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Floodplain dynamics in part of the Bhagirathi river near Karkaria and Jagannathpur villages, Nakashipara block, Nadia district, West Bengal.

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Abstract: *Floodplain is an accretional landform where ancient human civilization was built-up depending on its geographical favourability. Geomorphologically floodplain is the most dynamic of topographic surface. It is an extended area associated with varied fluvial landforms under lateral and vertical accretional processes. Changing nature of different fluvial landforms over a floodplain indicates its dynamism. The present paper is concerned with landform characteristics in part of the Bhagirathi river floodplain near Karkaria and Jagannathpur village, (extended from 23º30' N to 23º35' N latitude and 88º 20' E to 88º 25' E longitude) Nakashipara block, Nadia district, West Bengal. Forms and process of a river channel are always very dynamic under floodplain environment. Over the selected floodplain area of the Bhagirathi river different types of landforms are prominently observed like; channel bars, levee, abandoned channel, secondary channel, shifting and avulsion nature of channel etc. With the help of different quantitative techniques several types of accretional landforms in part of the floodplain have been analysed. Apart from these, anthropogenic interferences with the floodplain features have also been discussed as human plays an important role to modify the geomorphology of floodplain landscape.*

Keywords: *Floodplain dynamics, accretion, avulsion, fluvial landforms.*

1. INTRODUCTION:

The present paper is concerned with floodplain dynamics in part of the Bhagirathi river near Karkaria and Jagannathpur village, Nakashipara block, Nadia district, West Bengal. Dynamics in channel forms and behaviours are very common fluvial features over a floodplain which is an extended area associated with varied fluvial landforms under lateral and vertical accretional processes (Dutta,2007). Changing nature of different fluvial landforms over a floodplain indicates its dynamism. Forms and process of a river channel are always very dynamic under floodplain environment (Morisawa,1968). It is very prominently observed with formation and modification of different types of landforms like; channel bars, levee, abandoned channel, secondary channel, shifting and avulsion nature of channel etc. The paper has tried to study the dynamic character of the Bhagirathi floodplain based on different landform features with various quantitative techniques including people perception (Dey & Dutta,2012).

1.1 Location of the study area: The study area (fig-1) is situated on the left bank of Bhagirathi river at Nakashipara block in Nadia district of West Bengal. The latitudinal and longitudinal extension of the study area are 23°30´N-23°35´N and 88°20´E-88°25´E. Special emphasis has been given on the Bhagirathi channel bar including Karkaria and Jagannathpur Mouza.

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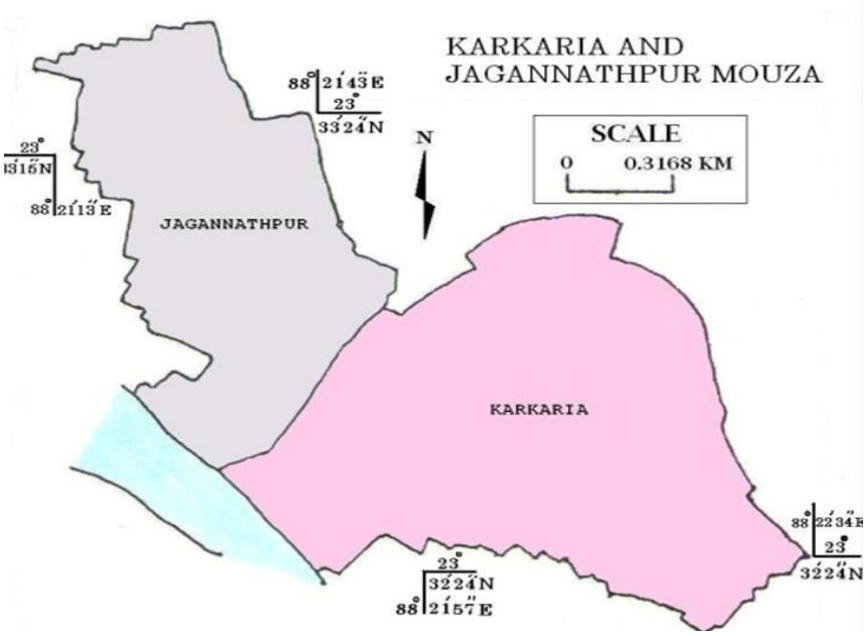

Fig:1: Locational map of Karkaria and Jagannathpur villages along the river Bhagirathi.(source:BLRO & Toposheet, SOI-1968)

1.2 Objective of the study: The main objective of the present paper is to investigate the landform characteristics in part of the Bhagirathi river floodplain near Karkaria and Jagannathpur village, Nakashipara block, Nadia district, West Bengal with various quantitative techniques.

1.3 Materials and methods: The present study is based on the application of modern methodology as well as intensive field work. Data and information have been collected from primary and secondary sources, with particular emphasis on intensive field work. After procurement of these materials, an analysis of these data are made adopting the advanced technique of measurement especially in terms of pre-field, field and post- field. In pre-field work different maps including mouza maps of two villages have been collected. During field survey measurement of stream discharge, areal measurement of the mid-channel bars and other landforms including status of bank erosion were studied by the researcher with the help of different instruments including GPS data. Analyzing of satellite image (LISS-III of 1996 (DST, Bikas Bhavan), Google image of 2006, 2008 and 2010,2021) and toposheet (1968) of the Bhagirathi river channel, it is found that areal change of Karkaria mid-channel bar as well as there is a distinct channel shifting of Bhagirathi river towards its left bank. Several factors (like; stream energy, geo-lithological characteristics, geomorphological characteristics, channel configuration, channel accretion, channel aggradation and riverbank stratification etc.) have been studied, which are responsible for the evolution of the floodplain and its associated landforms.

2. Floodplain formation processes:
Flood is a natural fluvial process which plays prime role to develop river floodplain**.** Scientists have emphasized two important processes of floodplain development, which are lateral accretion and vertical accretion. According to Leopold and Wolman (1960) principally the floodplain is built up laterally by channel deposits in a coalescing series of bars composed of sand and gravel and it is also built up vertically by aggradation of overbank deposits during flooding (Sarkar &Sarkar,2010).

2.1 Lateral accretion process: lateral accretion is inclined layers of sediment, deposited laterally rather than in horizontal strata, particularly by the lateral outbuilding sediment on the surface of a river point bar. The inclined surfaces thus record the progressive migration of the point bar. The dip of the lateral accretion deposit can be used to determine the size of the point bar and channel geometry. With the shifting of meander of a channel it is developed. Formation of point bars are the adequate geomorphic evidences of lateral accretion.

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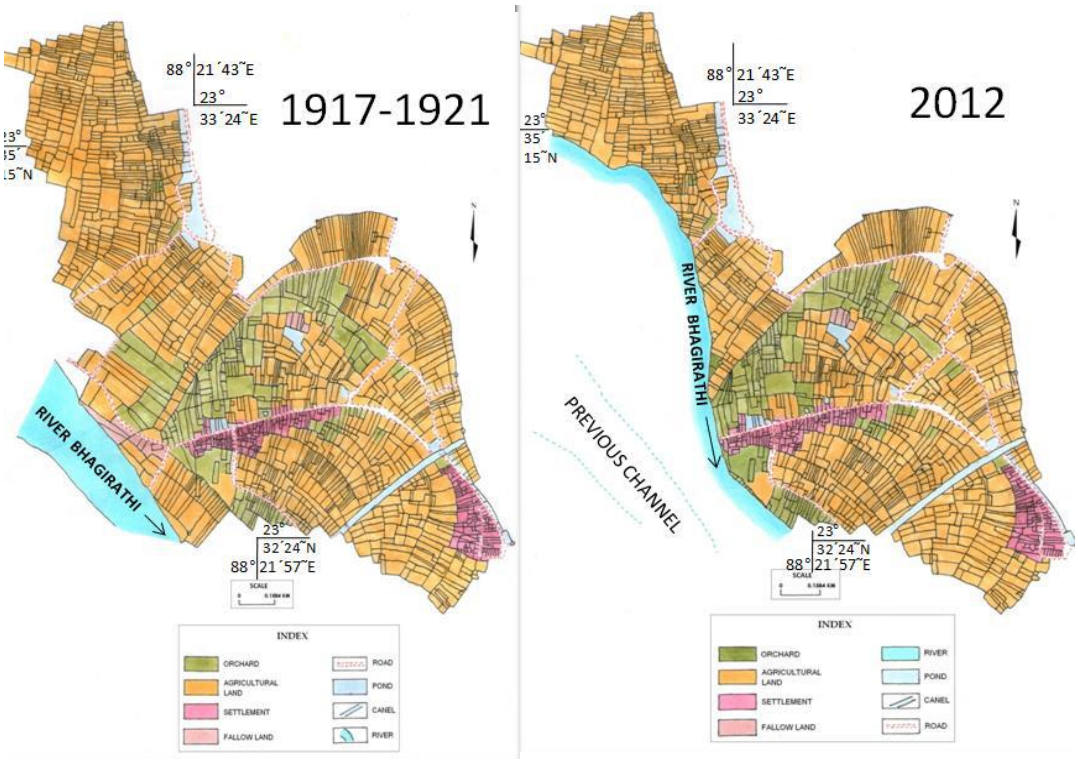

Fig:2:Spatio- temporal changes of the Karkaria -Jagannathpur mouza and the river Bhagirathi from 1917-2012.(source:BLRO & Toposheet, SOI)

Under the influence of lateral accretion channel of the river Bhagirathi is gradually shifts over its vast floodplain. A number of point bars along with meander course of the river Bhagirathi are observed by the author.

2.2 Vertical accretion: Vertical accretion (also called overbank deposition) occurs when rivers leave their channel confines during periodic flooding and deposit sediment on top of the floodplain surface. The floodplain, therefore, increases in elevation during a flood event (Mukhopadhyay & Let, 2014). As a result of the vertical accretion, aggradation of the river channel as well as the floodplain surface are clearly noticed.

3. Observed features over the part of the Bhagirathi floodplain:
Part of the floodplain landscape of the study area is characterized with several important features like; active channel, levee, abandoned channel, pointbar, mid-channel bar, avulsion of channel, channel shifting, severe bank erosion, etc.

3.1 Active Bhagirathi channel: The entire floodplain is developed under the influence of river Bhagirathi. Channel sedimentation is a natural process in flood plain areas. The active channel has developed a number of depositional and accretional landforms over its floodplain. Undoubtedly, the active channel of the river Bhagirathi is supplying necessary sediments to continue the lateral and vertical accretional features. The energy of the river Bhagirathi has a crucial role to develop such type of floodplain. Many Scientists (Nanson and Croke,1992) think that the type and characteristics of the floodplain are mainly developed on the basis of energy of the particular stream and sediment types. They have classified the floodplain mainly in three types; (a) high energy non-cohesive floodplain (b) medium energy non-cohesive floodplain (c) low energy cohesive floodplain. The Bhagirathi floodplain of the present study area falls under low energy cohesive floodplain where stream energy is very low (average 0.71 m/Sec) and the entire floodplain is made of clay, fine silt and sand. So ,the floodplain developing materials are cohesive in nature. From the photographs obtained during field survey it is noticed that the upper bank of the Bhagirathhi channel is made of cohesive materials like ; clay and fine silt, on the other hand, the lower bank is formed with non -cohesive sand (fig:8). As the area is under the Gangetic delta so the intensity of the slope of the entire landscape is very low, which influences the energy and the sediment size of the mentioned floodplain.

Sedimentation process in active channel decreases the cross-sectional area of river channel and for this reason during monsoon period or after heavy rainfall when water discharge is rapidly increases, it create extra pressure on side wall of the non -cohesive sandy lower river bank, which leads lower bank scouring and the upper banks along the active channel collapse causing bank erosion. Near the Jagannathpur bathing ghat across the Bhagirathi channel two cross

sections have been prepared depending on field data. Measurement of water discharge has also been studied based on floated method on 20.05.2012 at 11.30 am. Average depth of the cross-sectional area was 4.64 metre. Width of the cross section was recorded 140metre. Average area of the cross section was measured 649.6 square metre. Average velocity of the water through cross section was measured by floated method was 0.71 metre/second. So, the amount of water discharge through the cross section was calculated 461.216 cumecs(approx.).

3.2 Meandering channel: Meandering is a natural process in a river course commonly observed over the accretional floodplain topography (Mohamed et al 2017). Most of the rivers of the earth are subject to meandering due to both natural and human activities; they shift their course across the valley bottom. The zone within which a meandering stream shifts its channel across either its floodplain or valley floor from time to time is known as a meander belt. It typically ranges from 15 to 18 times of the width of a channel. Over the selected Bhagirathi flood plain, meander course of the river is very commonly observed (fig:8). Apart from this, from the toposheet and the satellite images many abandoned meander courses are also found (fig:6), which bear the historical episodes of channel migration of the river Bhagirathi in long past before.

3.3 Natural Levees: Levees are natural embankments which are formed when a river floods. When a river floods friction with the floodplain leads to a rapid decrease in the velocity of the river and therefore its capacity to transport materials falls. Under this condition suspended materials are deposited to form a levee. During the field survey a prominent natural levee has been identified. Most of the parts of the levee are altered by anthropogenic effects. At present the natural levee is used as kachha road for the local farmers(fig:8).

3.4 Abandoned channel: Over the Bhagirathi floodplain abandoned channel is a noticeable feature(fig:8). Abandoned channels are those channels left behind as meandering rivers migrate over their floodplains and remain among the most enigmatic features of the riverscape, especially related to their hydraulics and geomorphology. The feature is mainly developed due to channel avulsion process(fig:7). Over the floodplain of the selected study area total and partial channel avulsion are vividly expressed in the form of abandoned channel and the oxbow lake. Durin monsoon the abandoned channel are filled with rain water and those abandoned channels are naturally reconnected with the main Bhagirathi active channel. From the prepared cross section several geomorphic imprints of abandoned channels and secondarychannels(fig:7) are observed. The author thinks that those channels were active in long years ago and gradually with the process of lateral accretion and channel migration(fig:7) those channels were left as abandoned. Over a long time periods this is a repeated events under a floodplain environment.

3.5 Point bar: During the field survey a number of point bars have been identified(fig:8), which are under active lateral accretional process. Those point bars are subsequently joined with each other and newly developed land is observed in floodplain area(fig:8). A point bar is one of the accretional features which is made of alluvium that accumulates on the inside bend of streams and rivers below the slip-off slope. Point bars are found in abundance in mature or meandering streams of a floodplain. They are crescent-shaped and located on the inside of a stream bend. Those are mainly composed of sediment that is well sorted and typically reflects the overall capacity of the stream. They also have a very gentle slope and an elevation very close to water level.

3.6 Mid-channel bar: Mid-channel bar is another important channelform of the river Bhagirathi under study area(fig:8). The formation of mid-channel bar derives from instability condition of erodible bed subjected to turbulent flow in river channels. It can be described as a process of interrelationship between waterflow and sediment in terms of bed load, and suspended load.The author has analysed a mid-channel bar of the Bhagirathi river and its geometric change based on field recorded data.

3.6.1 Dynamic nature of Karkaria Mid-Channel Bar: Analysing the collected google images of years 2006, 2008 and 2010 and also GPS data of 2012 it is very prominent that the Karkaria mid-channel bar(fig;4&5) is very dynamic in nature. In the topographical map (SOI, 1968) no existence was found of that bar but in 2012 the area of the bar was approx 267000 sq. metre surveyed by the researcher with GPS. In the google image of 2006 the area of the Karkaria mid-channel bar was approx 309000 sq metre. In the google image of 2008 and 2010 the area of that bar were approx 355300 Sq. metre and 301800 sq metre respectively. So it is very evident that initially, area of the mid channel bar was increasing gradually and from the year 2008 the area of the bar is decreasing.

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WAYPOINT	DATE	TIME	LATITUDE	LONGITUDE	ALTITUDE
377	18-May-12	2:20:38PM	N23 33.009	E88 21.592	30 ft
378	18-May-12	2:21:43PM	N23 32.979	E88 21.548	24 ft
379	18-May-12	2:30:26PM	N23 32.971	E88 21.534	5 ft
380	18-May-12	2:31:38PM	N23 32.958	E88 21.536	4 ft
381	18-May-12	2:33:11PM	N23 32.892	E88 21.564	11 ft
382	18-May-12	2:35:32PM	N23 32.780	E88 21.587	-2 ft
383	18-May-12	2:36:38PM	N23 32.728	E88 21.595	14 ft
384	18-May-12	2:38:08PM	N23 32.745	E88 21.552	15 ft
385	18-May-12	2:39:41PM	N23 32.758	E88 21.509	15 ft
386	18-May-12	2:41:40PM	N23 32.765	E88 21.490	10 ft
387	18-May-12	2:44:26PM	N23 32.770	E88 21.463	15 ft
388	18-May-12	2:48:36PM	N23 32.785	E88 21.413	26 ft
389	18-May-12	2:56:45PM	N23 32.882	E88 21.339	25 ft
390	18-May-12	3:01:28PM	N23 32.948	E88 21.259	26 ft
391	18-May-12	3:05:23PM	N23 32.970	E88 21.159	29 ft
392	18-May-12	3:07:49PM	N23 32.977	E88 21.071	34 ft
393	18-May-12	3:11:05PM	N23 33.023	E88 21.141	36 ft
394	18-May-12	3:12:35PM	N23 33.041	E88 21.157	21 ft
395	18-May-12	3:15:01PM	N23 33.055	E88 21.210	15 ft
396	18-May-12	3:17:13PM	N23 33.072	E88 21.307	17 ft
397	18-May-12	3:18:16PM	N23 33.073	E88 21.359	21 ft

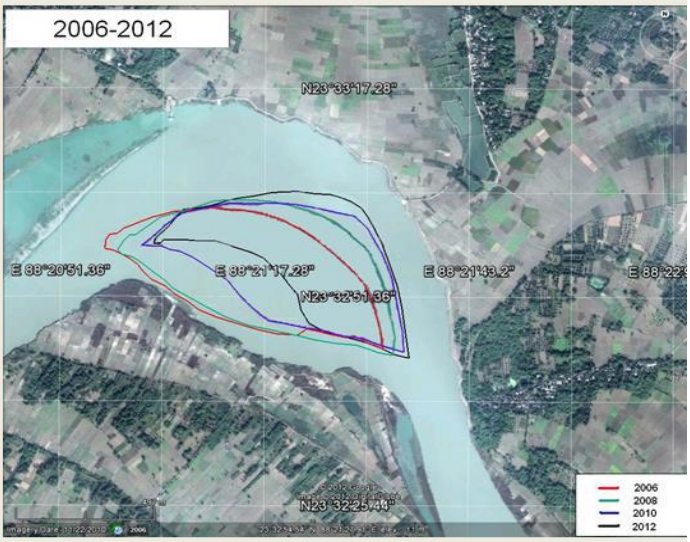

Fig:3: Evolution of the Karkaria mid channel bar fron 2006-2012(source: Google images and GPS data-2012)

For the vivid study of the geometry of the bar the length and width were also measured by the researcher. In the google image of 2006, 2008 and 2010 maximum length of the Karkaria mid-channel bar were 1077 metre,1063 metre and 1023 metre respectively. In 2012 the maximum length of the bar was 1019 metre and in the year 2021 the length of the bar has increased to 2740 metre (fig: 6). So, the length of the bar is increasing very rapidly.

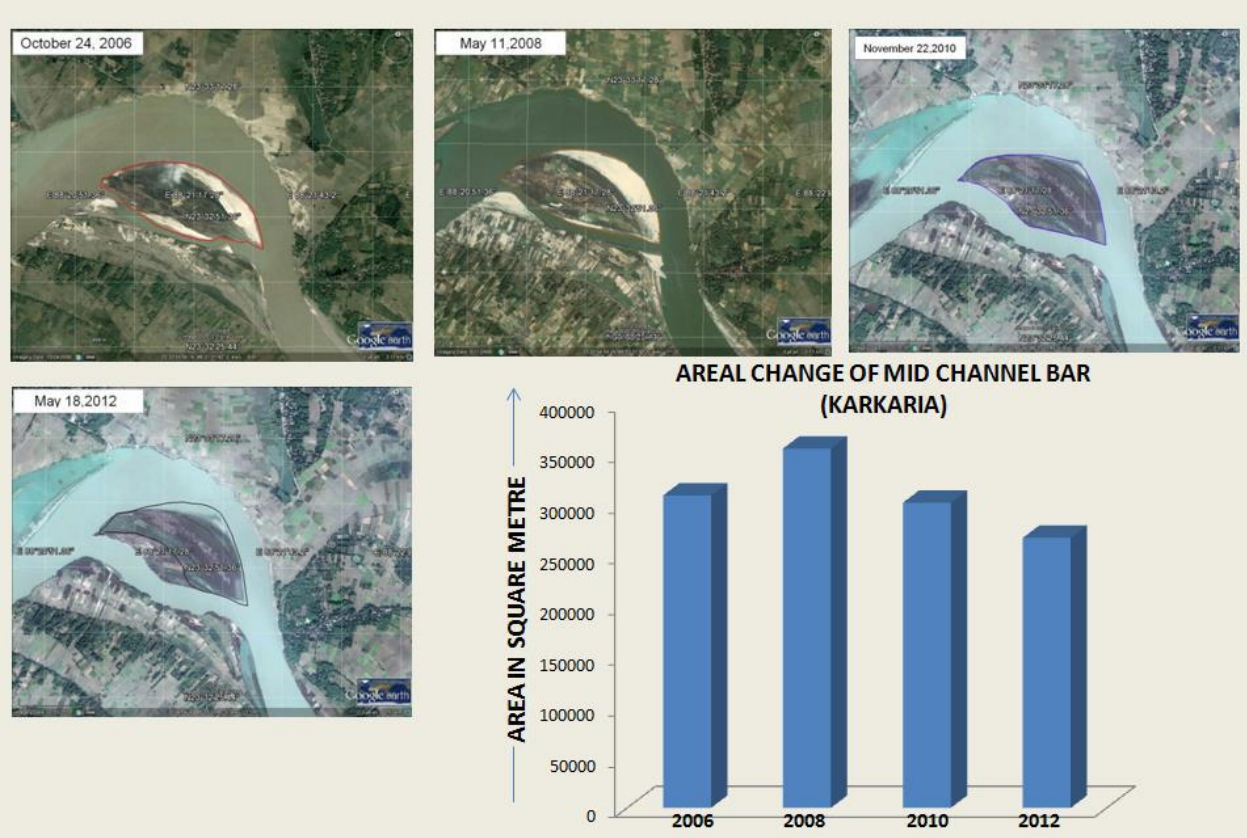

Fig:4:View of the Karkaria mid channel bar from different Google earth images showing the areal changes of the Karkaria mid-channel bar. (source:Google images and GPS data-2012)

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In the google image of 2006,2008 and 2010 the maxmimum width of the Karkaria mid-chnnel bar were 431 metre,493 metre and 509 metre respectively. In 2012, the maximum width of the bar was 532metre. The width of the bar has been measured from the google earth satellite image(2021) about 530 metre. From the chronological study it is very prominent that the maximum width of the Karkaria mid-channel bar is increasing gradually towards its left bank where Karkaria and Jagannathpur Mouza are situated (Dey & Dutta,2012).So, the present study suggests that chronologically the maximum width of the bar is reducing and the maximum length of the mid-channel bar is rapidly increasing.

3.7 Channel avulsion: Avulsion is the frequently diversion of channel. In floodplain topography it is very commonly observed. Nature of avulsion channels are very dynamic. In lean period the channel remains dry but during rainy season the abandoned channel becomes filled with water. In the cross section (fig:7) several secondary channels have been identified. At present the local farmers use the abandoned channels as agricultural lands. With the help of toposheet and satellite images many spill channels are also observed (fig:6).

3.8 The shifting of Bhagirathi river channel: Near the Jagannathpur and Karkaria villages shifting of Bhagirathi river (fig:7) is a major problem which has created damage of agricultural lands, houses and roads. For the analysis of channel shifting and bank erosion of the Bhagirathi river the researcher has used Jagannathpur mouza maps of 1917 and 2012 (Fig-2). From both of the landuse maps it is very clear that the river Bhagirathi has shifted towards its left bank damaging the land resources of Jagannathpur village.

In the diagram(Fig .- 5) the blue lines shows the outline of Bhagirathi river of the year 1968 and the red lines shows the outline of Bhagirathi river of 1996 and overlapping these maps, the erosion, accretion and depositional area have been identified. The river is shifting towards its left bank in the study area. Towards the outward parts of the meandering course of river Bhagirathi severe bank erosion event is being noticed while a vast point-bar has developed at the inward part of the meander under fluvial lateral accretional processes.

From the superimposed map of two different years (Fig-5) eroded area of Bhagirathiriver has been identified during 1968-1996 in the study area. About 5155000 sq. metre area has been eroded along the left bank of Bhagirathi river. The area under deposition of Bhagirathi river during 1968 to 1996 is about 4167500 sq. metre which have been observed along its right side of Bhagirathi river.

Accretion indicates gradual deposition of sediment along the edges of a channel by lateral migration. From vivid analysis of the superimposed maps of two different year 1968 and 1996, accretional area of Bhagirathi river has been identified in the study area, which is about 1602500 sq.metre.

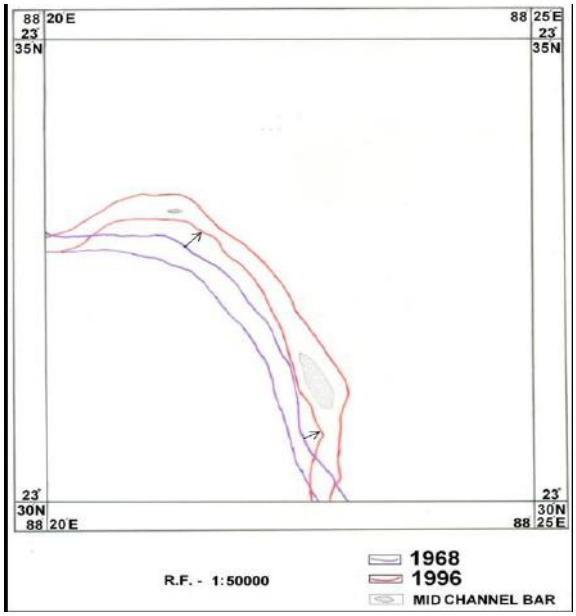

Fig:5: Superimposed outlines of the river Bhagirathi ;blue lines indicates toposheet,1968 and red line, depicts LISS-III 1996)

3.9 Severe bank erosion: In the study area shifting of Bhagirathi river has created severe bank erosion problem which is a major hydro-geomorphic hazard (Dutta ,2012) of the area. In the topographical map surveyed by S.O.I. in 1968 no existence was noticed of the Karkaria bar, but in 2012 the area of the bar was approximately 267000 square metre surveyed by the present researcher with G.P.S. As the bar is shifting towards the Jagannathpur village that is why the river water flow is bifurcated into two sub channels and stream flow is deflected towards the bank of Jagannathpur and this is an important mechanism of bank erosion and channel shifting along the left bank. Hence the river erodes its left bank near Jagannathpur Mouza(fig:8). The local people of Karkaria and Jagannathpur village are facing various problems such as damage of land resources, agricultural lands, orchards, roads, mango groves and also settlement areas. As a result of shifting of river channel, many villagers have already migrated from their village area. Every year huge land resources are engulfed by the river significantly in monsoon period. As a result, agricultural land and agricultural production are day by day hampered. Not only that, but also occupational structure of the local people of the both villages; Karkaria and Jagannathpur have been changed.

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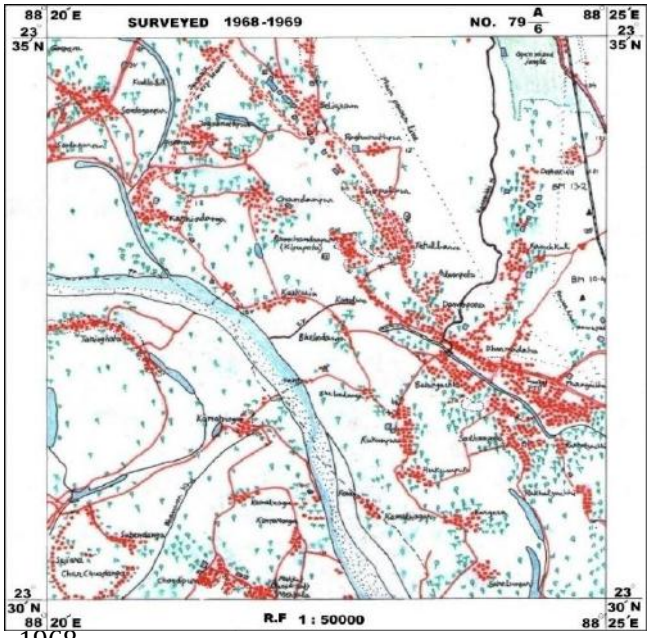
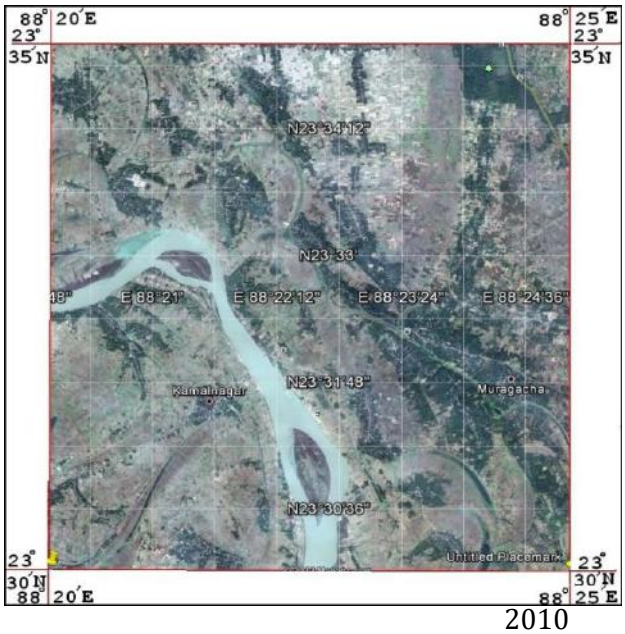
The farmers have changed their working pattern due to damaging of agricultural land by stream erosion. Earlier, 73% workers involved with agricultural field but at present it has decreased to 34%.



1968



2010

2021

Fig:6: Topographical sheet (1968) & satellite image(2010) (2021) showing mid channel bar, abundant channel, spill channel including changing form of Bhagirathi River channel

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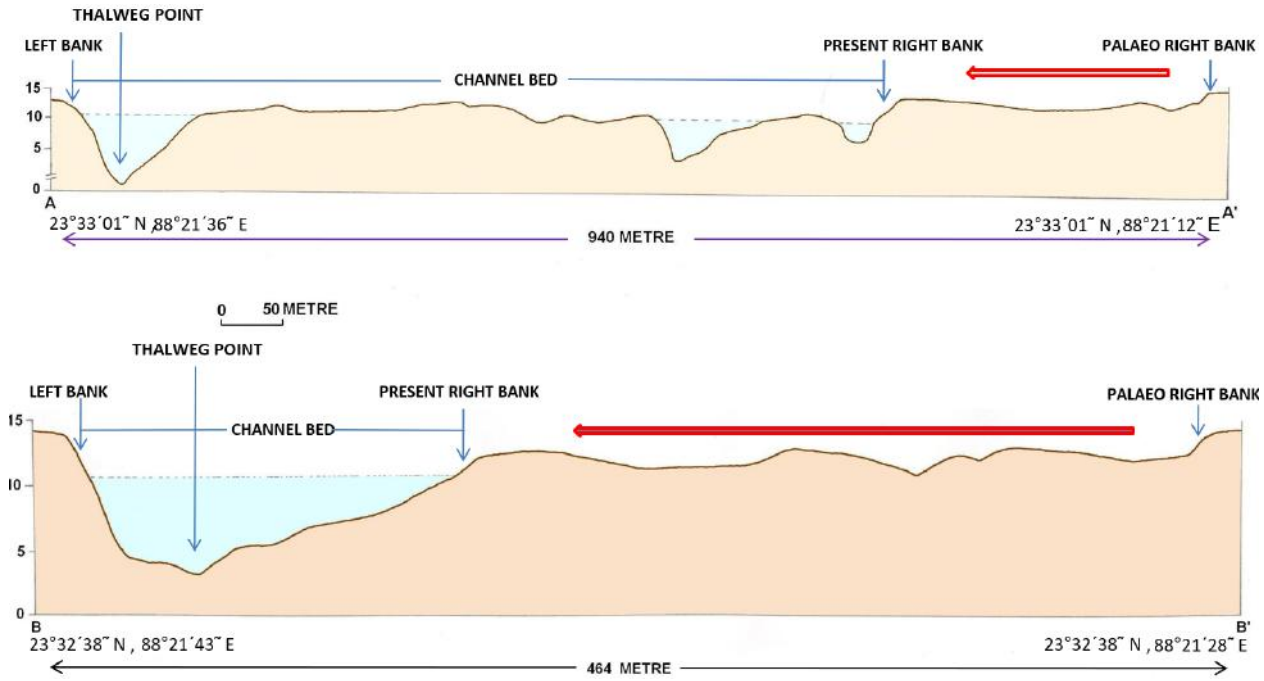

Fig:7: Cross-section AA' and BB' showing active Bhagirathi channel and several secondary channels, abandoned channels including the shifting trend of the Bhagirathi Channel, (Source: Field Survey,2012).

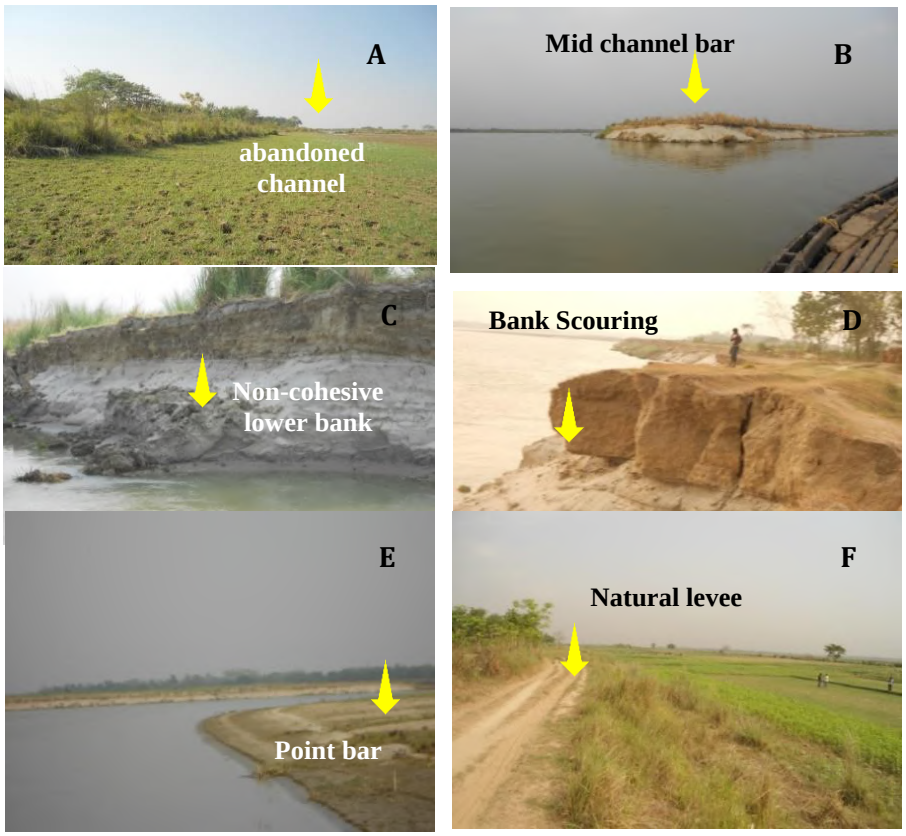

*Fig:8: Observed Bhagirathi floodplain features **A**: Low lying abandoned channel, **B**:Karkaria midchannel bar, **C**:Cohesive upper bank and non-cohesive lower bank, **D**:Scouring at non cohesive lower bank, **E:** Development of new point bar, **F:** Bhagirathi levee used as kachha road.(Source: Field Survey,2012).*

3.10 Channel aggradation: Due to fluvial deposition (mainly lateral and vertical accretional processes)channel aggradation is observed in the Bhagirathi river and as a result of channel siltation the cross -sectional area of the channel

is being reduced and during monsoon excessive water flow erodes the bank near Karkaria and Jagannathpur mouza. As the study area is a part of the lower Gangetic delta, so channel sedimentation is a common feature in Bhagirathi river. Point bars, mid channel bars, shifting nature of channel are the prominent evidences of the channel aggradation. Aggrading Bhagirathi river channel in Nadia district is one of the causes to enhance hydro-geomorphological dynamics of the floodplain in the selected area.

4. CONCLUSION:

Depending on vivid field survey, the present researcher has identified some major morpho-dynamic characteristics of the part of Bhagirathi river floodplain near Karkaria mid-channel bar and nature of channel shifting of Bhagirathi. From the over going discussion, it is very clear that the study area is situated in active floodplain zone characterized with several noticeable landforms measured with modern tools and techniques. The local people sometimes misunderstand the variability of the channel behaviour in the active floodplain. As a result, they construct their houses and agricultural land in active floodplain mainly over the abandoned zone of the river. Unfortunately, during monsoon period due to natural inundation of the abandoned channels, poor farmers of the said villages face serious economic loss. The length of the mid -channel bar is very rapidly increasing (1968-2021) and the width of the mid-channel bar is more or less stable. The author thinks that in near future the mid channel-bar will be converted into a longitudinal channel bar and after that it will join with the main floodplain. Fluctuation of stream energy, water discharge in different times of the year, geo-lithological characteristics and hydro-geomorphological features of the study area, channel accretional process have developed dynamic characteristics of the Bhagirathi floodplain landscape.

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REFERENCES :

1. Dutta, R.K. (2007): Landform-land use characteristics of Western Himalyan foothill with special reference to Haridwar district, Uttarakhand, published in the journal of Institute of Landscape Ecology and Ekistics, ILEE, Calcutta, Vol.30, No.2 pp.179-186.
2. Dutta R.K.(2012) : Hydrogeomorphic mechanism of bank erosion of the Ganga river and its management with special emphasis on bio-engineering techniques in the Western Himalayan foothill area, Haridwar district, Uttarakhand. ”Published in ILEE,Vol-35,No.1, PP.191-212
3. Dey,S.& Dutta, R.K.,(2012): Hydrogeomorphic mechanism of channel shifting of Bhagirathi river with special emphasis on Karkaria and Jagannathpur mouza,Nadia district, West Bengal, Indian journal of landscape systems and ecological studies, ILEE,Vol-35,No.2, PP.94-100.
4. Leopold, L. &Wolman, M. (1960): river meanders, bulletin of the geological society of America, vol. 71,June, pp. 769-794.
5. Mohamed A, Sherif Saad M., Mustafa, M., (2017): Evaluation of alluvial channel meandering phenomenon case study, University of Targoviste, Series 17(2), pp. 206-219
6. Morisawa, M., (1968): Stream their dynamics and morphology, Academic publishers, Kolkata, pp. 135-141.
7. Mukhopadhyay, S. & Let, S., (2014): Changing Flood Intensity Zone of Dwarka River Basin in Eastern India, vol.36, No.1 , pp. 123-132.
8. Nanson, G. C. & Croke, J. C. (1992): A genetic classification of floodplains. Geomorphology, 4 (6), pp. 459-486.
9. Sarkar, K. & Sarakar,I., (2010): Earth surface forms and processes-a geomorphological approach, Mitram, Kolkata, pp. 523-535.