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RESEARCH ARTICLE

CHANNEL SHIFTING AND ASSOCIATED SEDIMENTOLOGICAL CHARACTERISTICS OF THE KATWA-MAYAPUR STRETCH OF THE BHAGIRATHI-HOOGHLY RIVER, EASTERN INDIA

***Subha Roy and Somasis Sengupta**

Department of Geography, The University of Burdwan, Burdwan – 713104, India

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Corresponding author: Subha Roy

ABSTRACT

Channel Shifting is a natural phenomenon. But in the Bhagirathi Hooghly River System, the construction of the Farakka Barrage has completely disturbed the Dynamic Equilibrium condition of the river. Entry of excess water of the Ganga into the Bhagirathi Hooghly has suddenly rejuvenated the Bhagirathi Hooghly (B-H) and destroyed the stability besides increasing the discharge. As a result, B-H river formed oxbow lake and paleo channel. In this reason sediment logical character is changed in this river. So the resent study was conducted to correlate the phenomenon of channel shifting with the occurrence of sedimentary records. In this study we use different year (1975-2018) satellite image (ETM, ETM+, TM, LISS III, LANDSAT 7, LANDSAT OLI) and identified (using ARC GIS , ERDAS) how the channel of the B-H river has shifted over time and created paleo channels and oxbow lakes. Collected soil sample in some selected areas where channel shifting occurred in the B-H river. As a result, we see increasing sediment texture since 1970s and after the construction of the Farakka Barrage.

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INTRODUCTION

The Ganga River is the largest river in India, flowing through different states of India. In the lower course of the river through the state of West Bengal the river is divided into two major channels distributaries in Khejurital (Murshidabad District, West Bengal) (Biswas and Biswas,2014). One of the distributaries is the Padma going towards Bangladesh and the other named as the Bhagirathi Hooghly is flowing through the state of West Bengal (Murshidabad, Burdwan, Hooghly, Howrah and Medinipur districts). (Das, Adak and Samanta, 2014; Reaks, 1919). The Bhagirathi – Hooghly (B-H) River System is the most important river in West Bengal (Laha, 2015). This river flows in West Bengal for approximately 260 km, predominantly in southern direction (Mallick, 2013). This course of the river, which is now falling in the West Bengal part of the Ganga Brahmaputra Delta has been regarded to be the oldest outlet of the massive Ganga River into the Bay of Bengal, which, by siltation has now shifted to Bangladesh via the Padma River(Panda, Bandyopadhyay,2010). The B-H River System had been the principal distributary of the Ganga River till the 16th century (Oldham, 1870; Hirst, 1915; Reaks, 1919; Fox, 1938; Bagchi, 1944, etc.). Since Independence, the Kolkata Port was the major port in Eastern India. This river port, on the Hooghly River has been continuously suffering due to silt and sediment brought down by the river (Takur, Laha and Aggarwal, 2012). Furthermore, due to the shifting of the main distributary channel to the Padma in Bangladesh, the amount of water entering the Bhagirathi-Hooghly (B-H) River System was continuously declining (Mandal, Kayet, Chakrabarty and Rahaman,2016) This started to put the future of Kolkata Port into a big question. Secondly, decaying rivers in this area also raised the alarm of water scarcity. Keeping these concerns in mind, the Indian Government decided to construct a barrage over the Ganga River and digging out a canal (Farakka to Jangipur) to join the Bhagirathi River so as to divert the excess water of the Padma into the Bhagirathi-Hooghly River System(Guchhait *et al.,*2016). This canal length is 41 km and called as the Feeder canal, almost linear in shape. This project was taken by Indian government in 1963 and the barrage was completed in 1975 (Parua, 2010). It has been observed that since the construction of the Farakka Barrage the amount of water available in the B-H River System has increased enormously within a very short period Muhuri *et al.,* 2015). But the channel has not been able to accommodate such a huge volume of water easily (William *et al.,* 2009). As a result, the river is constantly shifting its position since the last few decades. It has been well recognized that fluvial systems are most sensitive elements of the landscape (Lawler, 1993). Any change in the prevailing geomorphic, hydrologic and tectonic conditions will be invariably reflected by fluvial responses at different spatial scales (Kale *et al.,* 2010). One of the most common responses of a river to hydrologic regime is depositionary environment changes (Fox, 1938, Wells and Dorr,1987). Therefore, fluvial archives and sedimentary records hold the key in deciphering the varying conditions of hydrologic regime with time (Hirst, 1915; Bridge, 1993,). The present study, therefore, seeks to correlate the hydrologic and sedimentological regime of the B-H River System by suitable remote sensing and sedimentological techniques.

Therefore, this study is characterized with the following objectives

- To analyze the changing nature of the course of the Bhagirathi-Hooghly River (1975-2018) in the stretch between Katwa and Nabadwip.
- To assess the sedimentological character in the depositionary environment between Katwa and Nabadwip.
- To correlate the occurrence and nature of sediments along the Bhagirathi-Hooghly River System in the stretch between Katwa and Nabadwip with respect to channel shifting.

The study area: The study area is a part of the Moribund Deltaic Region of the districts Nadia and Purba Bardhaman in the Indian state of West Bengal. The important rivers draining the studied area include the Bhagirathi, Jalangi and Ajay. This study area has been selected for a fluvio- geomorphological analysis of the Fig 1 Location Map of the study area. Bhagirathi- Hooghly stretch from the confluence of the Ajay River with the Bhagirathi River at Katwa to the Bhagirtahi-Jalangi Confluence at Mayapur near Nabadwip. This length of this stretch is approximately 33kms.The study area roughly extended from 23°39’30.98’’ N and 88°08’00.08’’E (Katwa, Purba Bardhhaman District) to 23°24’29.53’’N and 88° 22’58.69’’E (Mayapur, Nadia District).[Fig 1]

METHODOLOGY

For deciphering the nature and character of the channel shifting, remote sensing based applications were taken into consideration. In this case, satellite data ETM, ETM+, TM+, ETM PAN, LISS-III, LANDSAT-7 and LANDSAT-8 of Katwa to Nabadwip area (1975 to 2018) were downloaded from their respective websites (USGS and BHUVAN). Digitization (using QGIS and Arc GIS software) was carried out for the main channel of the Bhagirathi Hooghly River System for every year for which the image was available (1975 to 2018). The digitized maps were then overlain in a GIS environment to assess the degree of channel shifting.Field work was carried out and sediments were collected where the B-H river changed the course.In other words, the active channel sections (which are now remaining a paleo-channels were demarcated for sediment collection) the sediment samples that were collected from the field were then tested in the laboratory for their textural parameters using a Sieve.Overlay analysis was carried out in order to ascertain the changing conditions of channel path. Also, sediment records especially the textural data were correlated with the paleo-channels.

Bhagirathi Hooghly River in 1975 To 2018Katwa to Mayapur: Fig. 2 reveals that the river B-H has witnessed a major shift from 1970s to the present day between Katwa and Mayapur. Since 1975 [Fig. 2(A)] the river has been flowing in a meandering path, a normal character of rivers flowing through plains. But After 1975 when the construction of Farakka Barrage was complete at Jangipur (100 km upstream of Katwa), the excess water of the Ganga enters the channel of the B-H river.

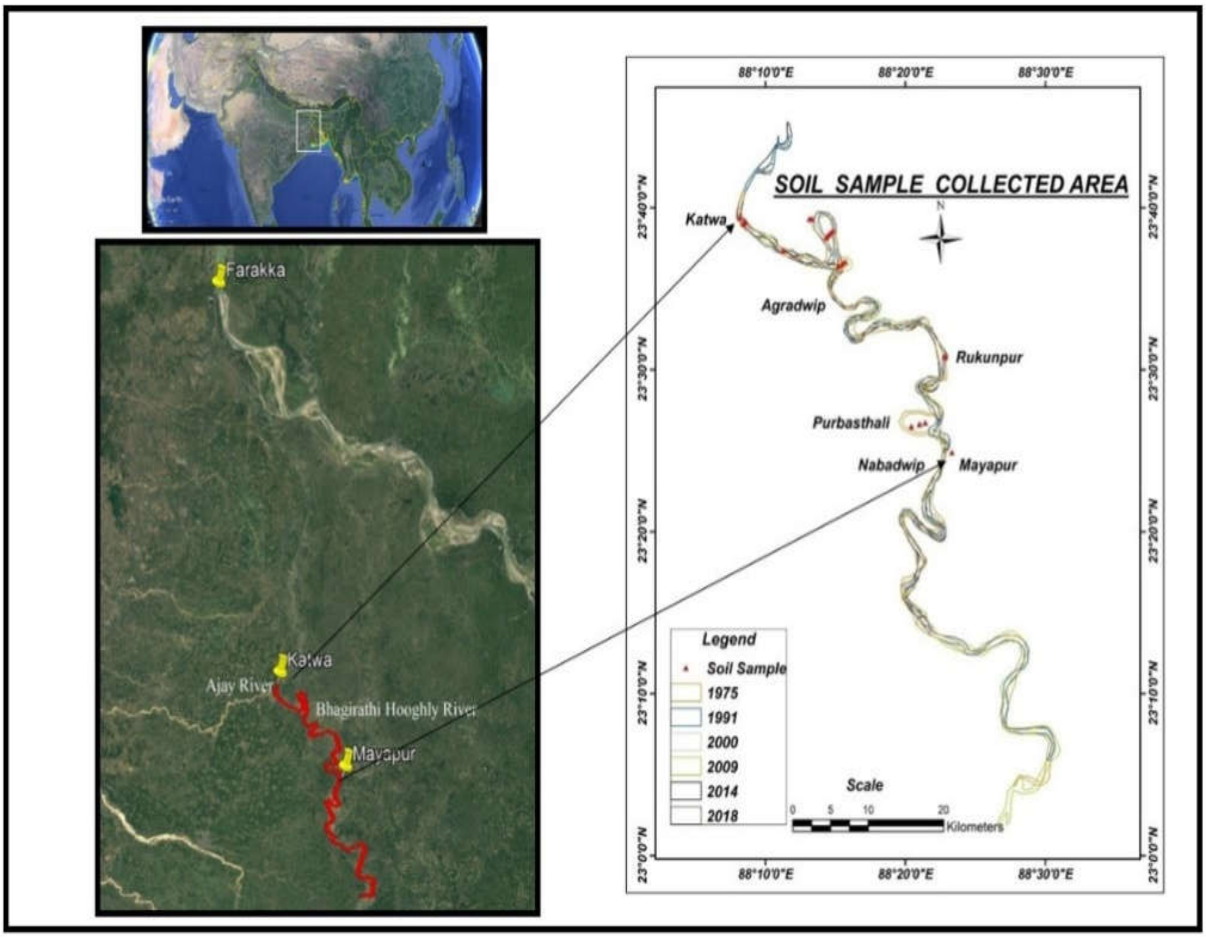

Fig 1. Location Map of Study Area

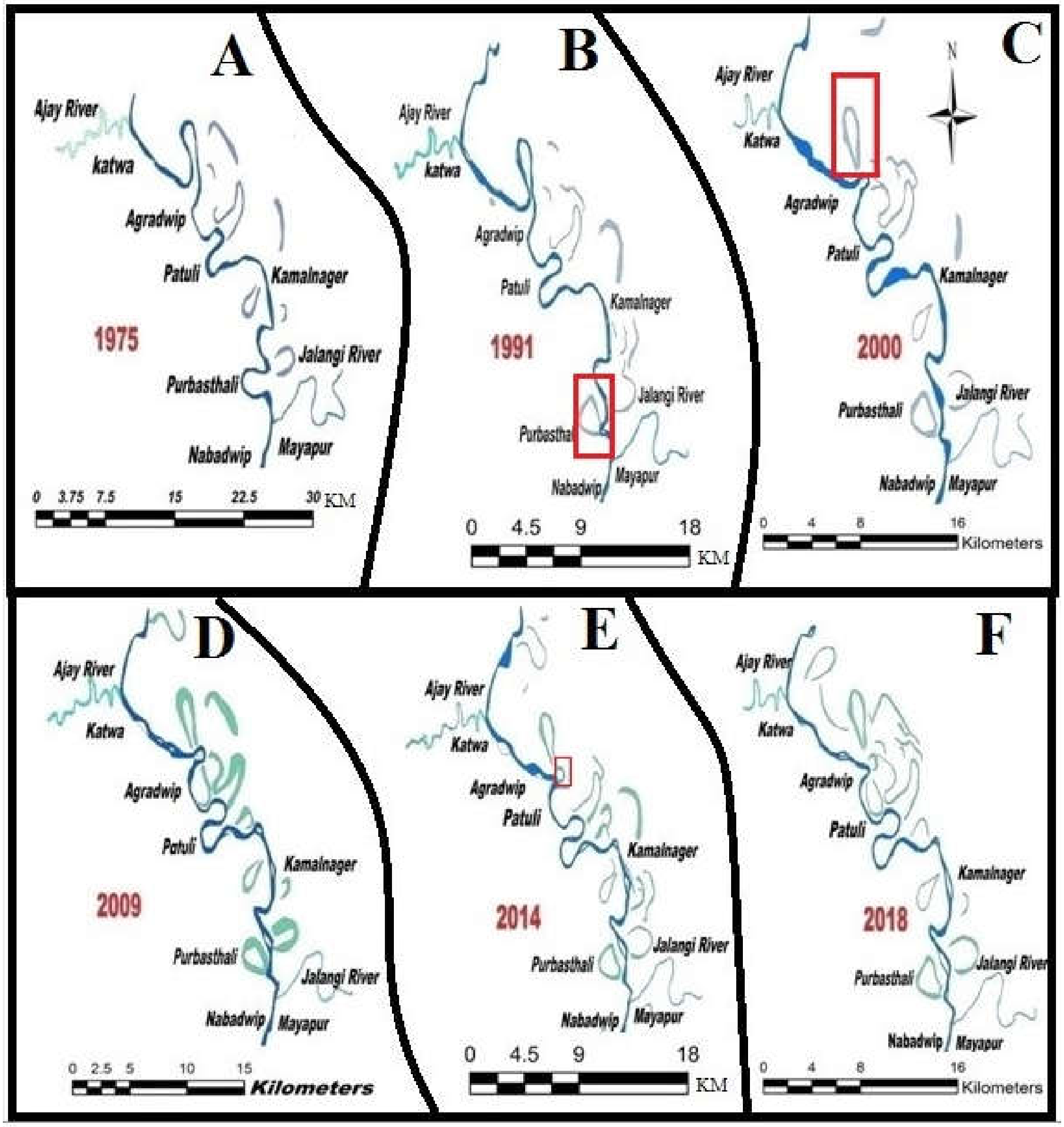

Fig. 2. Bhagirathi Hooghly river (Katwa to Mayapur) in 1975 to 2018

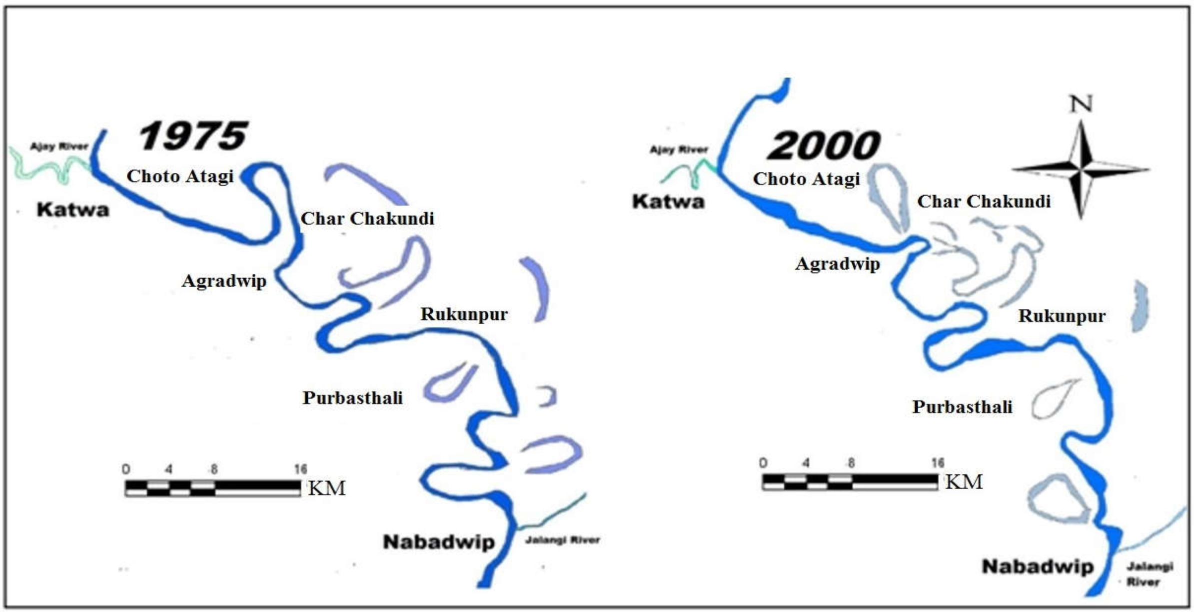

Fig. 3. Bhagirathi Hooghly river (Katwa to Mayapur) in 1975 to 2000

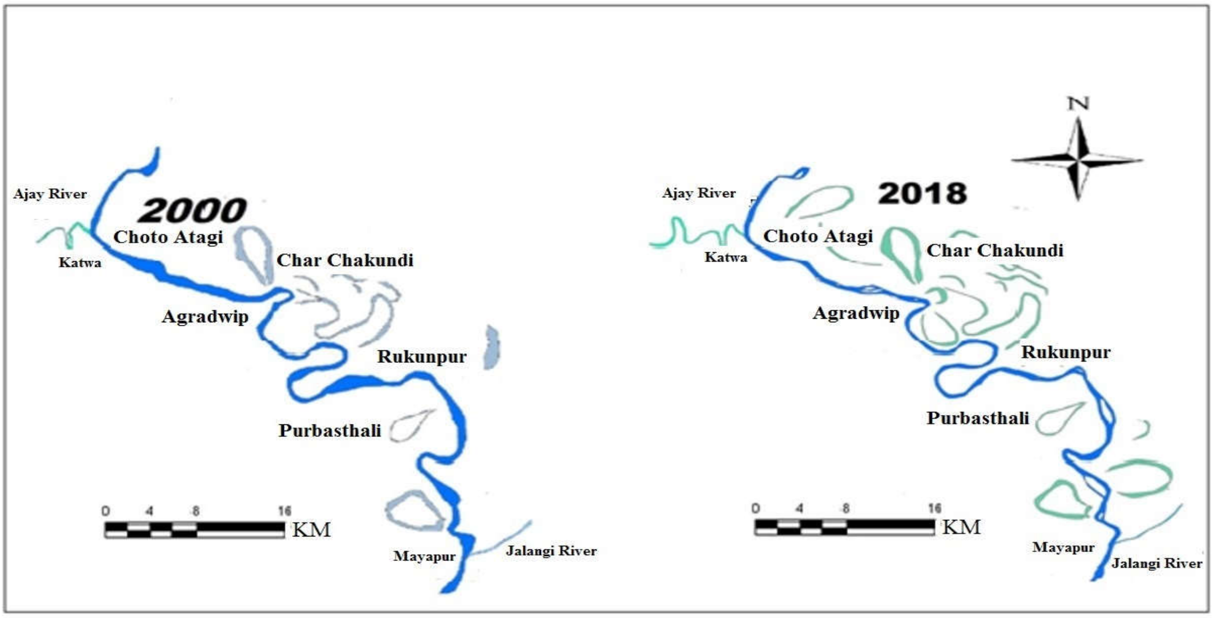

Fig. 4. Bhagirathi Hooghly river (Katwa to Mayapur) in 2000 to 2018

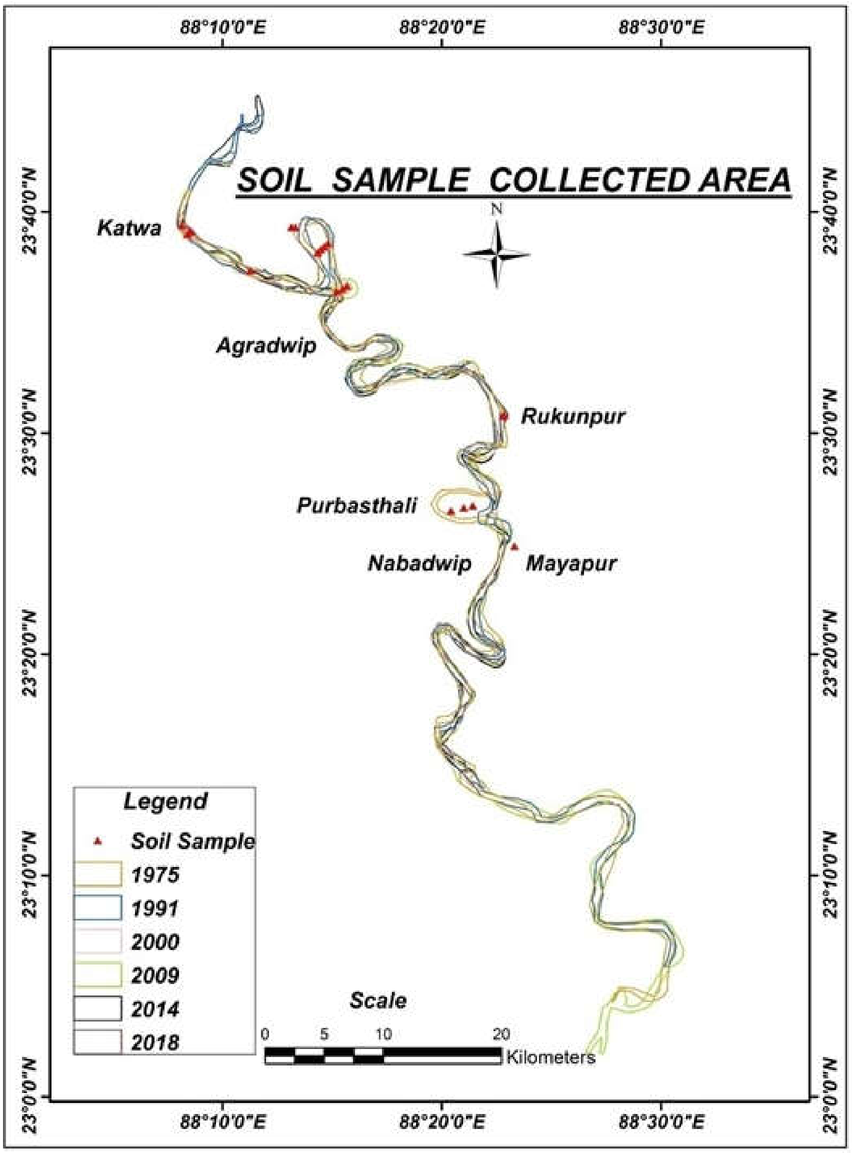

Fig. 5. Sample collection sites

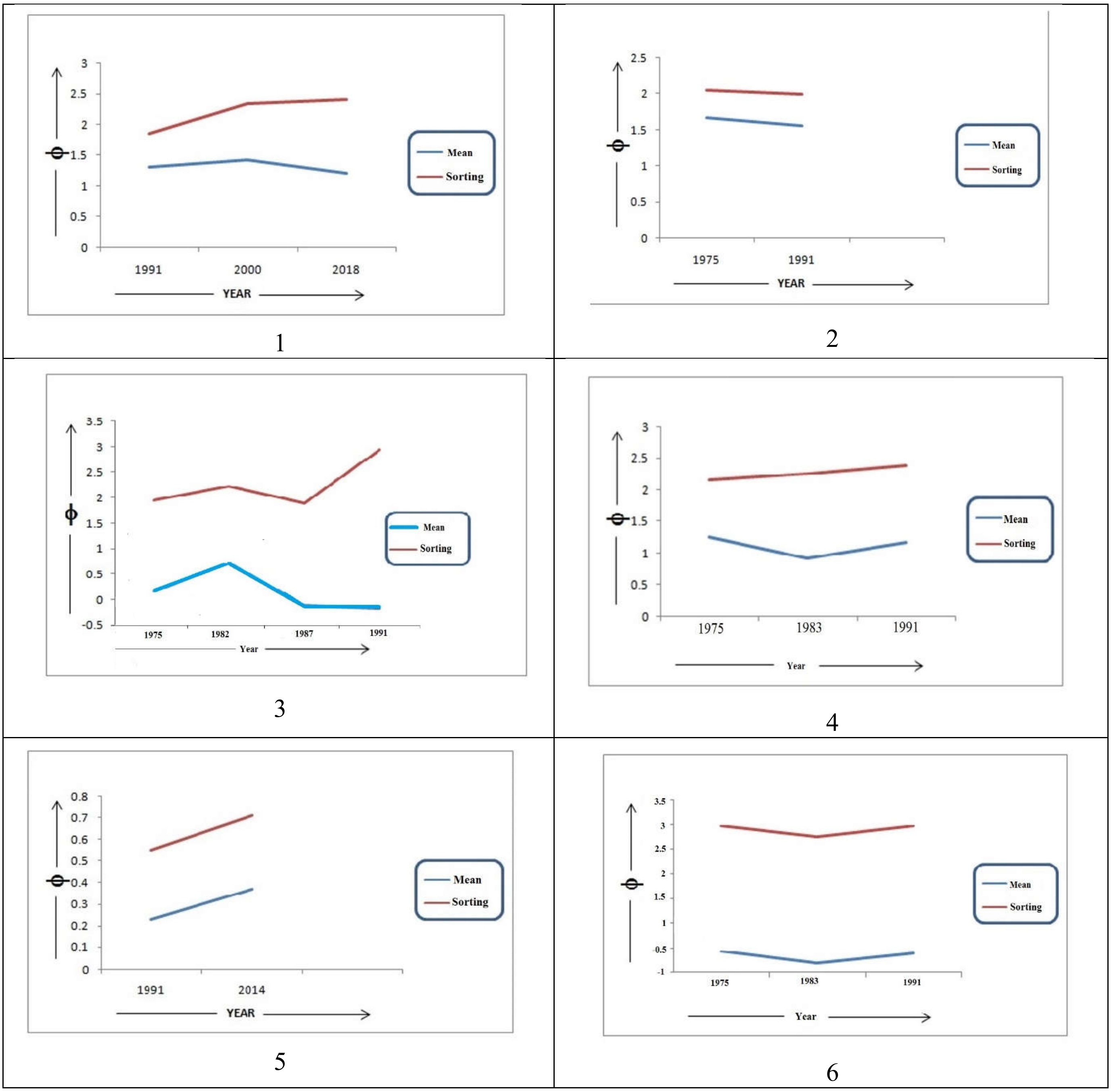

Fig. 6. Temporal Changes in various sedimentological size. 1. Katwa 2 = Agradwip, 3 = Char Chakundi, 4 = Rukunpur, 5 = Purbasthali, 6 = Mayapur

Table 1. Channel Shifting in Bhagirathi Hooghly River in 1975 to 2000 of different place

Place	Right Bank (in 1975 to 2000)(km)	Left Bank (in 1975 to 2000)(km)
Katwa	0.13	0.32
Agradwip	0.12	5.12
Patuli	0.47	0.61
Kamalnager	0.19	0.11
Purbasthali	3.51	0.20
Mayapur	0.05	0.71

Table 2. Channel Shifting in Bhagirathi Hooghly River in 2000 to 2018

Place	Right Bank (in 2000 to 2018)(km)	Left Bank (in 2000 to 2018)(km)
Katwa	0.12	0.13
Agradwip	0.32	0.33
Patuli	0.21	0.16
Kamalnager	0.04	0.01
Pubasthali	0.16	0.24
Mayapur	0.45	0.16

Table 3. Channel Shifted and Sediment Analysis

Place	Right Bank (in 1975 to 2018) (km)	Left Bank (in 1975 to 2018) (km)	Mean	Shorting
Katwa	0.06	-0.38	1.31	2.20
Choto Atagi	-5.59	-5.42	1.615	2.025
Char Chakundi	-3.33	-3.02	0.21	2.255
Agradwip	-104	-1.22	1.116	2.267
Rukunpur	0.3	0.22	0.3	0.63
Purbasthali	-4.69	-4.62	-0.66	1.87

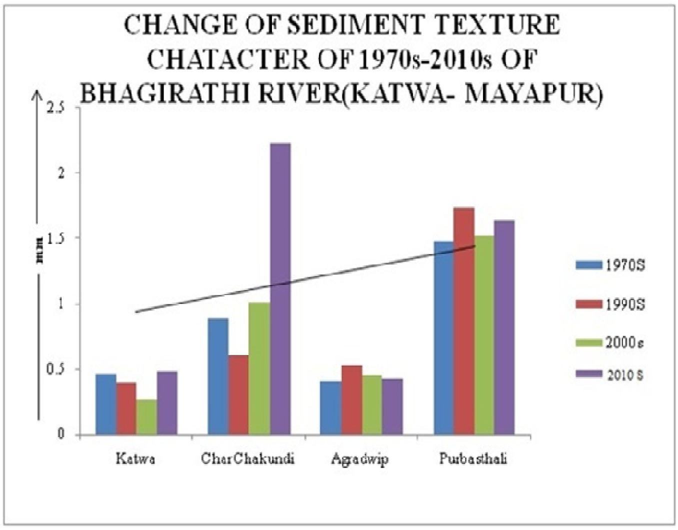

Fig. No 7

Therefore, in 1991 [Fig. Fig No-2 Bhagirathi Hooghly river (Katwa to Mayapur) in 1975 to 20182(B)] at Purbashali, an oxbow lake was formed. The process of oxbow formation continued in 2000 [Fig. 2 (C)] at Agradwip area in this stretch. In 2014's [Fig. 2 (E)] another oxbow lake was formed at Agradwip site. In recent time 2018's [Fig. 2 (F)] there was no oxbow lake formed in this stretch area. But, from this pictorial view we assume that, after 10 to 15 years another two oxbow lakes may be formed at the present course at Patuli in this stretch (Katwa to Mayapur)

Difference Between 1975 and 2000 Bhagirathi Hooghly channel: Fig. 3 and Table 1 summarizes the scenario about channel shifting between 1970 and 2000. At Katwa, the channel was shifted its left bank by 0.32 km which is relatively high as compared to the right bank i.e. 0.13 km. Another massive channel shifting was seen at Agradwip, where the right bank shifted by 0.12 km and left bank by 5.12 km.

Difference Between 2000 and 2018 Bhagirathi Hooghly channel: Fig. 4 and Table 2 describe about channel shifting between two years (2000's to 2018's). At Katwa, the B-H Channel which had witnessed a high left bank shift in 1975-2000 (0.32km), the shifting has reduced (0.12km).At Agradwip, the B-H river right side bank line shifted highly such as in (1975's to 2000's), the channel shifting in this di3rection reduced considerably(0.12km)The Mayapur stretch has increased its shifting from 0.05km to 0.45 km(Table No-2) in right side of B-H river and other things in (2000's to 2018's) at Mayapur B-H river left bank channel shifted 0.71km (Table No-1) after that in (2000's to 2018's) this area decreasing channel shifting such as 0.16 km (Table No-2). In recent time Mayapur area B-H river right side bank was more shifted in left bank side.

Relationship between channel shifting and sedimentology: As stated earlier that sediment fvlux has a relationship with flow character, sediment deposits were collected from various parts of the paleo-channels and current channel. It may be mentioned here that the oxbow lakes were originally the active channels in some periods of time. So, sediments were collected and compared with the results obtained for channel shifting. Sediment samples were collected from Katwa, Chotio Atagi, Char Chakundi, Agradwip, Rukunpur, Purbasthalki and Mayapur (Fig. 6). In most of the sites the sediment texture is increasing. Therefore, it appears that since the construction of the Farakka Barrage in the 1970s, the sediment textureis increasing. In 1970s before the construction of the Farakka Bridge, the Fig. No 4. Sample collection sitesB-H river sedimentlogical texture size is low but after 1975 with the construction of the barrage diverted water entered theFeeder Canal and finally into the B-H River System. So, this causes huge large sediment flow in the B-H river. Fig. 5. Temporal Changes in various sedimentological size. 1. Katwa 2 = Agradwip, 3 = Char Chakundi, 4 = Rukunpur, 5 = Purbasthali, 6 = Mayapur

Chronological Sedimentology: The chronology of the lower part of the Ganga-Brahmaputra Delta in the West Bengal State may be stated as two major phases: Pre Farakka Barrage and Post Farakka Barrage. The construction of the Farakka Barrage can be regarded as a typical case of the human/anthropogenic interference in the fluvial system. It is expected that a river will invariably respond to the changes in the hydrological and fluvial regime. One aspect of documenting this change is by the analysis of sediments or fluvial records. From the various graphs, it is seen that the mean particle size has increased since 1975 (pre Farakka) to 2018 (post Farakka). This can be explained by stating that due to the construction of Farakka Barrage, a major part of the water of the Padma River gets diverted to the B-H River System. Therefore, suddenly the amount of water gets increased and the geomorphic power of the river also gets augmented. This results in increase of depositionary particle size. (Fig.7)

Conclusion

Channel Shifting is a natural phenomenon. But in the Bhagirathi Hooghly River System, the construction of the Farakka Barrage has completely disturbed the Dynamic Equilibrium condition of the river. Entry of excess water of the Ganga into the Bhagirathi Hooghly has suddenly rejuvenated the Bhagirathi Hooghly and destroyed the stability besides increasing the discharge. As a result, the river in the area has constantly shifted its course, thereby forming many paleo-channels and oxbow lakes. One of the most common indicators of fluvial response is sedimentary records. Therefore, this study was conducted to understand whether the construction of the Farakka Barrage has resulted into any change in sedimentary characteristics of the area. From the remote sensing image, the paleo-course of the B-H River in the 1970s was identified. Then sediments of those areas wereanalyzed in the laboratory for their texture character. This study proved that the sediment size has increased from 1970s to 2010s.This may be due to the construction of the Farakka Barrage. Due to the Farakka Barrage, sudden increases the water content has increased the competence and capacity of the river. So, the sediments transported has increased in size and hence the mean size of the sediments have increased in the last 40 years.

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