

Impact Of Feeder Canal On Channel Morphology A Case Study Between Guptipara And Payradanga, West Bengal, India

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Abstract: Several morphological features of the Bhagirathi-Hooghly River can be identified in and around the Gangetic deltaic plain which have resulted in the development and flourishing of various towns and cities. With the passage of time heavy siltation has occurred in the Hooghly off-take point which has resulted in its eastward shifting and ultimately upland discharge to the Bhagirathi was drastically reduced. Then the construction of the Farakka Barrage and the Feeder canal increased the volume of water. Due to alternative process of erosion and deposition various phases of delta formation and sandbars have taken place. The focus of the study is to investigate and analyze the channel characteristics of Bhagirathi-Hooghly River lying between Guptipara and Payradanga. Other objectives of the study are centered around the investigation of the channel flow and the simultaneous active meander development processes and its consequent impacts on the socio-cultural environment. The confluence of the rivers Behula, Churni and Kunti with Bhagirathi-Hooghly has further accelerated the process of alteration in the channel characteristics. In conclusion, it can be stated that, in a deltaic region the river exhibits a meandering course, eroding one bank while accreting the other. The river has also shifted its course from time to time. All these indicate that River Bhagirathi is still showing signs of activity in that region.

Key words: eastward shifting, upland discharge, active meandering, delta formation.

INTRODUCTION: The Ganga Brahmaputra Delta is the largest delta on the Earth. It is the gift of two of the world's largest and significant rivers. The delta is surrounded by highlands on all three sides, the eastern and northern boundaries of the delta being delineated by the Chotanagpur Plateau, Rajmahal Hill and Meghalaya Plateau. The delta originated with the opening of the Rajmahal Garo-Gap (RGG)

in the Palio-Pleistocene while it acquired its present form during the latest Holocene (Bandyopadhyay, S., 2007). The river Bhagirathi-Hooghly is an effective part of the Ganga-Brahmaputra Delta system. The off-take of the Bhagirathi-Hooghly is located near Khejurala (Murshidabad district, West Bengal). From the map of James Rennell (1776) it is stated that the region was not usually navigable in dry season from the off-take of Bhagirathi in Murshidabad to the confluence point of Jalangi in Nadia. The main source of water of the river was maintained by Jalangi. The British government used the Jalangi for navigation because the upper part of Bhagirathi had not sufficient water. At that time, the main course of the Damodar River used to flow into the main Bhagirathi at a few kilometers north of Triveni. Then Damodar changed its course and flowed to Bhagirathi about 50 km south of Kolkata, causing a major change in its system. In 1831, a devastating flood occurred in the Bhagirathi basin, which has opened the Bhagirathi River for navigation. At that time the Jalangi River became sluggish. The lower segment of Bhagirathi had the additional facilities of strong tidal flow along straighter course. From that time, the entire course of the Bhagirathi from Nabadwip to Gangasagar (where Bhagirathi meets Bay of Bengal) is known as Hooghly for its tidal behavior.

The main channel of river Ganga (Padma in Bangladesh) is shifting continually and it might have affected the off-take of Bhagirathi-Hooghly. With passage of time heavy siltation occurred in Hooghly off-take point which resulted in its southward shift and ultimately upland discharge to the Hooghly was drastically reduced. In 1824 Bhagirathi had its off-

take near Farakka (22 kms north-west from Suti). But in 1825 River Ganga had shifted its course and a new off-take had emerged at Chokha (12 kms south-east from the previous off-take). Again river Ganga shifted its course and the new off-take of river Bhagirathi was at Suti in 1852. According to the maps of 1925 by the Indian Revenue Survey Department, River Bhagirathi had three off-takes - Nayansukh, Suti and Giria. But after so much shifting and river capturing ultimately in 1980 Mithipur (40 kms south-east of Farakka) has emerged as the off-take of river Bhagirathi(Rudra.k,20011). For this reason the government thought of making a barrage over river Ganga and then feed river Bhagirathi by cutting a feeder canal from it. The project was taken up in 1963 and the barrage was completed in 1975. The feeder canal which is excavated from river Ganga is 41 kms in length and meets river Bhagirathi near Jangipur. The feeder canal is almost straight in shape. After the feeder canal meets river Bhagirathi, due to the volume of water in the feeder canal, river Bhagirathi has to follow its route. The main aim of constructing the feeder canal was to provide river Bhagirathi the volume of water it needed and thereby to keep its navigability alive. The Feeder Canal increased the volume of fresh water in Bhagirathi-Hooghly River substantially. In the middle part of the basin the river has changed its main course and bank line several times. Due to the alternative processes of erosion and deposition various phases of delta formation and sandbar formation have taken place. In the past when the discharge was heavier, being aided by the large supply from the parent river Ganga, the river increased its length by meandering so as to reduce the gradient of the thalweg. But today, as the river is subjected to a reduced volume of discharge through the feeder canal of the Farakka Barrage, a tendency to straighten its course has taken place so as to increase its gradient, which enables it to maintain a perennial flow throughout the course in spite of its reduced discharge. But again increase in gradient of river tends to increase the velocity of the flowing water and as such the process of erosion is heightened, endangering the nearby settlements. These eroded materials will ultimately increase the suspension load of the river water, which will

eventually be unable to carry them downstream, and will drop them on its own bed to form sandy shoals ultimately helping in the winding course of the river Bhagirathi.

Initial works on the Bhagirathi-Hooghly River include the reports prepared by James Rennell(1778),Fergusson(1863),Garret(1910),Hist(1915),Adams and Williams(1919). Those reports emphasize on how the River was opened during course time. Significant works related to the Channel Characteristics of Bhagirathi progressed only after the independence of India. Bagchi,basu&chakraborty started the proceeding. Later Sen&Basu(1974),Bondhyopadhyay(1996),Rudra.k(2013) attempted a similar roll about this topic. This present paper is an investigation on the channel Characteristics, meandering evolution and delta formation process in Bhagirathi-Hooghly River.

STUDY AREA:

Bhagirathi is a perennial, rain-fed and flood-prone Indian River. It carries out almost all the geomorphic works of erosion, transportation and deposition during summer monsoon season, mainly June to September. For field investigation the study area 250 km north from the mouth and around 100km south from the Off-take point has been selected. This area extends from Guptipara, (23 north,88o39'12" east) located in the north of the river Hooghly District to Payradanga of Nadia District in the south.The course of the river is along the boundary of Nadia District. The study area is surrounded by Guptipara, Goshaidanga, Somrabazar and Balagarh in the west and Santipure,Fulia, Habibpur, Payradanga to the west of the River. In this area a paleo-channel of river Damodor named Behula joins to the east bank of the river near SabujDwip. Paleo-channel of Ganga, Churni's confluence point located near Payradanga.

For understanding the present condition of the Bhagirathi-Hooghly off-take, a field study has been taken at the Off-take point and its surrounding near Khejuritala of Murshidabad district of West Bengal. This area lies in the border of India-Bangladesh region.

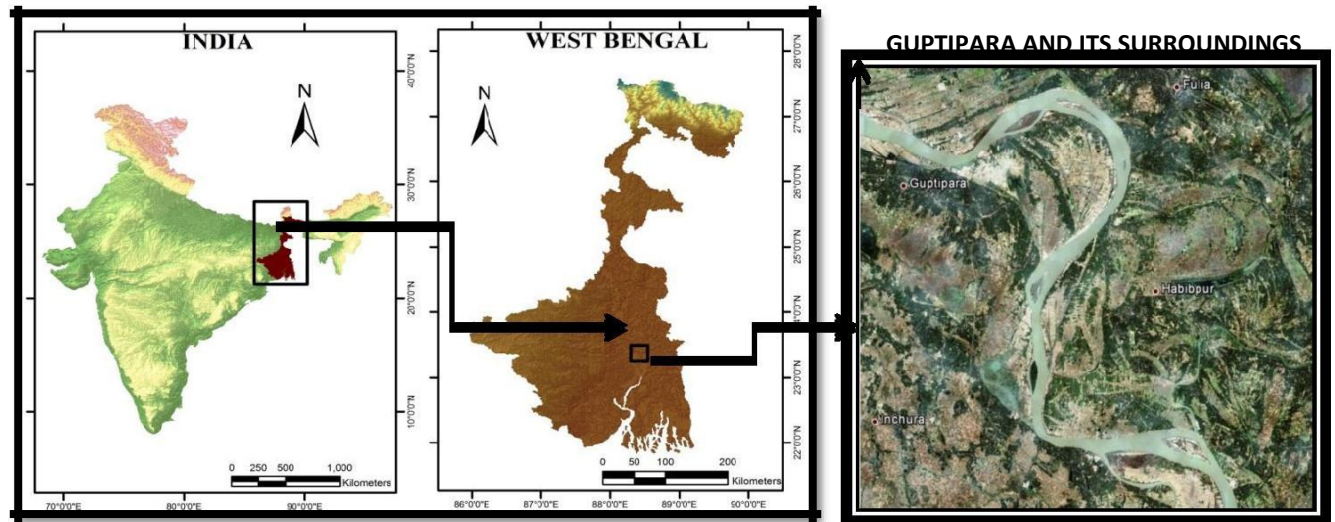


Figure no-1. Location Map of the study Area(Guptipara, West Bengal, India)

OBJECTIVES:

The objectives of this paper are-1. The Off-take of the Bhagirathi-Hooghly River has shifted over different period with the east-ward shifting of River Padma. So it is to investigate the present condition of Bhagirathi off-take and measure the main reason for decreasing the volume of water in Bhagirathi-Hooghly River.

2. To investigate the morphological characteristics of Bhagirathi-Hooghly draining the study area and its flow impact and riverbank erosion.

3. To study the meander development process in the study area with help of satellite map and previous maps.

4. To study the erosion and deposition processes with the help of a Delta Formation Model.

5. Bhagirathi has given birth to many longitudinal bars and islands (locally name as 'Char' and 'Dwip') in this region like Sabuj Dwip, Char Krishnabati, Sundarpur Dwip, Mangal Dwip, Fultola Char etc. So it is to identify the impacts of the Islands on local economy and tourism.

METHODOLOGY:

The whole analysis has especially emphasized on the river characteristics of Bhagirathi-Hooghly in this

region. For this reason we have used ArcGIS 9.2, MapInfo Professional 9.0 software taking the Google images, GLCF (Global Land Cover Facility) satellite images such as 1)25.01.1967, corona image, resolution 2 mt. 2)11.11.1989, landsat 4TM, resolution 30 mt. 3)15.11.1999, landsat ETM plus, resolution 30 mt. 4)21.01.2010, landsat 5TM. This paper is a field based, so we have done many field surveys. For computation of long and cross profiles of the River from Guptipara to the confluence of Churni and in Bhagirathi Off-Take Total Station, Eco-sounder and Global positioning system(GPS) have been used. Alongside we have used the Mueller's Standard Sinuosity Index (SSI, 1968) and new-fangled information in relation to fluvial aggradation and degradation.

RESULTS:

Condition of the Bhagirathi Off-Take: The off-take of Bhagirathi has a significant characteristic. From figure no 2 it can easily be said that, in 1967 the river Padma had flowed beside this region. Then with the passage of time in 2010 we see that the off-take has shifted towards south. At that time river Padma has totally shifted to east ward. At Khejuritala, a big sand bar has been formed at the Bhagirathi Off-take and now this region is totally isolated from the main channel of Padma. So, there has been enormous decrease in the volume of water at Bhagirathi-Hooghly.

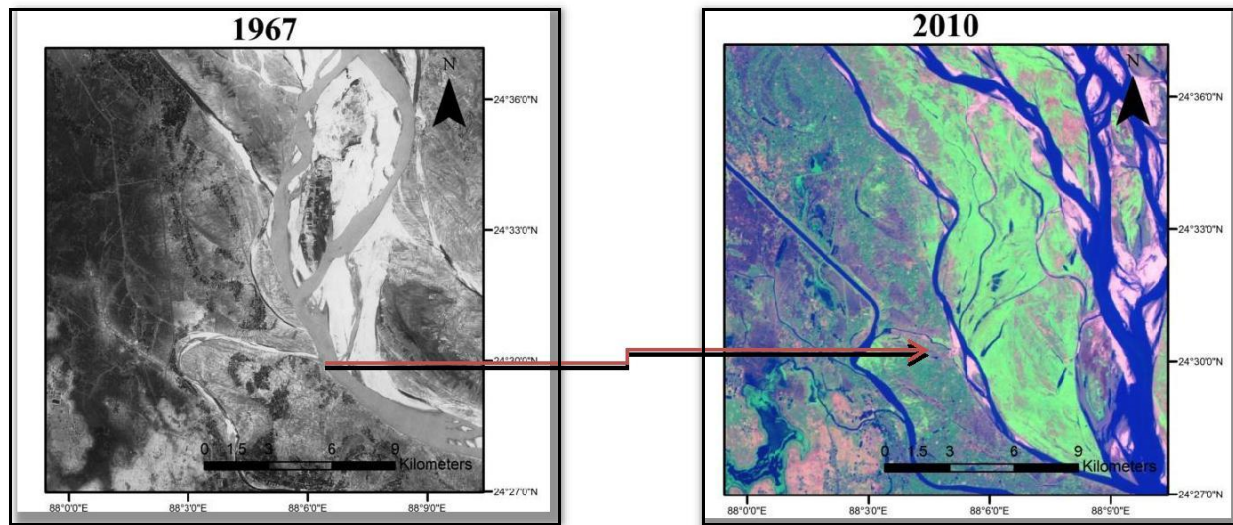


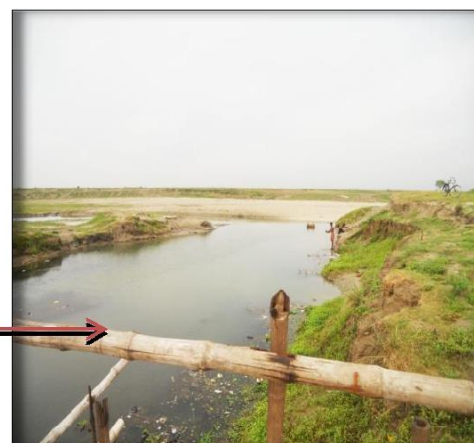
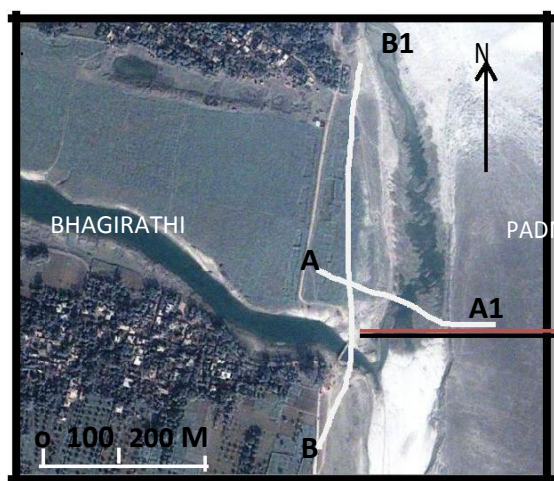
Figure no-2. Condition of Bhagirathi Off-Take: A Comparative Study

Two profiles have been computed across the Bhagirathi Off-take for better understanding the present condition of the Off-Take point.

Profile A-A1: Here we see the cross section between the dry beds of Padma River at the Bhagirathi off-take near Khejurtala. A-A' is the cross section line shown in the map at Fig. 4. We can see the total distance of the profile is almost 250 metres and each major unit is of 50 metres. Following the profile we can see a short upliftment of land on the un-metalled road over the embankment. After that the ground flattens for some distance and then there is a gradual decrease of slope and elevation due to the dry bed of Padma River. After crossing the river the slope and elevation then increases up to the embankment on the other side.

Profile B-B1: Here we see the cross section across the Bhagirathi River which is shown by 'B-B1'. The profile stretches up to 600 metres in length and 25 metres in height. At first we see a short rise in the profile due to the embankment. Then there has been almost a sudden fall in slope and elevation due to the river bed. The other side of the river bed is not as high as the previous one. Then a low rise in slope and elevation is seen till the end of the profile. It means there is no such variation in height in that portion.

From figure no-2 and 3 we have noticed that, now the main source of water in Bhagirathi is Feeder Canal. There is no source of water in Padma River bed near Off-Take.



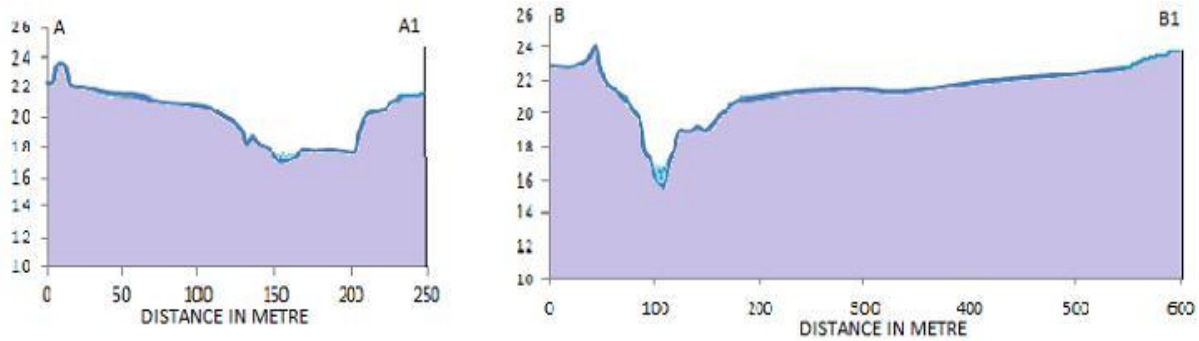


Figure no-3-Profiles and pictures of Off-Take point in Murshidabad, India

We have noticed a lean flow in Bhagirathi bed and River Padma is dry in this area. Padma has shifted it's entire course towards Bangladesh. A big sand bar has formed at the Off-take. The source of water from Padma is totally shifted. The back flow from feeder Canal is the source of water in Bhagirathi bed in Khejuritala.

The study area has many significant channel characteristics. Different channel lengths at different areas are observed here. Due to the alternative processes of erosion and deposition we notice different marks like-Sand Bar, Mid channel Bar etc. For better understanding we have done several cross profiles from north to south with the help of Total Station, Eco-sounder and Global Positioning System (GPS).

Channel Characteristics of Bhagirathi at Guptipara:

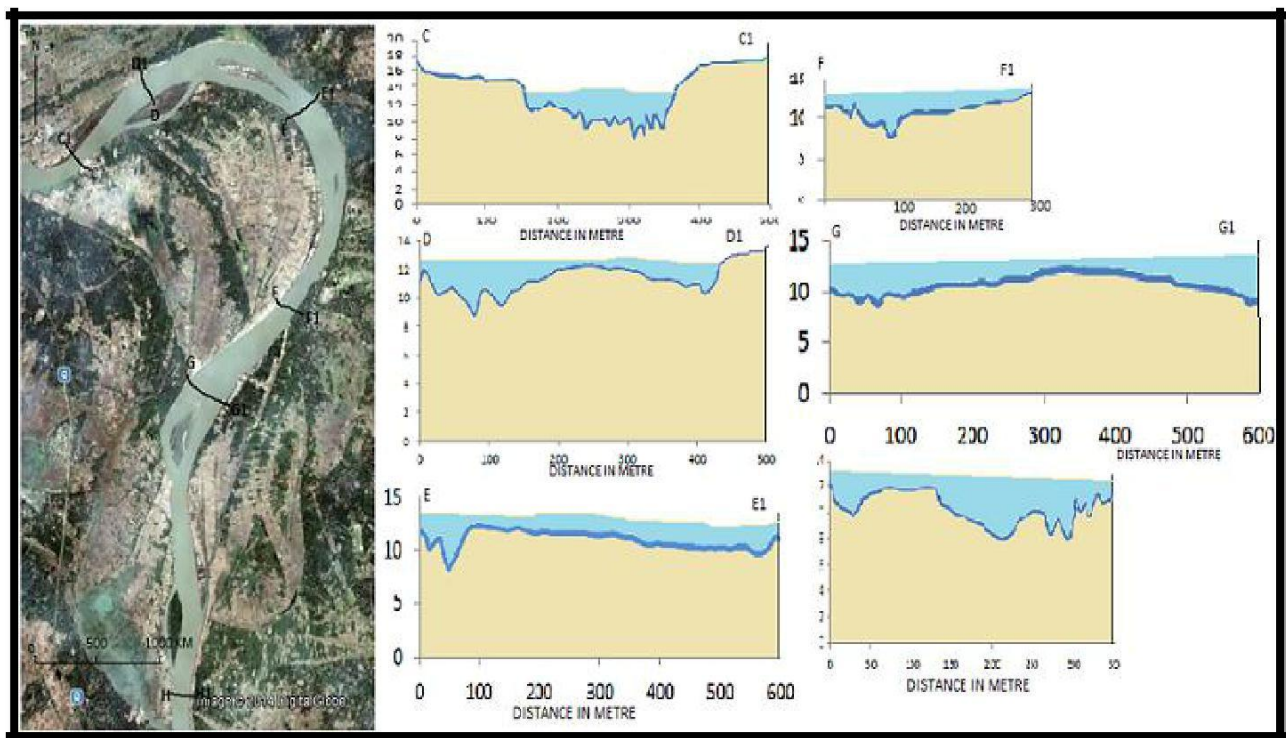


Figure no-4. Cross Profile across the Bhagirathi River (Between Guptipara and Payradanga).

C-C1,D-D1, E-E1 have been taken from Guptipara in west to Santipur in east. Pool and Ripples are notified

in the bed. Mid-Channel bars are major significant features in this area. In this portion River is 500 to

600 metres long. The Profiles F-F1,G-G1 are taken from Charkrishnabati in east to Rosulpur in west. These profiles show a sudden fall of slope and elevation due to the river bed. The other side of the river bed is not as high as the previous one. Then a low rise in slope and elevation is seen till the end of the profile. It means there is no such variation in height in that portion.E-E1 extends for the smallest distance. In this Area River has maintained a linear flow. Profile G-G1 is located near Sundarpur Dwip. The Dwip has got present condition in last 10 years. The last profile located near Confluence of Behula Nadi. H-H1 profile is only 350 metres long. Towards the point H1there has been a significant increase in depth of water of 8 metres. The increase of depth in one side of river has also been attributed to the continuation of active meandering processes.

Bank erosion (degradation) and fluvial deposition (aggradation) are the direct evidences of geomorphic instability phenomenon and it shapes the channel morphology of a particular reach (Garde, 2006; Mondal and Satpathi, 2012).Theperiods of stronger monsoon are associated with erosion and increased sediment supply.

Riverbank erosion is a major incidence in this area. At present the most erosion effected area is Steamer Ghat near Santipur. This area situated at the concave side of the river. From the cross profile, we notice that the thalweg line situated near to the bank. At most times of the year the erosion process goes on but erosion is the most effective during the monsoon. The study area had the additional facilities of a strong tidal flow up to Nabadwip, where the confluence of Jalangi situated. Alsothe deposition process has taken a great role in this region for changing channel characteristic.

Flow impact on Channel Morphology:

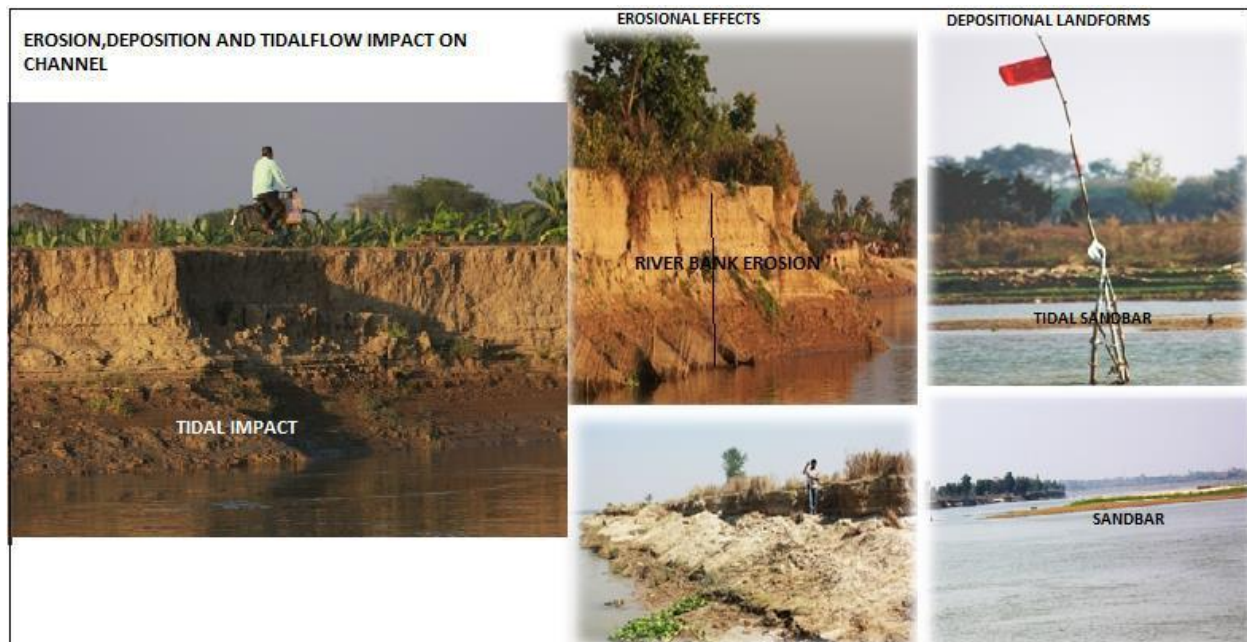


Figure no-5. Flow impact on Channel Morphology.

Changing Scenario of the Meandering Belt:

:In this study area Bhagirathi has an active meandering belt. At the time of James Renne(1780), River Bhagirathi-Hooghly had flowed beside

Ranagath(Nadia district).With the passage of time it changed his course. For better understanding we used previous year images.

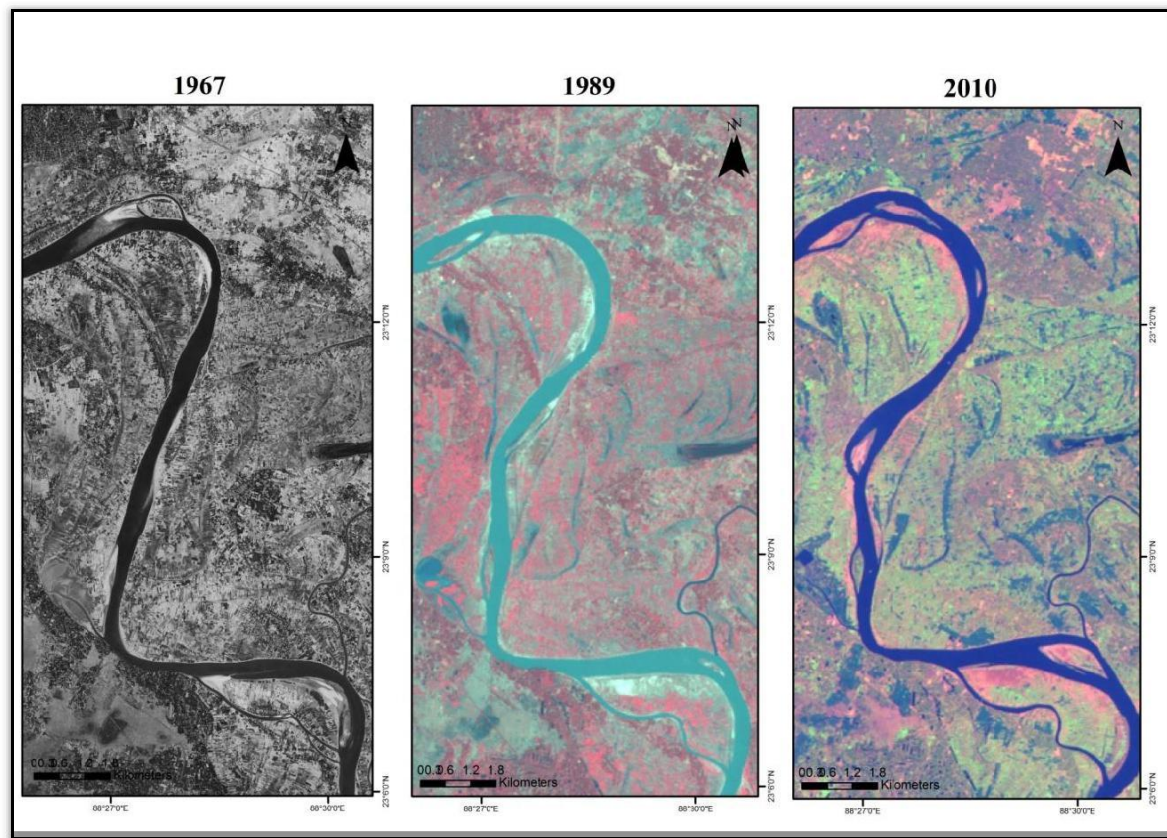


Figure no-6. Changing scenario of Guptipara-Payradanga Meandering Belt using different map of 1967, 1989,2010.

Sinuosity Index of the Meandering Belt between Guptipara and Payradanga:

From the chart we can see that the sinuosity Index of river Bhagirathi in three different years. In the year 1967 the sinuosity index is 1.67. Then a major

change had occurred after construction of FarakkaBarrage (1975). Due to this flood the sinuosity increased to 1.75 in 1989. Then in the next 20 years of study we can see that the sinuosity index has increased gradually.

Table 1: Calculation of Sinuosity

YEAR	CHANNEL LENGTH	VALLEY LENGTH	SINUOSITY INDEX
1967	24.612	14.726	1.67
1989	26.033	14.822	1.75
2010	25.59	14.67	1.74

The Model Depicting the Channel bar Formation on fluvial Environment:

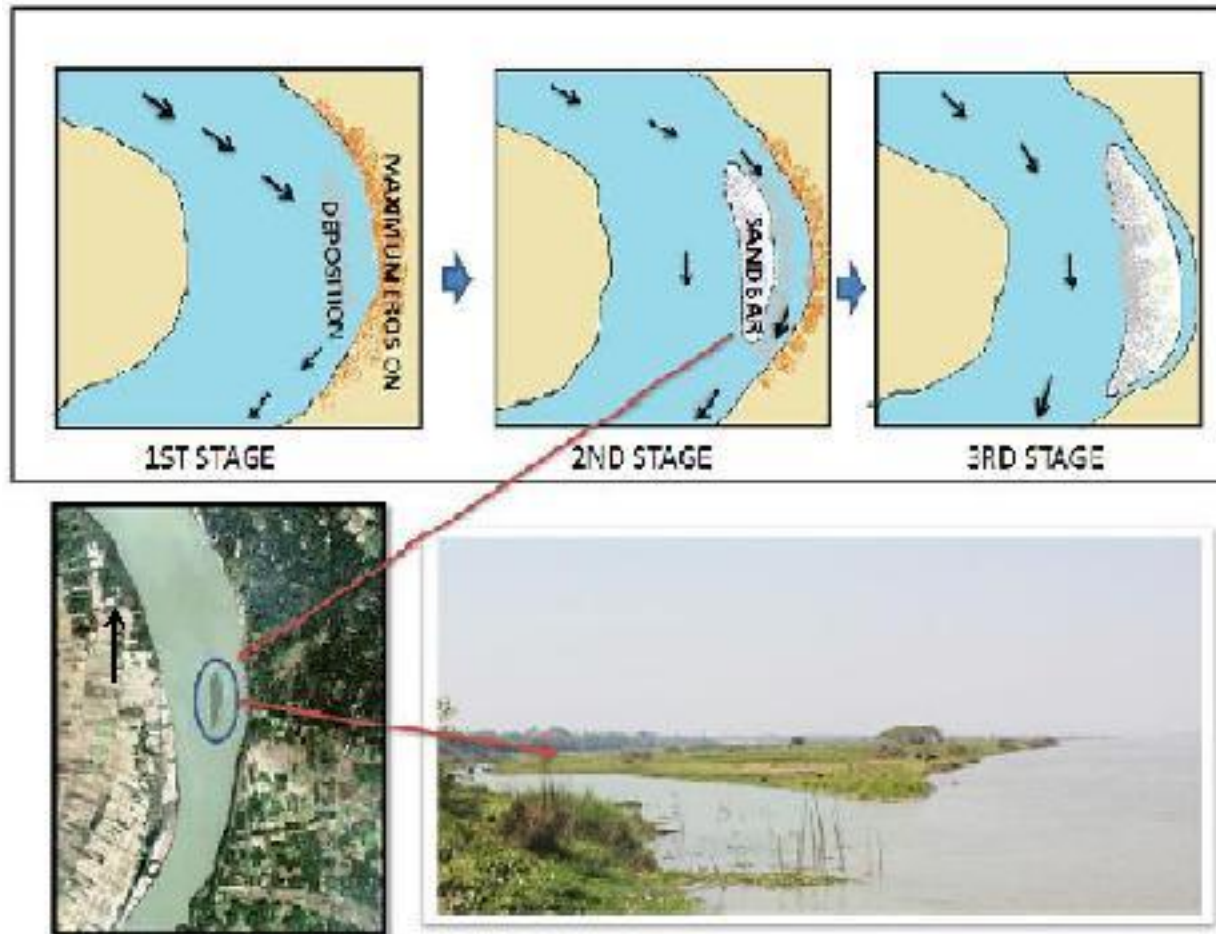


Figure no-7. A Model depicting the channel bar formation.

The successive stages in the channel bar formation depict maximum erosion at the concave side of the river at the 1st stage.

- In the 1st phase the velocity of the river water is high. That's why the flow of the water struck the concave slope of the river and due to river hydraulics erosion occurred at the concave slope and it gradually increased.
- In the 2nd phase the eroded materials have been deposited in the nearby area within the channel bed and sand bar has been

formed. Due to increased erosion the area and height of the sand bar increased.

- In the 3rd phase area and height of the sand bar has increased so much that has all most connect with the concave slope of the channel bed. The velocity of the river decreases gradually and the river flows along the two sides of the sand bar, But due to the less wide of channel alongside of the concave slope the flow of water is much less in that portion and that's why the other side of the sand bar has become the main flow of the River.

This has been the theory applied for the formation of sand bar called Badhagachi Char at Bhagirathi-

Riverine Islands in the Study Area:

Bhagirathi-Hooghly is mainly the last stage of River Ganga and due to plain surface the velocity of the river is so decreased that it mainly causes deposition than erosion. In the study area the channel of the river is so winding that it has almost created a meandering channel pattern. That's why so many riverine islands have been formed due to deposition of the eroded material that the river carries from the upper stage.

Mangal Dwip, Sundarpur Dwip and Sabuj Dwip are some of these riverine islands formed in the study area. Mangal Dwip is located near Shantipur (Nadia district), Sundarpur Dwip is located near the southern

Hooghly River near Guptipara.

part of Guptipara, Sabuj Dwip is located near Somrabazar (Hooghly district). In the early years these riverine islands are mainly isolated from the main land as merely sand bars created by the rivers, but in the later years the people of the local area have been using these riverine islands as a source of income and have redecorated the interior of these islands as picnic spot. But due to the unsustainable use of physical resources these islands are in a stage of deforestation. That's why the government has undertaken these islands and make these islands Eco-tourist spot. Now a day Eco-tourism in these islands is in full phase and these islands are the source for economic consumption without destroying its natural beauty.

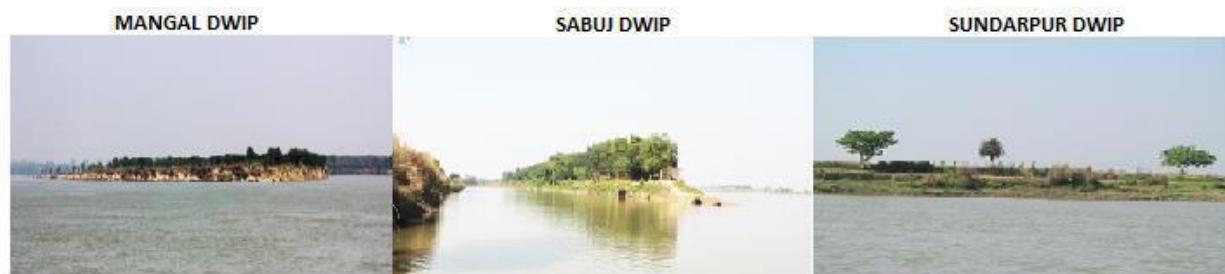


Figure no-8. Riverine islands.

CONCLUSION:

After doing all the pre-field, field and post-field survey in conclusion it can be stated that in a deltaic region the river has a meandering course, eroding on one bank and accreting on the other. The river also shifts its course from time to time. It deposits the sediments along its bank and thus raises the level of the land. This entails the degeneration of river off-takes and confluences and also the development of new off-takes and confluences. This indicates that river Bhagirathi-Hooghly is still active in that region.

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