is more than a kilometer wide causing severe erosion along the bank (Sarma et al.).

Figure 11: Bank erosion and breach by River Brahmaputra near Guwahati

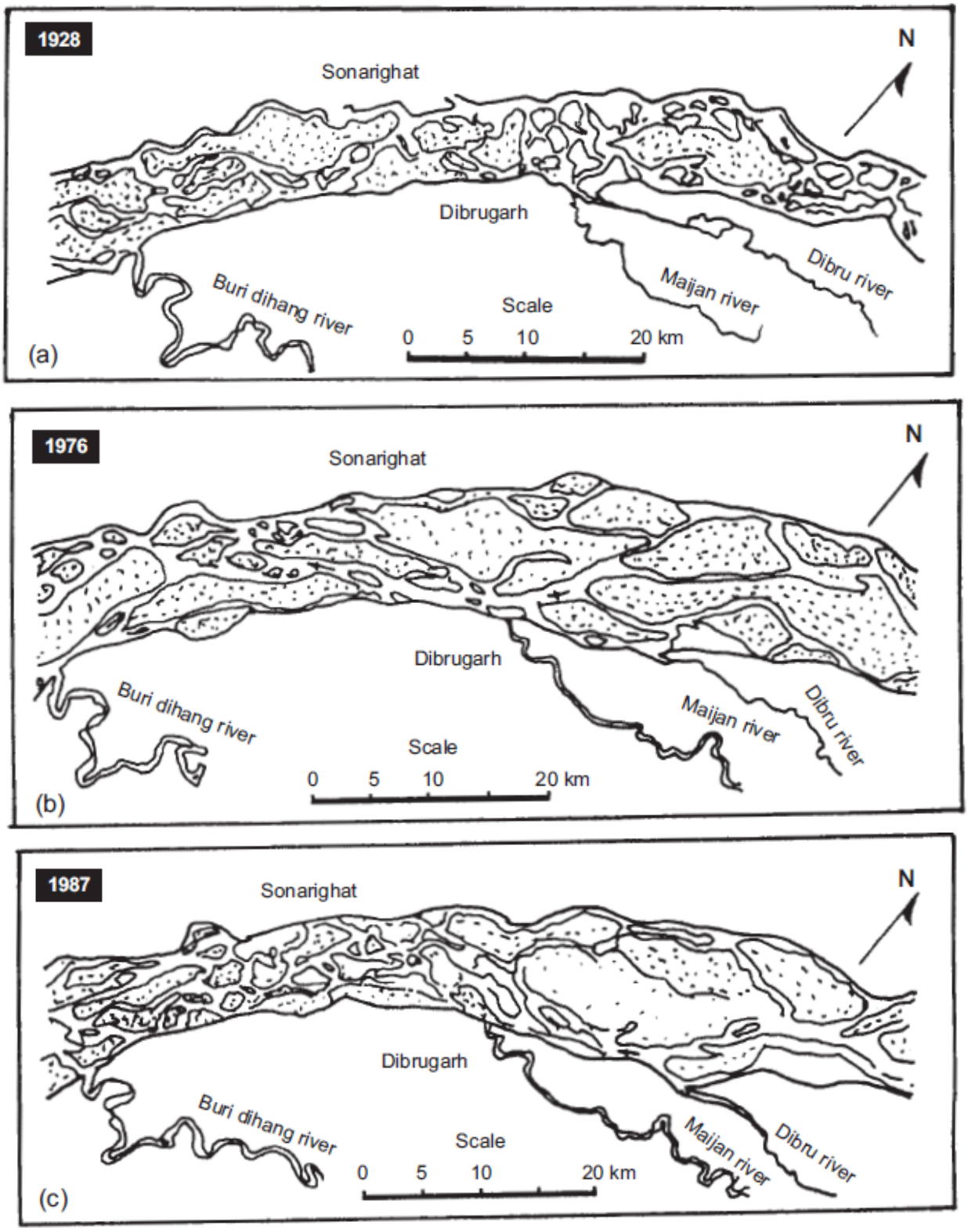

Figure: 12 Plan form of the Brahmaputra near Dibrugarh in years 1928, (a) 1976 (b) and 1987 (c) reveals the bank line migration

Majuli Island as an Outcome of Gradational Process:

Majuli is not a normal alluvial island – it was a piece of land known as Majali, on the south bank of the Brahmaputra till the year 1750. An extreme flood caused the Brahmaputra (Luit) to divert its course southwards on the east of Majali, thereby joining it with the Dihing River. Subsequently the Brahmaputra diverted its main flow through the lower reach of the Dihing, and the land in between the two rivers became the Majali Island which is now called Majuli.

Majuli Island is inhabited by 150,000 people and is under constant threat of bank erosion especially during the monsoon season. Owing to active bank erosion, the area of the island has reduced from 1,300 sq. km as in 1950 to 900 sq. km at present. Table 2 gives a view of erosion in Majuli by Brahmaputra River.

Table3. Area of Majuli eroded by the Brahmaputra since 2000-2007

Year	No. of families eroded	Area affected (in hectares)
2000	567	9124
2001	63	14
2002	204	200
2003	100	68
2004	401	667
2005	471	257
2006	150	94
2007	564	230
Total	**2520**	**10650**

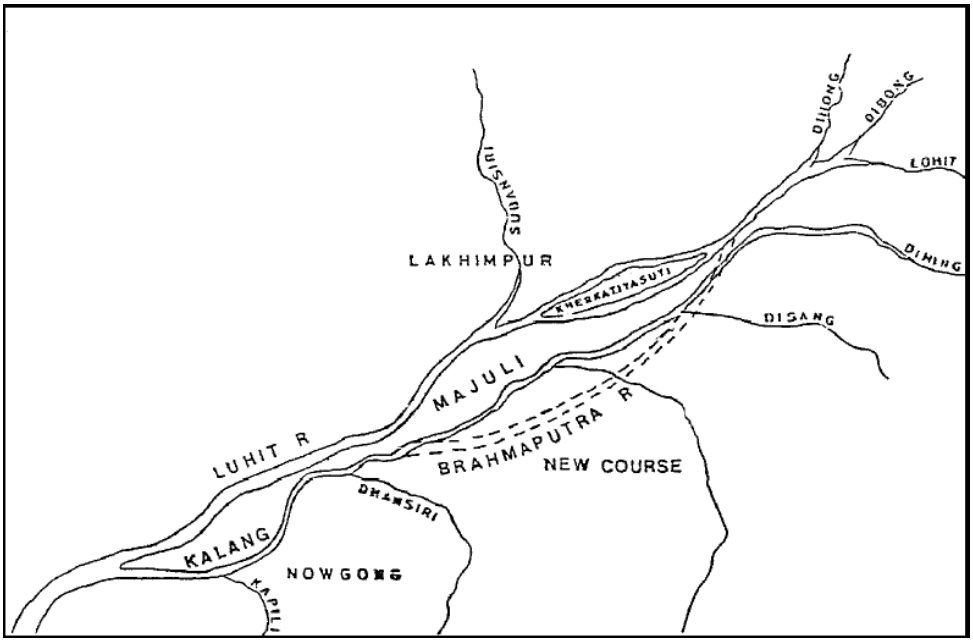

Figure13: A sketch of Majuli Island before 1735 A.D. (Source: Brahmaputra Board)

Bank Erosion at Ajnathuri (near Guwahati):

The extent of erosion has been measured at sections having significant changes, all sections on the north bank show northward erosion. The stretch at a distance of 6.8 km from the Saraighat Bridge (measured along the north bank) exhibits the most significant change, with a land loss of 1.34 km (measured along the north direction). The bank-line up to a distance of 3 km from the bridge and 8krn beyond is relatively stable, thus approximately 5 km of the reach is facing severe erosion. The total area of erosion on the north bank has been found to be approximately 5.2 km 2. The south bank is relatively stable as compared to the north bank. The maximum extent of bank erosion has been found to be 67m in March 2003. Anti-erosion measures like boulder pitching were taken up in the year 1974. Later major protection works in the form of land spur was introduced in 1985-86. Significant amount of sediment deposition has also been observed in the imageries towards the south bank (Bhakal et al., 2005).

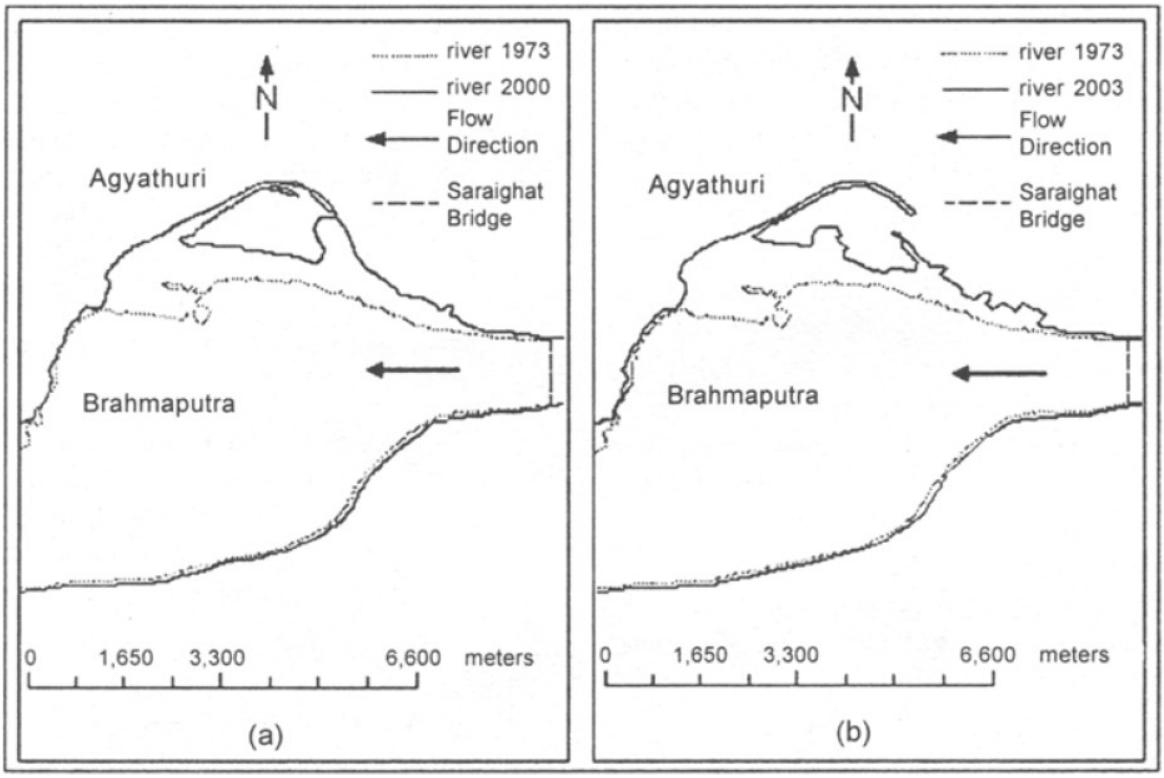

Figure14: Bank line migration at Ajnathuri (Source: Brahmaputra Board)

Bank erosion at Dhubri:

A study on bank line migration of Brahmaputra River in Dhubri region was conducted where a small tributary, Jinjiram joins the main river. The river island formed between the river Brahmaputra and Jinjiram. During the period from 1959-2001, the size of the island decreased considerably, as the severe erosion of Brahmaputra River has swept away a large area over the last 40 years. The island lost 388.6 sq. km (56.4%) of its area since 1959-2001. In the first thirty years (1959-1991), the island is decreased by 108.74 sq. km which is equivalent to 38.97% on the other hand; in the last ten years (1991-2001) the area has decreased by 279.86sq. km, which is 28.56% to the total area of the island.

The small islands in the region are all less than about 5 sq. km in size and they mostly survive up to six to seven years in same location, while some of them last for one to two years only. The high velocity of the river erodes portion of the islands in the upstream locations and deposits the eroded material in the downstream direction. The islands, therefore, appear to be unstable and move downstream. The dynamic nature of these islands is due to the deposition of silt and alluvium carried by the Brahmaputra River which is more pronounced during floods. The river changes its direction from westward to southward. Here, the curvy nature along with the very mild slope is the cause of deposition. It is concluded that the river bed has risen over the years causing recurrent devastating flood in the Dhubri region (Chandramouli et al.).

Some Information about Brahmaputra River

Table4: Recorded maximum and minimum discharge of the Brahmaputra River at different sites

Name of site (State, Country)	Chainage in km from the mouth	Catchment area in sq. km	Recorded discharge (cumec)	
			Max.	Min
Shigatse (Tibet, China)	2,105	88,620	3,380	–
Chushuldzong (Tibet, China)	1,933	113,500	6,230	–
Tseladzong (Tibet, China)	1,515	186,730	10,200	–
Pasighat (Arunachal Pradesh, India)	1,029	249,000	29,640	1,076
Guwahati (Assam, India)	542	424,100	72,794	1,757

Table5: Reach wise travel time (time lag) of flood wave of the Brahmaputra River from Pasighat to Dhubri.

From Station (chainage in km)	To station (chainage in km)	Distance along the river (km)	Travel time of flood wave (Hrs)
Pasighat (1029)	Dibrugarh (917)	112	12
Dibrugarh (917)	Neamati (809)	108	24
Neamati (809)	Tezpur (672)	137	24
Tezpur (672)	Guwahati (542)	130	24
Guwahati (542)	Goalpara (432)	110	24
Goapara (432)	Dhubri (357)	75	15
Total		672	123

Table6: Observed highest flood level of the Brahmaputra River in the valley reach

Station	Chainage from the Mouth (km)	Danger Level (m)	HFL (m)	Return period of HFL (Years)
Dibrugarh	917	104.24	105.95	108
Neamati	809	85.04	86.84	32
Tezpur	672	65.38	65.66	30
Guwahati	542	49.68	51.04	25
Goalpara	432	36.27	36.88	23
Dhubri	357	28.65	29.97	21

Some Information about Brahmaputra River

Table7: Width of the Brahmaputra River in different reaches

S.N.	Reach (Chainage in km from the mouth) and reach length	Width of the river (km)			
		Mean	Maximum (chainage in km)	At nodal point (chainage in km)	Place
1.	Kobo (977) to Dihingmukh (877), 100 km	8.19	14(967)	4.8(977)	Kobo
2.	Dihingmukh to Dhansirimukh (747), 130 km	8.18	13(870)	5.1(864) 3.7(832)	Near Desangmukh Bechamara
3.	Dhansirimukh to Pandu (535), 212 km	8.12	13.1(730)	4.4(727) 3.6(674) 1.2(535)	Gamiri Near Tezpur Paudu
4.	Pandu (535) to Dhubri (357), 178 km	7.93	18.5(503)	2.4(517) 2.4(422)	– Jogighopa

Table8: Number and duration of floods of some major tributaries

S.N.	Tributary	Annual Number of Floods		Annual Flood Duration (Days)	
		Max.	Min.	Normal	Max.
1.	Burhi – Dihing	5	2	19	41
2.	Desang	9	2	12	36
3.	Dikhow	5	Nil	3	13
4.	Jhanji	3	1	2	4
5.	Dhansiri (S)	10	1	–	55
6.	Kopili	45	3	32	68
7.	Puthimari	7	1	9	16

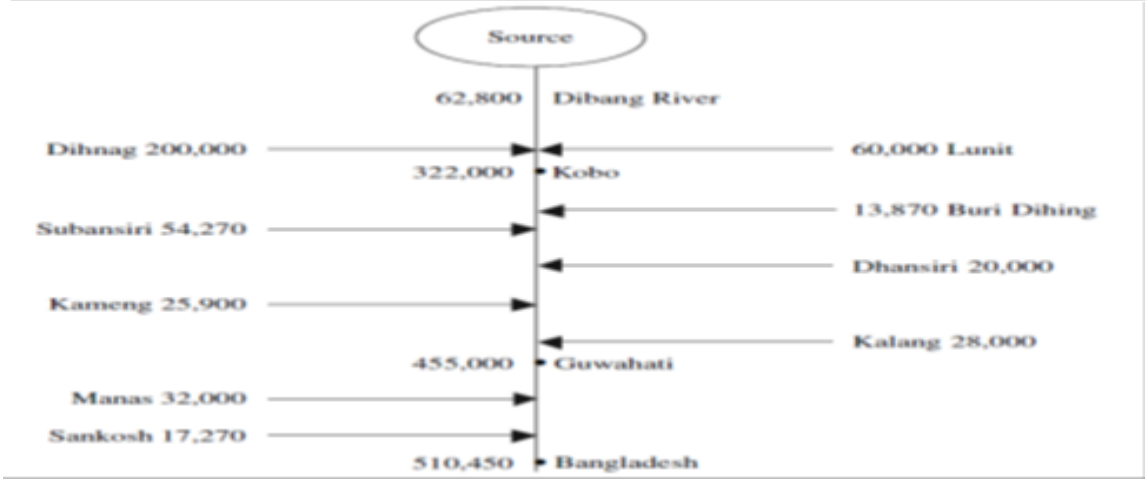

Figure12: Flow diagram of Brahmaputra River

Bank erosion by North Bank Tributaries:

A number of tributaries join the main river course of Brahmaputra from north. The two north bank tributaries, Subansiri and Manas are trans-Himalayan rivers. Besides these, the major part of the catchment area of the other north bank tributaries, such as Ranganadi, Borgong, Jia-Bharali and Sankosh, lie deep inside the Himalayan mountainous terrain of Bhutan and Arunachal Pradesh. Details about the river and the basins of the north bank tributaries are furnished in Table 9.

Subansiri is among the largest tributaries of the Brahmaputra. Gold was commercially mined from its basin till the recent past. Hence it derived this name (Subarna = Gold in Sanskrit). It is a snowfed perennial trans-Himalayan river. Draining an area of 37_ 700km2, Subansiri has a maximum discharge of 18,799 cumec and minimum of 131 cumec. It contributes 7.92% of the total yield of the Brahmaputra.

Manas is the biggest tributary of this reach which has a maximum discharge of 7,641 cumec. It contributes 5.48% of the total discharge of the Brahmaputra. Another big river of this reach is Sankosh which contributes 2.81% of the total discharge of the Brahmaputra.
Details about the river and the basins of the south bank tributaries are furnished in Table 10.

Table9: Some parameters of major north bank tributaries of the Brahmaputra River

S. N.	Name of Tributary	Distance of confluence (km) from mouth of Brahmaputra	Altitude at source (m)	Length (km)			Catchment Area		
				In Hills	In Plains	Total	In sq. km	% in hills	% in plains
1.	Simen	917			–				
2.	Jiadhol	877	1,247	–	130	99	1, 346	22.7	77.3
3.	Subansiri	820	5,389	312	–	442	37, 000	95.7	4.3
4.	Ranganadi	811	3,440	–	21	–	2, 940	76.2	23.8
5.	Borgong	719	700	21	66	42	550	63.6	36.4
6.	Jia-Bharali	675	–	198	–	264	11, 843	71.9	28.1
7.	Gabharu	635	–	–	–	–	295	19.3	80.7
8.	Belsiri	617	–	–	–	–	751	24.6	75.4
9.	Dhansiri (N)	607	–	–	75	–	956	34.8	65.2
10.	Noa-nadi	567	–	–	–	–	366	18.6	81.4
11.	Nonoi	552	–	–	–	120	860	23.8	76.2
12.	Barnadi	542	–	10	102	112	739	17.2	82.8
13.	Puthimari	509	3,750	74	116	190	1, 787	33.4	66.6
14.	Pagladiya	507	1,300	19	180	197	1, 820	24.2	75.8
15.	Manas	422	4,900	270	105	375	41, 350	85.9	14.1
16.	Champamati	400	–	–	60	–	1, 038	13.2	86.8
17.	Gaurang	380	–	–	57	–	1, 023	18.5	81.5
18.	Tipkai	377	–	–	–	–	1, 744	9.8	90.2
19.	Sankosh	337	7,300	214	107	321	10, 345	92.4	7.6

Table10: Some parameters of the south bank tributaries of Brahmaputra River

S. N.	Name of tributary	Chainage of confluence with Brahmaputra (km from mouth)	Altitude at source (m)	Length (km)			Catchment Area		
				In hills	In plains	Total	Total (km^2)	Percent in hills	Percent in plains
1.	Dibong	982	4,267	136	57	193	12, 270	96.5	3.5
2.	Lohit	977	4,876	310	84	394	23, 400	79.6	20.4
3.	Dibru	929	–	0	149	149	1, 852	0	100.0
4.	Buri-Dihing	877	2,300	–	–	363	8, 730	56.8	43.2
5.	Desang	852	2,594	80	150	230	3, 950	45.7	54.3
6.	Dikhow	842	1,823	104	96	200	4, 370	78.4	21.6
7.	Jhanji	832	1,416	53	55	108	1, 349	64.7	35.3
8.	Dhansiri (S)	757	–	252	102	354	12, 580	51.3	48.7
9.	Kopili	557	1,630	127	129	256	20, 068	79.1	20.0
10.	Kulsi	477	–	99	48	147	4, 005	77.0	23.0
11.	Krishnai	445	–	39	26	65	1, 615	80.0	20.0
12.	Jinari	437	–	32	28	60	594	69.0	31.0
13.	Jinjiram	337	–	0	160	160	3, 467	70.4	29.6

Table11: Observed highest flood level and danger level of some tributaries in the Brahmaputra valley

Sl. No.	Tributary	Observation Site	Danger Level (m)	Observed HFL (m)	Year of Occurrence
1.	Subansiri	Chowaldhowaghat	100.43	101.31	1972
2.	Ranganadi	Pahumaraghat	–	95.92	1979
3.	Jia-Bharali	N.T. Road Cr.	77.00	80.89	1970
4.	Dhansiri (N)	N.T. Road Cr.	–	84.14	1979
5.	Puthimari	N.T. Road Cr.	51.82	54.20	1973
6.	Pagladiya	N.T. Road Cr.	52.75	55.51	1970
7.	Manas	N.T. Road Cr.	47.55	49.88	1974
8.	Sankosh	Srirampur	–	46.71	1968
9.	Lohit	Dhola	128.27	129.49	–
10.	Burhi-Dihing	Khowang	102.11	103.51	1980
11.	Desang	N.H. Cr.	92.00	93.88	1980
12.	Dikhow	A.T. Rd. Cr.	93.30	95.60	1979
13.	Dhansiri (S)	Golaghat	89.50	90.68	1971
14.	Kopili	Dharamtul	56.31	57.85	1966

Conclusion:

The Brahmaputra River does not display a stable morphology. The alluvial plains of the river are nearly 96 to 112 km wide and 644 to 805 km long. The bed is about 10 km wide. The bed slope is very gentle, varying from 1 in 6,600 to 1 in 9,900, and at some places, the river bed lies below the mean sea level. The channel is highly braided and short-term channel migration is quite drastic; rates of movements as high as 870m a year being common. The most significant bank line modifications take place during the falling river stage, when sediment is deposited as in the channel, causing migration of the thalweg.

The Brahmaputra River is highly braided in the reach downstream from Pasighat. The width of the Brahmaputra River from Kobo to the Indo-Bangladesh border varies from 6 km to 18 km except in nine reaches (nodal points) where it traverses through deep and narrow throats. The width of the river at the nodal points varies from 1.2 km to 5.1 km.

Heavy bank erosion by the Brahmaputra River at different reaches takes place owing to excessive sediment load, erodible nature of bank material, and formation of char islands. Active bank erosion is generally observed to take place both upstream and downstream of the nodal points and also in the downstream reaches of the confluence of major tributaries. The instability of the Brahmaputra River coupled with silt and sand strata of its banks is also responsible for considerable bank erosion in its valley reach. There is a tendency of the Brahmaputra River to shift southward within the valley reach; this tendency has become more prominent after the great earthquake of 1950 which raised the whole land mass of the northeastern part of the valley by 3 to 4 m. This southward thrust has initiated widespread erosion in the south bank near the Dibrugarh town which is continuing even after construction of different anti erosion schemes. A few kilometers downstream of the nodal point near Guwahati, the river is observed to have a northern migration since 1920 and active bank erosion has taken place in the Nalbari and Barpeta districts of Assam. The situation is different further downstream of the next nodal point near Jogighopa where the river shows a tendency of migration towards the south. The south bank in this reach is facing active bank erosion.

Erosion is more prominent during recession stages of the flood waters. Owing to the variation of the river width along its course, the velocity of flow also changes and as a result scouring and siltation also take place. In the last few years, owing to active bank erosion at some affected reaches, the river width has increased from 8 km to 10 km and in some other reaches from 15 km to more than 18 km.

Sources of Table and Figures

All the figures and tables are adopted from cited literatures.

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