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Bank Erosion and Shifting Nature of the Hooghly River at Sundalpurchar and Gosainchar Mouza, Ranaghat-I Block, Nadia District, West Bengal, India

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Abstract: River bank erosion is a common fluvio-geomorphological phenomenon in the lower part of a river. Due to bank erosion, the shifting of river channel is also occurred and with many factors of erosion, channel geometry has an important role in this regard. There is a relationship between the channel geometry and river bank erosion. The Bhagirathi-Hooghly River has an oscillatory nature of channel shifting and this shifting occurred through the bank erosion. Our study area i.e. Sundalpurchar and Gosainchar mouza are located in the left bank of the Hooghly River and this bank is vulnerable due to erosion. The Hooghly river channel has been shifted along this bank towards east. As a result, lands of this area are eroded and new land has been developed in form of mid channel bar named Mangaldwip.
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Key wards: Channel geometry, Channel pattern, Hydraulic action, Mid-channel Bar, Bank erosion

.1. Introduction

In the humid and sub humid regions, most of the rivers complete their processes in three stages i.e. young, mature and old. Among these three stages, in the old stage, river flows in meandering course due to gentle slope. As a result, lateral erosion and channel shift are occurred in the river valley which causes bank erosion. The bank failure (separation and entrainment of bank materials in forms of grains, aggregates or block by fluvial, sub aerial and geotectonic processes [1]) in the lower reach of every river is a common phenomenon. The lower part of the Ganga is not exceptional from these events. Along the Bhagirathi-Hooghly River, a distributary of the Ganga, the bank erosion is a common fluvial hazard [2]. The present paper is related with bank erosion problem and channel shifting of the Hooghly River of Sundalpurchar and Gosainchar mouza under Ranaghat-I Block, Nadia district, West Bengal.

2. Materials and Methods

The study will primarily involve literature studies including studying related books, articles in details to build up a clear idea about the study. This stage also includes the collection of toposheets of different years, satellite imagery, mouza maps, District Planning Map of Nadia from different sources. Channel geometry and bank erosion has been measured by using different equipment like Dumpy Level, GPS, Currentmeter, Tape, Soil and Water Testing Kit. Different types of photographs are captured from different places. The collected information has been studied through different analytical and interpretative methods and finally the collected data and information have been assimilated for the preparation of final paper.

3. Study Area

The study area is located in the lower part of the mature Gangetic deltaic plain in West Bengal. Ranaghat-1 block of Nadia district in the left bank and Balagarh block of Hooghly district in the right bank of the Hooghly River. The geographical extension of the study area is latitude of 23°4’25” to 23°9’14” North and longitude of 88°25’ East to 88°33’3” East covering an area of 143.83 sq. km.[3].

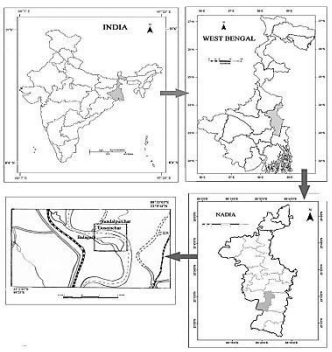

Fig 1: Location Map of the study area

4. Results and Discussion

4.1 Morphological nature of the study area

Our study area annexes the lower mature Gangetic delta which was formed due to the sedimentation of the Ganga and its distributaries. The area is under the flood prone zone. The area is located almost in the central part of the course of the Hooghly River. The slope of the right bank is towards South-West direction, but the direction of the left bank is towards South. The area is generally low gradient in nature. There are some physiographic divisions in the study area i.e. river bank erosion occurring at Balagarhghat to Sibpurghat, the bar of the Hooghly river (Area-143.83 sq. km, length–4400metre,width-1866metre, height-6metre),the central part covered by inside Hooghly valley(the elevation of this geomorphic division varies from 10m to 13.5m) and the confluence of the Churni River.

4.2 Channel Geometry of the Hooghly River at the study area

Channel geometry determines channel morphology of a river. Channel geometry represents the size and shape of cross secctional and longitudional channel form including channel width, channel depth, weted perimeter, channel slope, channel bends, shape of channel thalwegs and their inter-relationship [4]. Channel geometry is not uniform in a whole river course. Channel geometry of a lower portion of a river includes larger width, greater slope, relatively low channel depth, long weted perimeter, asymmetric channel forms, channel thalwegs are close to convex slope of river bank and meandering as well as braided channel bends. To measure the channel geometry in our study area, three cross sectional profile have been prepared and channel geometry related data shown in the table 1.

Table 1: Channel Geometry of the Hooghly River
Source: Field Survey
Note: The measurement of discharges also made after following Darcy's rules'= A.V, where Q= Discharge, A= Cross sectional area, V= Velocity.

Profile No.	Width of Channel (m)	Average Depth (m)	Velocity (km/h)	Cross sectional Area (m2)	Wetted Perimetre (m)	Discharge (m3/s)	Hydraulic Radius	Valley Form
1	600	3.20	1.76	1920	3000	3379.2	0.64	Asymmetric
2	560	4.02	1.76	2251.2	3150	3962.12	0.71	Asymmetric
3	520	3.18	1.76	1651	2100	2905.76	0.78	Asymmetric

5.2 Relation between channel geometry and bank erosion in the study area

The channel geometry is closely related to bank erosion as well as oscillatory nature of the channel. Here we tried to relate the some aspects of channel geometry with the bank erosion in our study area.

1) Channel width: Channel width represents cross sectional distance of a channel representing stage of the river [4]. In the lower part of the Hooghly River, the channel has a maximum width (520-600 metres) due to low gradient of slope and lateral erosion.

2) Channel Thalwegs: It represents the line denotes that connect all the points of maximum depth of water from the source to the mouth of a river along the channel [4]. The line is mainly close toSundalpurchar and Gosainchar which are on the left bank of the river. This portion of channel is very erosive due to high velocity (1.76 km/h), greater depth (3.18 – 4.02 metres) as well as formation of eddies.

2) Weted perimeter: Weted perimeter denotes weted portion of a channel. In our study area the weted perimeter is much longer (2100 - 3150 metres) because of low gradient of slope and comparatively of maximum width. As a result, discharge is high (2905.76 - 3962.12 m^3/s) which indicates thatlateral erosion as well as bank failure is high during flood.

3) Channel forms and pattern: The nature of channel has been asymmetric in our study area. In this type of valley, the depth of water is high and also formed turbulence which promotes more bank erosion. In our study area, there are two mid channel bars i.e. Rajdwip and Mangaldwipwhich dividethe main channel and form braided channel pattern which promotes oscillatory nature of river.

4.3 Mechanisms of bank failure in the study area:

Hydraulic action and mass failure are the two important processes for bank erosion. The removal of bank material by

Fig 2: Some photographs of bank failure in Sundalpurchar and Gosainchar

hydraulic action is closely related to near-bank velocity condition and in particular to the velocity gradient close to the bank, which determines the magnitude of hydraulic shear [5]. Otherwise bank failure occurs when bank material becomes unstable. The stability of banks is determined by the balance between the shear stress exerted the down slope component of gravity (driving force) and shear strength of the bank material (resisting force)[6]. In our study area, the high hydraulic action (driving force) due to curvature bank and tidal action exceed the shear strength (resisting force) as the percentage of silt (52.44%) and sand (34.08%) is too much high on the left bank of the Hooghly River. So, the bank failure has been continuing throughout the year and it is more active during the flood period.

4.4 Shifting nature of the Hooghly River channel

Shifting nature of the Hooghly River in our study area is a common fluvio-geomorphic phenomenon which can be observed in the lower part of any rivers. This shifting nature is like a pendulum of a wall clock which occurs along the left and right bank of river Hooghly. Here, to show the shifting nature, a map has been prepared on the basis of the maps of the year 1924, 1972 and 2012 respectively of the position of the Hooghly channel. From the map it can be seen that the Hooghly river channel has a tendency to shift eastward along the left bank and it is also regulated by the formation of a mid-channel bar named Mangaldwip char. So, the shifting of channel is more active in the left bank i.e. Sundalpurchar and Gosainchar mouza.

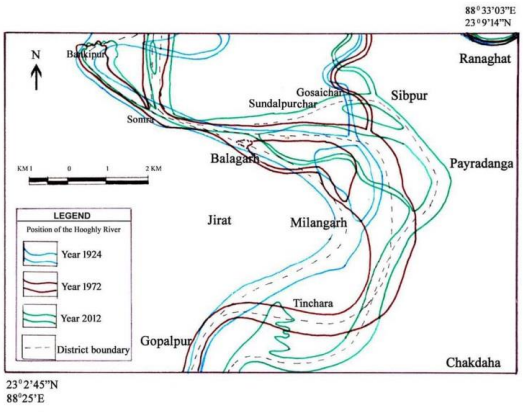

Fig 3 : Position of the Hooghly River channel

Fig 3: Position of the Hooghly River

4.5 Land loss and land gain in the study area

Bank erosion produced several impacts: physical, economic, social and political and even act international level. Physical impacts include changes in channel plan form and its morphology [7]. The formation of mid-channel bar and loss of lands are a part of morphological changes. There is a saying that the devastation of one side indicates the reformation of the other side. So the channel shift as well as bank erosion indicates loss of lands on the erosion prone bank (left bank in our study area) and deposition on the concave bank (right bank). As our study area is located in the left bank of the Hooghly River, every year huge amount of lands are eroded by the river. Here 1.618 Km^2 land have been eroded since 1917-2012.On the other hand, few amount of land have been raised from the river bed inform of island due to sedimentation named Mangaldwip (0.52 km^2) in the mid channel though it is negligible in respect of land loss. The most affected area is Sundalpurchar (JL No 187) and Gosainchar (JL No. 189 and 190) located in the left bank. Here the area under land loss and land gain is shown by a simple bar-graph.

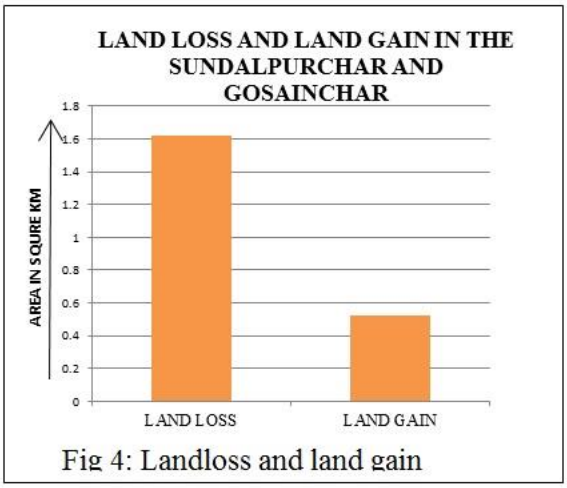

Fig 4: Landloss and land gain

5. Conclusions

From the above disscussion it can be said that the Bhagirathi-Hooghly river has a erosive nature. The channel shifting of this river from the past decades prove that this shifting occurrs through the bank erosion. Though channel geometry has an important role in this regard, there are many other factors like climate, subsrface condition, biology, man-induced factors etc. are also responsible for this.

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