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Estimation of Areal and Linear Extent of the Ganga-Padma Riverbank Erosion in Samserganj C.D. Block of Murshidabad District, West Bengal, India

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Abstract : *Samserganj C.D. block of Murshidabad district is facing serious riverbank erosion problem with extensive destruction of agricultural lands and settlement area in last few years. Displacement of settlement due to bank erosion has become a serious issue of the area. Hence, estimation of areal and linear measurement of erosion is very important for planning and implementation of hazard management strategies as well as future land use policy of the area. Based on LANDSAT 8 OLI/TIRS 2014 and 2024 satellite images, it is measured by the present authors that from 2014 to 2024, along the left bank of the Ganga-Padma river near Samserganj block, about 1.044 sq. km. area has been eroded. On the other hand, about 4.635 sq. km. area of the block has been washed away by the river along its right bank. Along the left bank of the river maximum linear shifting due to accretion has been found about 1735.375 meter near Shibpur. As a result of serious erosion, along the right bank, maximum shifting of the river channel has been observed about 388.197 meter in Chachanda and Dhusaripara. From 2014 to 2024 the approximate rate of erosion near Dhusaripara village has been estimated to be 38.81 metre per year. Several physical and non- physical factors have made the river bank erosion problem as a very complex issue in the area under study.*

Key words: *Areal Shifting, Linear Channel Shifting, Channel Siltation, Hazard Management*

Introduction

River-bank erosion is a serious hydro-geomorphological hazard in Samserganj block of Murshidabad district. In last few years the intensity of the problem has gradually increased causing severe destruction of hundreds of houses and land properties. Hence, in Samserganj river-bank erosion hazard has become a national issue. Many of helpless dwellers of the block have lost their houses and agricultural lands. As a result, a noticeable number of families have lost shelter and they are facing extreme socio-economic difficulties due to the erosion. Dhusaripara town has 17800 population with population density of 5400 persons/sq.km (Census of India, 2011).Several times the problem has been highlighted in a number of research articles and newspapers. The present work is concerned with estimation of areal and linear extent of river bank erosion in Samserganj C.D. block with special reference to Dhusaripara census town. Excessive

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bank erosion caused several environmental adverse effects in the Dhusaripara census town of Samserganj C.D. block. The present work is a small effort to illustrate the areal and linear measurement of the Ganga-Padma riverbank erosion in Samserganj C.D. Block of Murshidabad District, West Bengal. Calculation of areal and linear measurement of erosion is very significant for implementation of future land use planning in the area.

Leopold &Wolman (1960) had benchmark contribution on analysis of river meanders. Nanson & Croke (1992) scientifically illustrated genetic classification of floodplains. Rudra (2010) intensively studied the dynamics of the Ganga in West Bengal, India from 1764–2007. Panda and Bandyopadhyay (2010) illustrated the morphodynamic altercations of river Bhagirathi in Murshidabad district with the help of remote sensing and GIS techniques. Thakur et al. (2012) worked on river bank erosion hazard of the Ganga river, upstream of Farakka barrage using remote sensing and GIS. Dey et al. (2012) discussed hydrogeomorphic mechanism of channel shifting of Bhagirathi river with special emphasis on Karkaria and Jagannathpur mouza, Nadia district, West Bengal. Rabbi et al. (2013) studied on river bank erosion and its impacts on land displaced people in Sirajgonj riverine area of Bangladesh. Mukhopadhyay et al. (2014) illustrated changing flood intensity zone of Dwarka river basin. Islam (2016) discussed river bank erosion problem and its impact on economy and society along the left bank of river Bhagirathi in Nadia district, West Bengal. Pal and Pani (2016) studied about seasonality, barrage (Farakka) regulated hydrology and flood scenarios of the Ganga river. Lovric and Tosic (2016) depicted assessment of bank erosion, accretion and lateral channel migration using remote sensing and GIS at lower part of the Bosna river. Billah (2018) worked on mapping and monitoring of erosion-accretion in an alluvial river using satellite imagery; the river bank changes of the Padma in Bangladesh. Ghosh and Sahu (2019) studied on the environmental impact of the Ganga-Bhagirathi river bank erosion in Jangipur sub division of Murshidabad district, West Bengal. Das and Samanta (2022) focused on the impact of flood and river bank erosion on the riverine people in Manikchak block of Malda district. Ghosh (2022) discussed on the identification of prime factors of active river bank erosion in the lower course of the Ganga-Bhagirathi river. Mondal (2022) worked related to river bank erosion of West Bengal. Sarkar (2022) worked on bank erosion and associated problems in upper Mahananda basin in Darjeeling district of west Bengal. Saha and Sahu (2023) studied on the impact of river bank erosion on riparian society; a micro level study along the Ganga-Padma river in Samserganj C.D. block of Murshidabad district. Ritu et al. (2023) worked on prediction of Padma river bank shifting and its consequences on LULC changes. Ali (2024) intensively investigated the Brahmaputra riverbank erosion as a major geo-environmental problem in the lower Assam, India. Bairagya and Ghosh (2024) explained causes and impact on human life of Samserganj C. D. block, Murshidabad. Biswas (2024) worked on dynamic effect of variation of river water level on riverbank erosion. Dutta (2025) focused on economic effects of displacement due to river bank erosion in Majuli district of Assam, his study depicts that the bank erosion has a cumulative impact through the combined effect of socio-cultural as well as socio-economic problems of the displaced people. Suman (2025) has carried out a study on sedimentation and bank erosion of the Brahmaputra

river between Salmora and Kamalabari in the southern part of Majuli district of Assam, India. Mishra (2025) has been carried out a study on dynamics of river course through soil erosion and sediment yield simulation in Ramganga river basin. Deka(2025) studied on bank erosion and bank migration in the southern part of Majuli island of Assam district of India.

However, earlier researchers hardly analyzed the areal and linear measurement of the Ganga-Padma river-bank erosion of Dhusaripara town of Samserganj C. D. block. However, the present work has emphasized on estimation of areal and linear measurement of the Ganga-Padma river-bank erosion as well as bank shifting rate due to erosion and accretion of Dhusaripara town of Samserganj C. D. block, Murshidabad from 2014 to 2024 with the help of LANDSAT 8 OLI/TIRS 2014 and 2024 satellite images. In the work due weightage has been given on field based perception of local people of Dhusaripara census town. The present authors have focused on the problems related to river bank erosion as well as present impacts of the bank erosion in the Samserganj C. D. block and various erosion prone areas of West Bengal.

Study Area

The study area is located at Dhusaripara census town under Samserganj C.D. block in Murshidabad district of West Bengal, India. The study area is extended from 24°37′31″N-24°39′11″N and 87°59′8″E - 88°0′54″E (Fig. 1). The Dhusaripara town is located on the right bank of the Ganga-Padma River, which is one of the most active bank erosion prone areas in downstream of Farakka Barrage. Total area of this census town is 3.31 sq. km. According to the Census of India 2011, total population of the town is 17800 and population density is 5400 per sq.km.

Objectives of the Study

The primary objective of the paper is to estimate areal and linear measurement of the Ganga-Padma bank erosion including riverbank shifting rate. The paper also seeks to study the perception of dwellers regarding the problem of Dhusaripara town, Samserganj C. D. block, Murshidabad.

Materials and Methods

In order to fulfill the objective of the paper, modern methods, including field techniques, have been applied. Relevant primary and secondary data and information have been utilized in the work. Previous literatures have been vigorously studied to identify research gap and design the plan of work. Field based data collection, observation and perception study have been given due weightage as those information have important role to analyze the problem scientifically. Google earth images from 2008 to 2023 have been used to detect the channel shifting of the Ganga River. A change detection map of the study area was created using Google Earth Pro, to identify channel shifting in the Samserganj river bank area. In order to identify areal, linear and temporal shifting of the Ganga river in Samserganj C. D. block special emphasis has been given in the paper. Satellite images (1984, 1994, 2004, 2014, 2023, 2024) have been collected from USGS

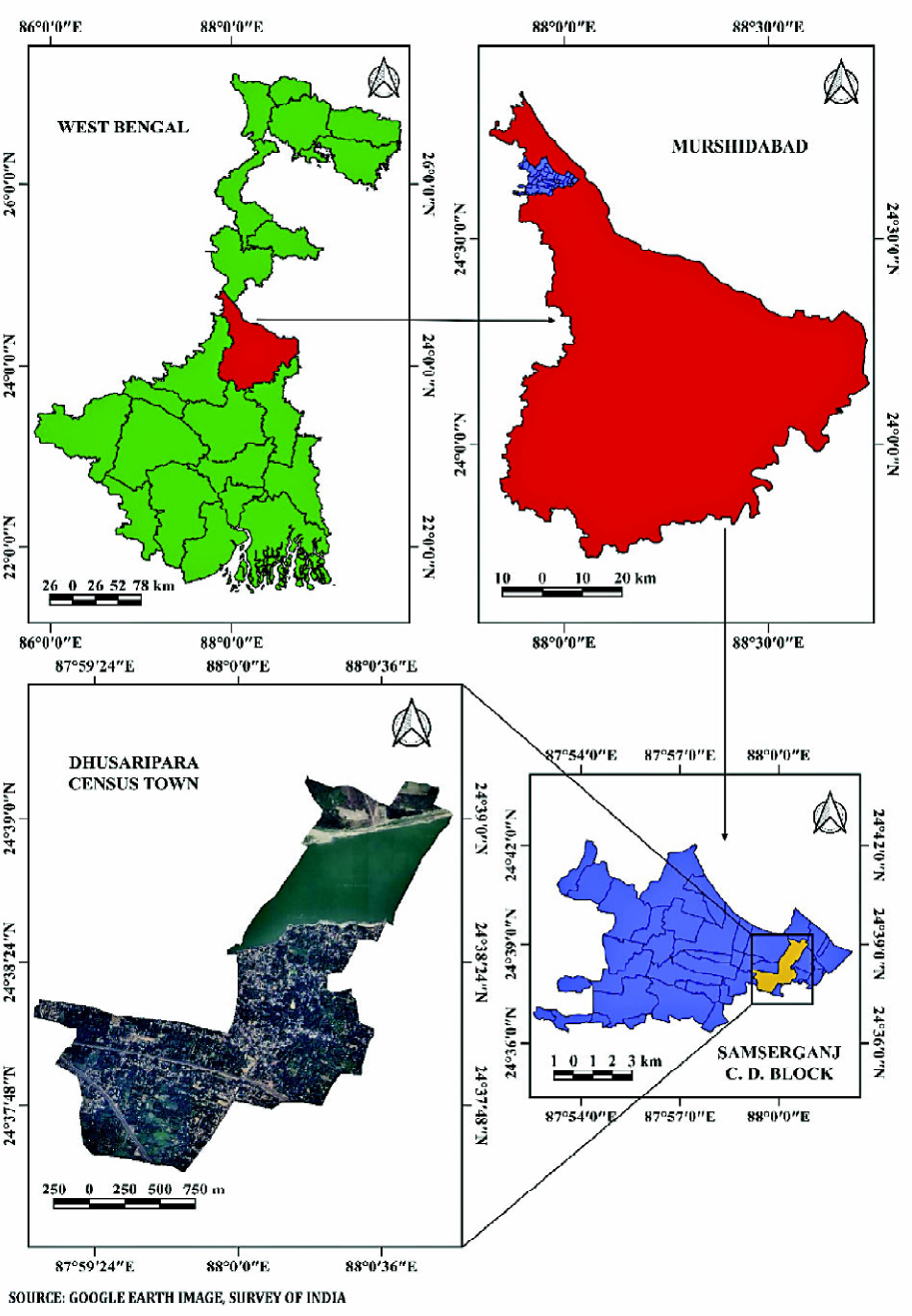

Fig. 1: Location map of the study area.

Source: Survey of India maps

Earth Explorer to analyse vividly the problem. The village and town maps of the Samserganj C. D. block, Dhusaripara were obtained from the Survey of India website to estimate the affected areas. Spatio-temporal shifting of the Ganga-Padma river from 1984 to 2024 has been analyzed to understand the trend of shifting channel courses. Primary and secondary data and information were discussed in present work for qualitative and quantitative analysis of the serious problem. Seventy households of Dhusaripara town were surveyed, who faced severity of the problem. Survey was also conducted to understand people perception regarding causes and socio-economic impact of the hazards. Through the questionnaire schedule, the field survey was conducted in Dhusaripara census town on 17.02.2024, 24.02.2024, and 25.02.2024. Household survey was also conducted for understanding the socio-economic impact of bank erosion as well as the present situation of the victims. District Resource Map (Geological Survey of India) of the Murshidabad has been studied to attain the objective of the research work. Based on secondary data, assessment of areal and linear measurement of the erosion including erosional rate in Dhusuripara town has been done. In the present work authors have emphasized on estimation of areal and linear measurement of the Ganga-Padma river-bank erosion of Dhusaripara town of Samserganj C. D. block, Murshidabad with the help of LANDSAT 8 OLI/TIRS 2014 and 2024 satellite images.

Fig. 2: Severity of the bank erosion problem in Dhusuripara Census town.
Source: Field Survey, 2024

The authors have measured channel sinuosity index of the Ganga-Padma river in study area with Leopold and Wolman (1957) technique to understand the changing channel pattern and instability of the river due to siltation from 2014 to 2024. Erosional and accretional characteristics of the river channel have also been discussed in the paper for better understanding about the causes of channel shifting. In order to study the socio-economic impact of the serious bank erosion problem, landuse pattern of the block has been analyzed in the paper. For better understanding about the future effect of the problem, trend of land use land cover change from 2014 to 2024 has been discussed.

River Channel Siltation

The researchers think that spatio-temporal variability of river channel siltation is closely linked with channel shifting phenomenon and associated problem in the study area. Based on the channel bars from satellite images, assessment of river channel siltation has been done. The total surface area of the channel bar in 2013 was around 3.84 sq. km. During monsoon of the year 2013 area of the channel bar was started to erode by heavy flow. In the year 2015 and 2017 channel bars have been seen along both side of the river bank, covering the area of 2.74 sq. km. and 2.94 sq. km. respectively. The increasing channel bar along the left bank of the river has changed the river flow towards the right bank and mostly towards Dhusaripara census town. The area of the bar from year2019 to 2021 sharply increased by 3.47 sq. km. to 5.33 sq.km. Surely, that indicates vast channel siltation, and that is the main reason for devastating bank erosion in the Dhusaripara census town and adjoining areas. Though, several previous literatures have already mentioned direct influence of the Farakka barrage on siltation and associated bank erosion problem. In the year 2023 left bank of the river Ganga-Padma has been captured by the channel bar, total area of the channel bar was 7.37 sq.km. So, it can be said that spatio-temporal changes of pattern and area of the channel bar, river course changed its flowing direction and directly hit the right bank causing serious bank erosion problem.

Spatio-temporal shifting of the Ganga-Padma river course (1984-2024)

Spatio-temporal shifting of the Ganga-Padma river (1984-2024) near the study area has been analyzed with the help of Google Earth Pro images. From this map (Fig. 3) it is clear that the Ganga-Padma river changes its course time to time. This map shows the shifting of the Ganga-Padma river course from 1984 to 2024. In the year 1984, main river course flowed from the upper most part of the study area. After 10-year, sediment deposition had been seen along the left and right bank of the river causing reduction of channel course area. But at present, the Ganga-Padma river changes its course drastically. The river course has shifted from upper part to middle portion of the study area. In the year 2004 river expanded its courses eroding the North-West part of the Samserganj C. D. Block, and also erosion has been seen along the right bank of the river. In last10-years river has shifted its course towards the right bank eroding some parts of the block and sediment deposition have been seen in the northern part of the block. At present, river

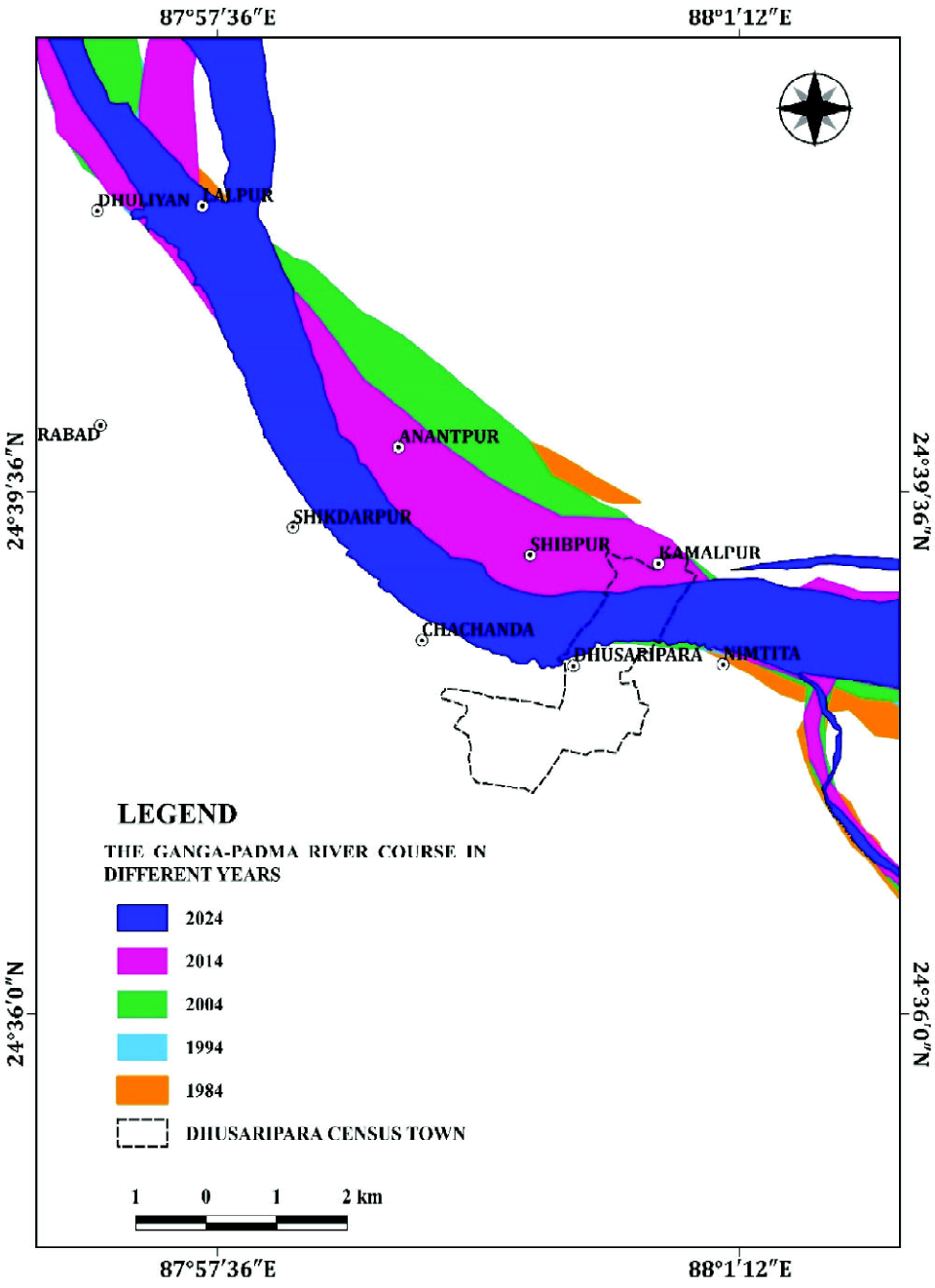

Fig. 3: Spatio-temporal shifting of the Ganga-Padma River (1984-2024) in the Samserganj C. D. Block.

changes its course sharply and flows towards the right bank. As a result of the vast siltation in the left bank, river flow has been diverted to right bank and serious erosion takes place along the right bank.

The author have measured channel sinuosity index of the Ganga-Padma River with Leopold and Wolman (1957) technique to understand the changing channel pattern and instability of the river due to excessive sedimentation. From 2014 to 2024 the channel sinuosity index has also enhanced 0.8(straight) to 1.3 (sinuous). It indicates the straight channel converts into sinuous channel pattern increasing channel instability due to extensive development of point bar along left bank. If, the sedimentation process continues then the channel pattern may convert into meander in near future amplifying the magnitude of erosion on right bank.

Areal measurement of the Ganga-Padma river-bank erosion and deposition of Samserganj C. D. Block

Areal measurement map of the Ganga-Padma river bank erosion of Samserganj C.D. block has been prepared with the help of LANDSAT 8 OLI/TIRS 2014 and 2024 satellite images.

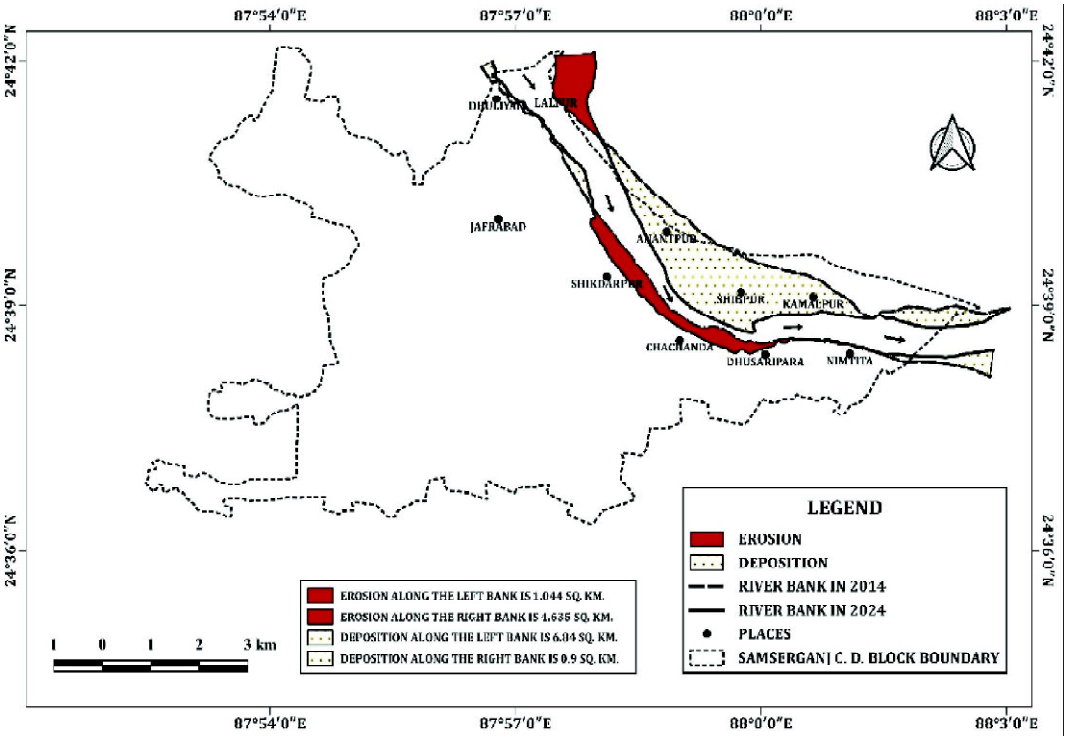

Fig. 4:

With the help of this map (Fig. 4), it is clear that maximum erosion has taken place along the right bank of the Ganga-Padma river. Along the right bank about 4.635 sq. km. area has been eroded in last 10year (2014-2024). Erosion is also observed in Shikdarpur, Chachanda villages and Dhusaripara census town. Along the left bank about 1.044 sq. km. area has been eroded. Erosion found in the left bank at Lalpur village. Deposition occurs along the right bank, the area is about 0.9 sq. km. and along the left bank maximum deposition is found, it is about 6.84 sq. km. Because of the excessive sediment deposition in the left bank, direction of the channel flow has been diverted towards right bank of the Ganga-Padma river. As a result, river waterflows directly erode the right bank of the river where the study area is located.

Linear measurement of the Ganga-Padma River of Samserganj C.D. Block: Linear measurement of bank erosion technique helps to quantify erosion and accretional rates over time. Riverbank erosion and accretion are crucial processes for determining sediment flux, sediment transport and storage in channel. These information is also very significant for predicting future erosion or depositional patterns and assessing the effectiveness of erosion control measures in an area. The linear measurement map (fig: 5) of the Ganga-Padma river bank erosion and deposition

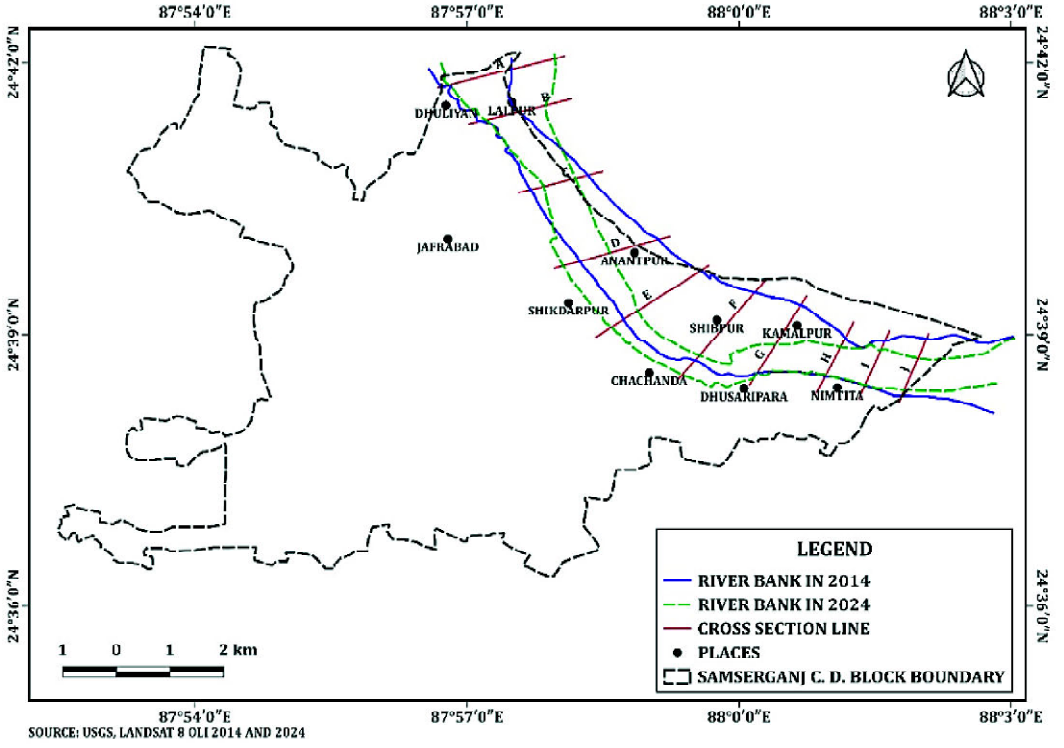

Fig. 5: Linear measurement of erosion and accretion of the Ganga-Padma river-bank, Samserganj C. D. Block.

of Samserganj block has been prepared with the help of LANDSAT 8 OLI/TIRS satellite images (2014 &2024). With the *Figure 5: Linear measurement of erosion and accretion of the Ganga-Padma river-bank, Samserganj C. D. Block*. help of this map, it is prominent that maximum linear shifting of bank due to accretion has been found on the left bank at cross section-E of the river, it is about 1735.375 meter near Shibpur. The approximate accretion rate at the cross section E is 173.53 metre/year. On the other hand maximum linear shifting due to erosion has been recorded 826.91metre with approximate rate of erosion 82.69 metre/year at cross section A. Along the right bank maximum linear shifting has been found 388.197 meter as a result of serious erosion at F cross section where Chachanda and Dhusaripara villages are located, near these villages the erosional rate is about 38.81 metre per year. On the right bank at cross section C , maximum accretional shifting is noticed 254.866 metre with the rate of 25.48 metre per year.Table:1 indicates cross section wise (A-J) linear extent of erosion and accretion as well as their approximate rate from 2014 to 2024 along the Ganga –Padma river near Dhusaripara.

Table 1: Linear measurement of shifting including erosion and accretion rates of the Ganga-Padma river bank in Samserganj from 2014 to 2024. (source: calculated by authors based on LANDSAT8 OLI,2014 &2024)

Cross section	Left bank erosion / accretion (metre)	Left bank erosion / accretion rate (metre/year)	Right bank erosion / accretion (metre)	Right bank erosion / accretion rate (metre/year)
A	**-826.913**	**82.69 (erosion)**	155.586	15.55(accretion)
B	-524.566	52.45(erosion)	89.680	8.96(accretion)
C	242.024	24.20(accretion)	**254.866**	**25.48(accretion)**
D	944.024	94.40(accretion)	-327.074	32.70(erosion)
E	**1735.375**	**173.53(accretion)**	-263.024	26.30(erosion)
F	1639.727	163.97(accretion)	**-388.197**	**38.81(erosion)**
G	920.00	92.00(accretion)	-11.616	1.16(erosion)
H	200.534	20.05(accretion)	20.974	2.09(accretion)
I	188.646	18.86(accretion)	8.099	0.80(accretion)
J	422.667	42.26(accretion)	124.452	12.44(accretion)

Lateral and vertical accretion processes in the Ganga-Padmafloodplain of Samserganj: Development of vast point bar along the left bank of the Ganga -Padma river is a prominent geomorphic evidence of active lateral accretion over the Ganga-Padma floodplain of Samserganj. Dynamics in channel forms and behaviours are very common fluvial features over a river floodplain which is an extended area associated with varied fluvial landforms under lateral

and vertical accretional processes (Dey & Dutta 2012). The figure 3 also indicates dynamic characteristics of the Ganga -Padma river over its floodplain. Scientists (Nanson & Croke 1992) have already 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. 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 develop the progressive migration of the point bar. Under the influence of lateral accretion channel of the river Ganga-Padma is gradually shifts over its vast floodplain, presently towards right bank. Beside the lateral 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 et al., 2014). However, in the study area, lateral accretion process is more dominant than vertical accretion and along the left bank strong accretional process one of the major causes for the development of extensive point bar along left bank as well serious erosion along the right bank.

Landuse and landcover change in Samserganj,2014-2024

In order to study the socio-economic impact of the serious bank erosion problem, landuse pattern of the block has been analyzed in the paper. For better understanding about the future effect of the problem, trend of land use land cover change has been discussed. Comparative analysis regarding landuse and landcover change of the Samserganj C. D. block has been discussed with the help of LANDSAT 8 OLI/TIRS satellite images (2014 and 2024). With the help of these maps (Fig. 6), it is clearly observed that within ten years land use and land cover patterns are drastically changed. Table 2 clearly indicates changes of land use land cover in Samserganj block from 2014 to 2024. Vast siltation along the river channel including shifting of channel can be identified from these maps (Fig. 6). In the last 10 years the most remarkable growth found in the settlement and channelbar areas. Concentration of settlement areas have increased in 2024 (23.2sq. km.) in compare to 2014 (8.37 sq. km.). Intense settlement is also noticed along the vulnerable right riverbank. In 2014 the areas of river channel bar including point bar were 2.59 sq. km. and due to rapid siltation, the areas of bars have significantly increased 8.74 sq. km. From 2014 to 2024, large area of agricultural lands and vegetations have been converted into settlement areas, which is very alarming issue for near future in respect to bank erosion. Vegetation cover has been slightly decreased in 2024 (17.29 sq. km.) in compare to 2014 (17.95 sq.km.). The area of river channel bar has also enlarged within the tenure. Temporary agricultural practices also have been seen on the channel bar. In 2014, soil digging area stands for the zone from where mud is collected for brick kilns and other purposes but in 2024 that areas have been totally washed away under severe erosion.

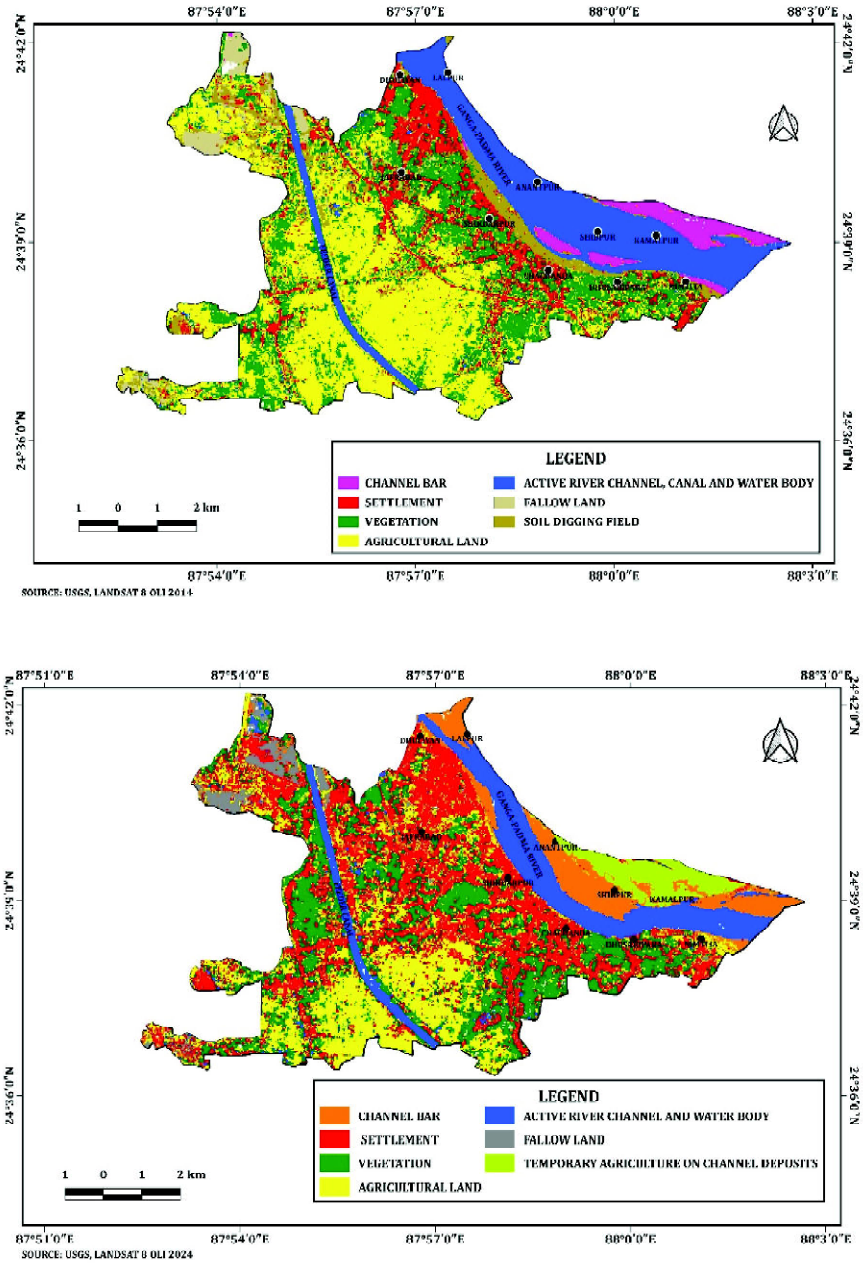

Fig. 6: Change detection ofland use and landcover map of Samserganj C. D. Block (2014 and 2024), the upper map indicates landuse and land cover of Samserganj block in 2014, the lower map shows land use and land cover of Samserganj block in 2024.

Table 2: Landuse and landcover change in Samserganj block (2014-2024)

Land Use elements	Area in 2014 (sq.km)	Area in 2024 (sq.km)
Active channel and water body	14.02	10.07
Settlement	8.37	23.2
Channel bar	2.59	8.74
Agricultural land	27.94	19.95
Vegetation cover	17.95	17.29
Soil digging field	8.7	0
Fallow land	3.09	3.36

Perception study of the local dwellers on Samserganj bank erosion

Perception study of seventy households of Dhusuripara village were conducted to understand causes and socio-economic impacts of the bank erosion hazard. Depending on the field survey, 26% respondents think that heavy siltation in the river bed is the primary cause of bank erosion. 23% households mentioned water release from the Farakka barrage as a main reason of the erosion problem. 17% people stated that turbulent flow in river during monsoonal season plays important role for erosion. Others think that because of channel shifting and loose bank materials, river bank erosion occurs in the area frequently. As per the field recorded data, almost all families lost their agricultural lands and some of the families lost their houses. The serious erosion has deep impact on displacement of settlement in the study area. Fig. 7 shows number of respondents who lost their houses and agricultural lands . As per field recorded data, 38 households out of 70 have lost their only houses, covering about 119.5 katha lands. On the other hand, 28 households lost their both agricultural lands and houses consisting of about1255.48 katha lands. The local dwellers who had lost their houses have got 1 katha of land as compensation from the government, which is located only 2 km far from the vulnerable riverbank in the Basudebpur, NatunShibnagar, Madhupur villages. In spite of severe bank erosion some people are still not leaving their broken houses because of the sentiments of their own lands and houses. Some of the dwellers had decided to leave their houses and they were demolishing their own houses for collecting house building materials so that they can reuse the resources to build their new houses in different places.At present, in order to protect the river-bank, irrigation department are applying some engineering techniques including sand bags, net wire, boulders filling etc. They are also excavating some portion of the point bar along the left bank. The excavated sands are used to fill the bags which are using to protect the right bank.

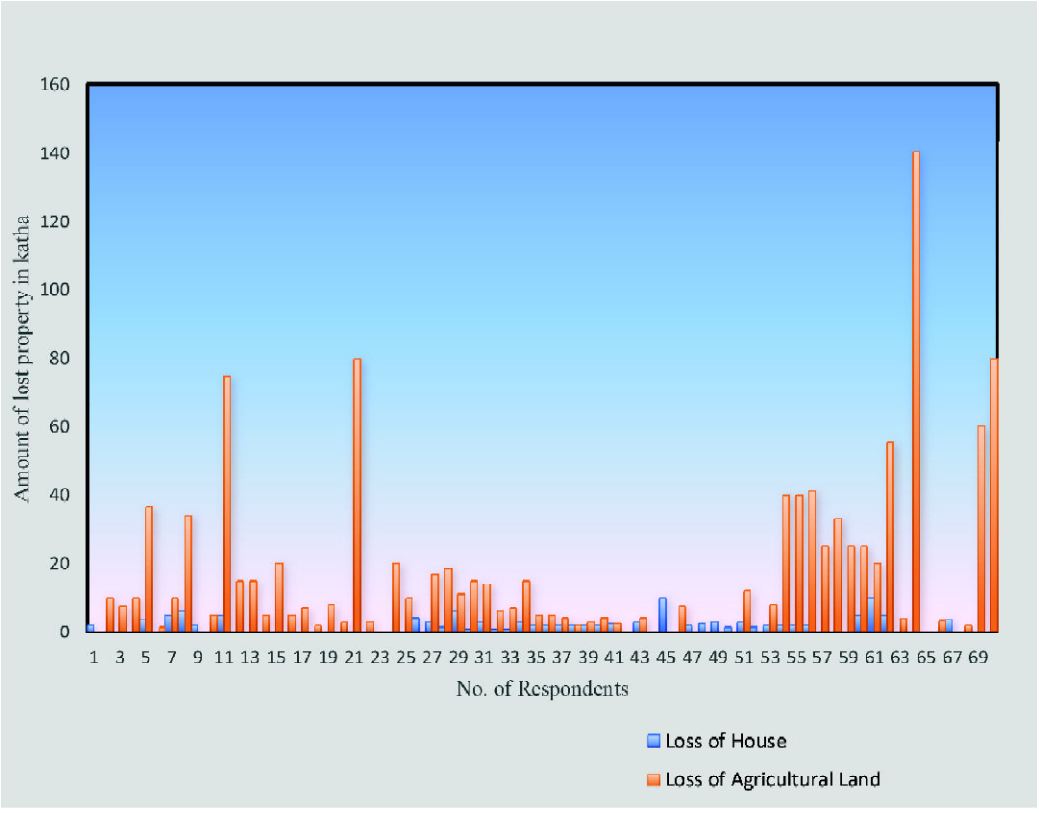

Figure 7: Loss of houses and agricultural lands. (source: field survey, 2024)

Major findings and observation

Based on the comprehensive studies following observations have been identified

(1) From 2014 to 2024, along the left bank of the Ganga –Padma river near Samserganj block about 1.044 sq. km. area has been eroded and along the right bank about 4.635 sq. km. area has been engulfed by the river. As Dhusaripara town located on the right bank of the river has been severely affected.

(2) Along the left bank of the river, maximum shifting due to erosion has been found about 826.913 meter and on the other hand, along the right bank maximum shifting as a result of erosion has been observed about 388.197 meter in Chachanda and Dhusaripara census town. Maximum erosion rates calculated on left and right bank are about 82.69 metre and 38.81 metre per year respectively.

3) Lateral accretion process has dominant role in development of extensive pointbar along the leftbank. Approximately 6.84 sq. km area of pointbar has been developed by the lateral accretion from 2014 to 2024. Under the influence of rapid accretion, shifting of channel has become very prominent in the area.Maximum linear shifting rate of the leftbank has been measured is173.53 metre/year and on the rightbank the rate of maximum extent is about 25.48 metre /year. As a result of rapid lateral accretion from 2014 to 2024 the channel sinuosity has also enhanced 0.8(straight) to 1.3(sinuous).It can be said that if channel lateral accretion process on the leftbank continues, the channel sinuosity will intensifying riverbank erosion along rightbank where study area is located.

(4) Depending on the above comprehensive study it can be said that the primary causes of bank erosion in the study area are huge water discharge from the Farakka barrage and extensive pointbar development due to channel siltation along the left bank.

(5) The study area is characterized with drastic change of land use and land cover from 2014 to 2024. About 14.83 sq.km settlement areas have increased along the rightbankfrom 2014 to 2024, hence, the widespread settlement area may be highly exposed and effected with severe erosion problem.

Conclusion

The comprehensive study of estimation of linear and areal measurement of bank erosion of the study area is very effective measure for future landuse planning inSamserganj area as well as in implementation of management strategies for the serious erosion problem.Samserganj block is facing serious bank erosion problem since 2019 causing widespread destruction of human settlement and agricultural lands. Many people are bound to leave their settlement due to the serious problem. Those people who lost their house they have got one katha of land for rehabilitation which is about two km far from the river in the Basudebpur, Natun Shibnagar, Madhupur villages, though those villages are not entirely safe from future erosional problem. Because of rapid lateral accretion, from 2014 to 2024 the channel sinuosity has also enhanced 0.8(straight) to 1.3(sinuous).So, it can be said that if channel lateral accretion process on the leftbank continues, then the channel sinuosity may increase riverbank erosion problem and channel shifting problem along rightbank where study area is located. The State government as well as central government have already taken some initiatives towards the management process, though according to the local people these initiatives are not enough.

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