Morphodynamic Setting and Nature of Shifting of the Jamuna River in Nadia and North 24 Parganas, West Bengal, India

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Abstract: ***Jamuna, flows through Nadia and North 24 Parganas Districts, is a tributary of Ichhamati River. River Jamuna originates from River Hooghly opposite to Tribeni in the District of Nadia and fall to river Itchamati at Tipi in the Dist. of North 24- Paraganas. Over the year the discharge of the main channel in the stream portion dried up. The river is facing the problem of siltation leading to thin flow of water in the dry season and floods in the rainy season. Shifting of river course is an episodic event by which an unstable bank tries to reach into a stable one. Diurnal and seasonal fluctuation in the tide-dominated discharge plays an important role. A set of relevant morphodynamic variables like rainfall, discharge, groundwater, geology and soil, and also human factors have been considered for understanding the nature of Shifting of river course. The present study is based on field level observations of channel morphology together with available historical spatial data.***

Keywords: Channel Geometry, Morphodynamic, Shifting of river course, Flood, Groundwater

1. Introduction

The Jamuna branches of the Hooghly opposite Triveni and passing through North 24 Pargana Originating in Nadia district from the river Hooghly near Triveni, river Jamuna traverses a distance of about 60.59 km in eastward direction. Before out falling into river Itchhamati near Tipi under Swarupnagar block of North 24 pargana district. The portion of river Jamuna is between river hoogly and kalyanai ranaghat main rail line for a lengh of about 10.69 km has become defunct and do not carry any eastward discharge. . The whole basin area of river Jamuna is 255.06 mile^{2}. Channel undergoes many subtle and not easily detected changes from season to season, year to year. Channel changes a part of the natural equilibrium in stream dynamics. In this river basin are the cross profile and the valley size is increases from upstream to downstream. The hydraulic radius increases with distance downstream in Jamuna river basin. As a whole in the course of river Jamuna is characterized by seral bends and meandering courses. While meandering, the river forms sharp loops and horse-shoes. During the formation of these horse-shoes sever damage is caused to the valuable lands and village located on its concave banks. It appears that the formation of horse-shoes along the course is a characteristic of the river itself. It has therefore, been proposed to study its characteristics by model experiments and to devise adequate means of protection which could successfully combat the river against washing away the costly lands and villages. In this connection it has been felt necessary to make water level fluctuation water discharge, suspended sediment load at the most affected recharges of the river in order to find out the nature of river bank erosion.

2. Location of Study Area

The basin area of Jamuna river is started from 88°25’22’’E to 88°55’42’’E and 22°51’08’’N to 23°9’55’’N. The whole field work was done in three part of the basin area viz. i) upper part of Jamuna river near Kachrapara, Nadia dist. ii) middle part of Jamuna river near Chowberia, Nadia and iii) lower part of Jamuna river near Gobardanga North 24-Paragana dist.

3. Objective

1. To find out the required detailed field surveys covering the topological, Geological, geotechnical, geophysical and hydro geological aspects, agriculture soil survey etc.
2. To investigate the morphological aspects such as morphometric analysis, channel geometry.
3. To study the changes of channel capacity width, depth, meander, etc.
4. River Bed Shifting of the study area.
5. Identification of terrain unit/geomorphology unit and their spatial distribution and the existing land use and land cover pattern.

4. Methodology

i. Collection of District Planning Map of Nadia and North 24- paragana district, published by National Atlas And Thematic Mapping Organization (NATMO).and collection of satellite image of different years.
ii. Basin map and necessary literature of the study area are collected from Irrigation Office.
iii. Information regarding characteristics of local soil, hydrological condition, nature of landform, water depth of the river, vegetation characteristics, crop production, land use character etc. are collected by field survey.

iv. The area was visited in pre-monsoon season. To know about the water level of the river in monsoon period.
v. The information collected from the maps and satellite imageries are verified in the ground observation.
vi. The GPS survey of different portion of river Jamuna was conducted to indebty the recent situation of the study area.
vii. Finally, the study area is plotted and cross sections of different portion of river Jamuna were drawn and a hypsometric curve was also drawn to prove that the river is in the dying condition and it loses its erosion power.
viii. Sinuosity index has been prepared to understand the channel morphometry.

5. General Geology

The geology of Jamuna river basin area has been classified into three litho logical classes. As geological unit the Hooghly formation near the Bhagirathi river area very few section is characterized by the present day flood plain deposits of an oxidized and less compact fine to very fine silver grey micaceous sand silt and dark grey clay occurring at lower most topography level around river banks In the age of late Holocene to recent. The land form elements of this surface are still in the process of formation. As a geological unit, Chinsura formation In the middle portion of river Jamuna near Haringhata, Gaighata and some portion of Gobordanga is characterized by an alternation of oxidized to unoxidised fine to very fine sand and silt with clay and it lies in the relatively lower elevation than the oldest Bethuadahari formation. The sediments of this formation are absolutely are absolutely devoid of any ferruginous and calcerious concritions with geomorphic features like natural levee and flood basin zone in the age of middle to late holocene. Very few south –west portion of river Jamuna near tipi has been accumulated with vary fine sand and silts with geomorphic features like channel bar, point bar and meander scroll.

6. Geohydrology

Ground water in the area of Jamuna basin is locate within thick sand horizons and exhibits acquifers of both shallow and deeper depths. The geohydrological condition of the vast basin area of Jamuna river has been characterized by aquifer with primary intergranular porosity (yield 38 lit/sec). The water level of this area has been fluctuated in different places. In the top most area of the basin depth-to-water table is 2-3 meter below ground water. Near Haringhata area the depth-to-water table is 3-4 meter below ground water.in the south west portion of basin area near Gobordanga the depth of tube well tap > 15.4 meter aquifer. And the area is generally under flowing condition. Shallower aquifers are brakish in this area. The PH of the ground water is near 8.

7. Landform and Channel Morphometry

The district of Nadia and North 24- Parganas are situated in the heart of Bengal delta occupying the alluvial plains around Ganga river and its tributeries.The basin area of river Jamuna is 255.06 miles sq. this area has been classified into three geomorphic units. Therefore:

1. Flood plain
2. Lower mature deltaic plain
3. Upper mature deltaic plain and paradeltaic fan surface.

The flood plain represents the present day channels deposits on the bank of river Bhagirathi. This surface is prone to flood and water logging. The lower mature deltaic plane occurs at the next higher relief having narrow stretch of land in the Haringhata Kachrapara area of Nadia district. The upper mature deltaic plane and the paradeltaic fan surface covering vast land of the district from west to east of the area occupies the highest ground above the occasional and usual flood levels. The river is now in dying condition as there is no permanent source of water. In the lower portion near Gobardanga the tidal action is happened once in a month. During high tide water enter into river Jamuna which carries a good amount of silt. Due to lack of upland discharge specially in non monsoon period some quantity of carried silt deposits in river bed. Further drainage through the river depends upon the ruling water level of river Itchamati. About two hrs tide lockage period is observed over 12 hours time in the river which is also a factor for silt depositing in the river bed. Local fisher man use to put up obstruction over the river for catching of fish. This obstruction easily attracts silts. This siltation obstructs natural flow to the river for which the catchment of it gets under water for a considerable period of time. In the middle portion the agricultural activity is prominent beside the both bank of Jamuna and sometimes seasonal cultivation is very much active in the bed of river Jamuna in dry period. In the upper portion the river is connected with big jhil called Mathura Jhil and Gayeshpur Kulia Jhil.

A hypsometric curve is an empirical cumulative distribution function of elevations in a catchment. Differences in hypsometric curves between landscapes arise because the geomorphic processes that shape the landscape may be different. The data plotted are the dimensionless ratios h/H and a/A. the ratio h/H is plotted on the vertical axis, with h the height of a given contour above the lowest point in the catchment, and H the height of the highest point on the bounding divide above the same lowest point. The ratio a/A is plotted on the horizontal axis, with a the area above a given contour, and A the total area of the catchment. It is obvious that, as erosion makes progress, the hypsometric integral for a given catchment will reduce.

The total river basin area is 660.268 sq.km. The river basin is divided into 2 contours. The highest elevation of the basin is 11.8mt. and the lowest is 5.5mt.

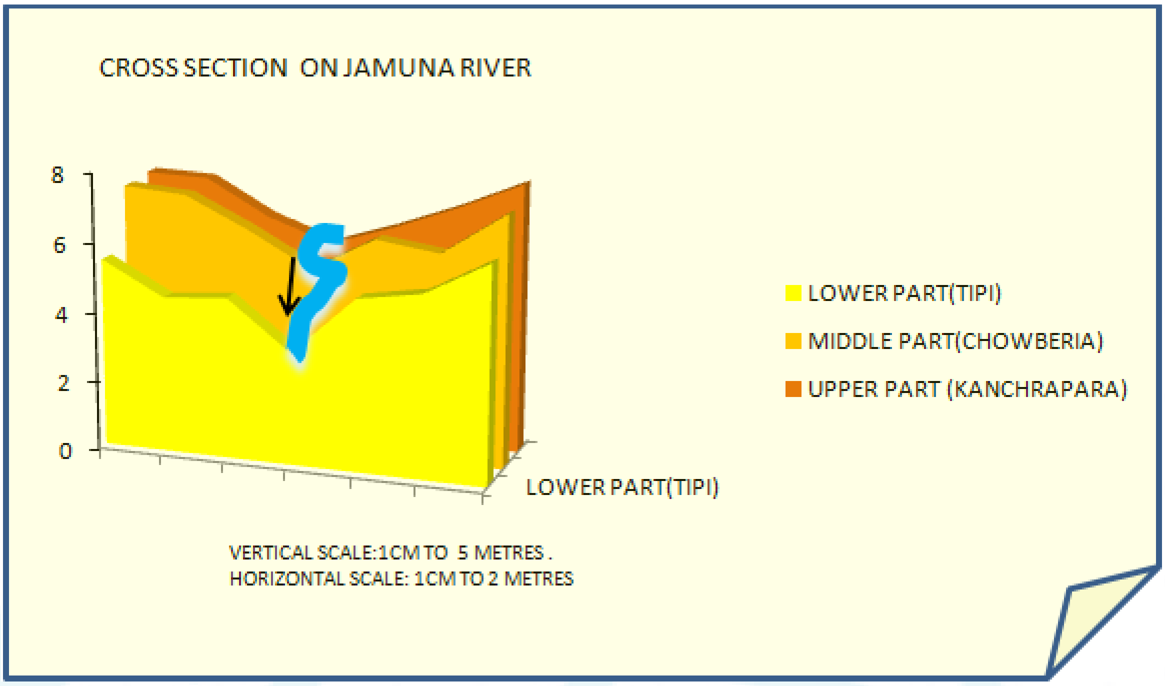

Figure 1: Cross section of the river

Table 1 & 2: Computation of Hypsometric Curve

Elevation zone (mt.)	Area (sq.km.)	a/A (%)	a/A (cumulative)	h/H	h/H
<6	30.08	4.55	4.55	.9206	92.06
6-9	290.34	43.973	48.52	.444	44.4
>9	339.84	51.47	100.00	0	0

a/A (X_i)	h/H (Y_i)	(X_i. Y_{i+1})	(X_{i+1}. Y_i)
4.55	92.06	202.264	4467.487
48.52	44.4	0	4440
100	0		
		$\sum$ (X_i. Y_{i+1})= 202.264	$\sum$ (X_{i+1}. Y_i)= 8907.487

Hypsometric Integral = 1- {$\sum (X_i . Y_{i+1}) - \sum (X_{i+1} . Y_i)$}/10000
= 1- 202.264 - 8907.487/10000
= 1-.8705
= .1295

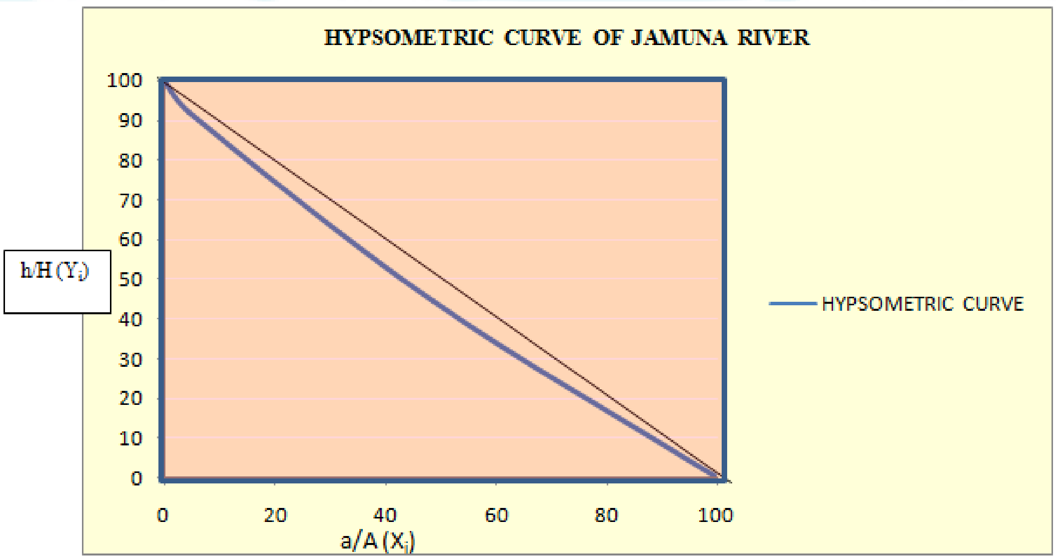

Figure 2: Hypsometric Curve of Jamuna River

The degree of erosion is determined by the hypsometric integral and its value ranges between 0 to 1. If it is below 0.35, then there are few relict monadnocks. In River Jamuna basin the value of hypsometric integral is .1295 so it is in monadnock phase and it going to be an equilibrium phase.

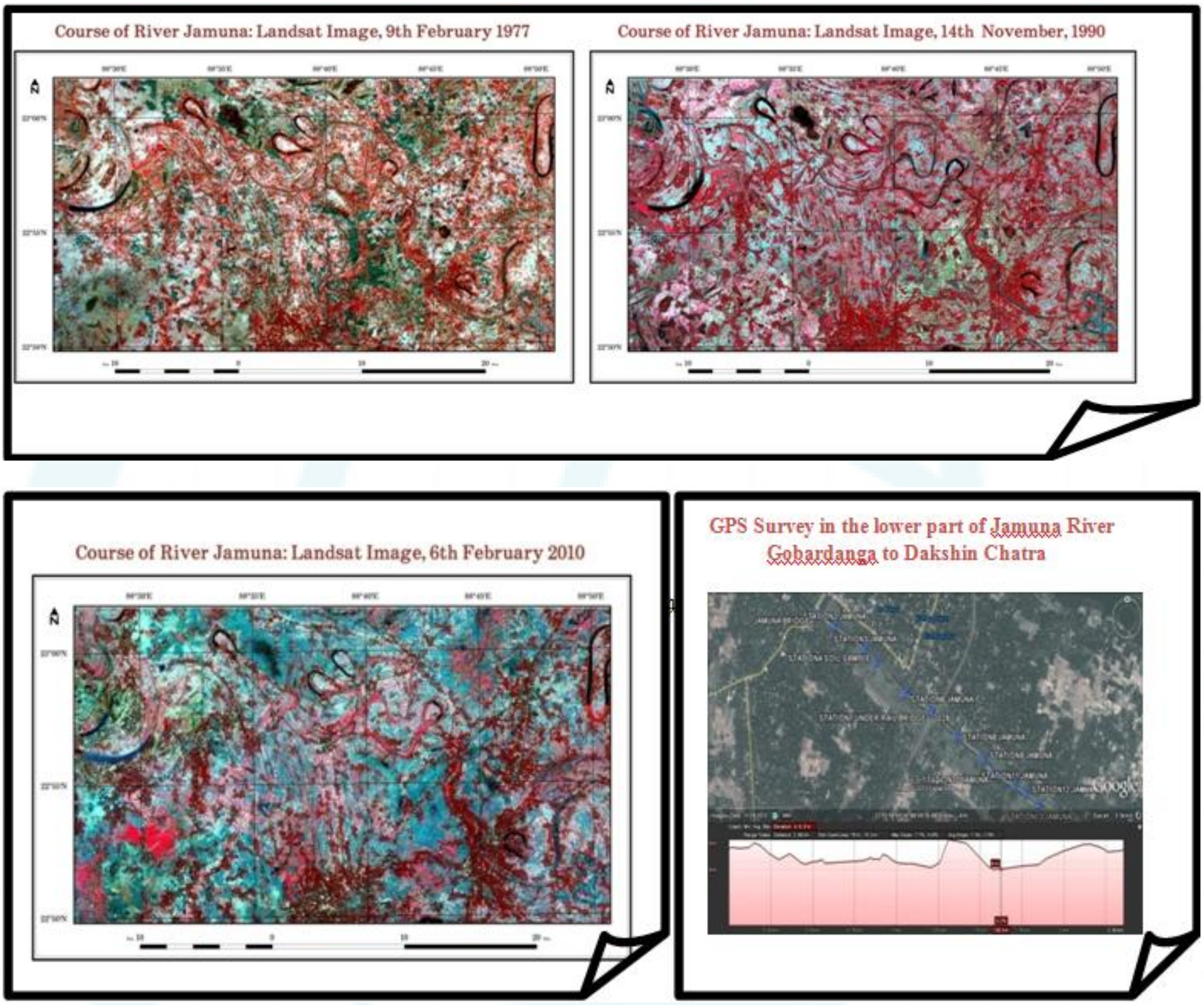

Figure 3: Satellite Images and GPS Survey of the study area

There are three satellite images, collected to identify the changes of river courses and change of landform through the river basin in two different months November and February. From the satellite images and SOI map (Map no: 73 B/13) meandering change has been depicted:

VERTICAL SCALE SHOWS
LATITUDE IN DECIMALE AND

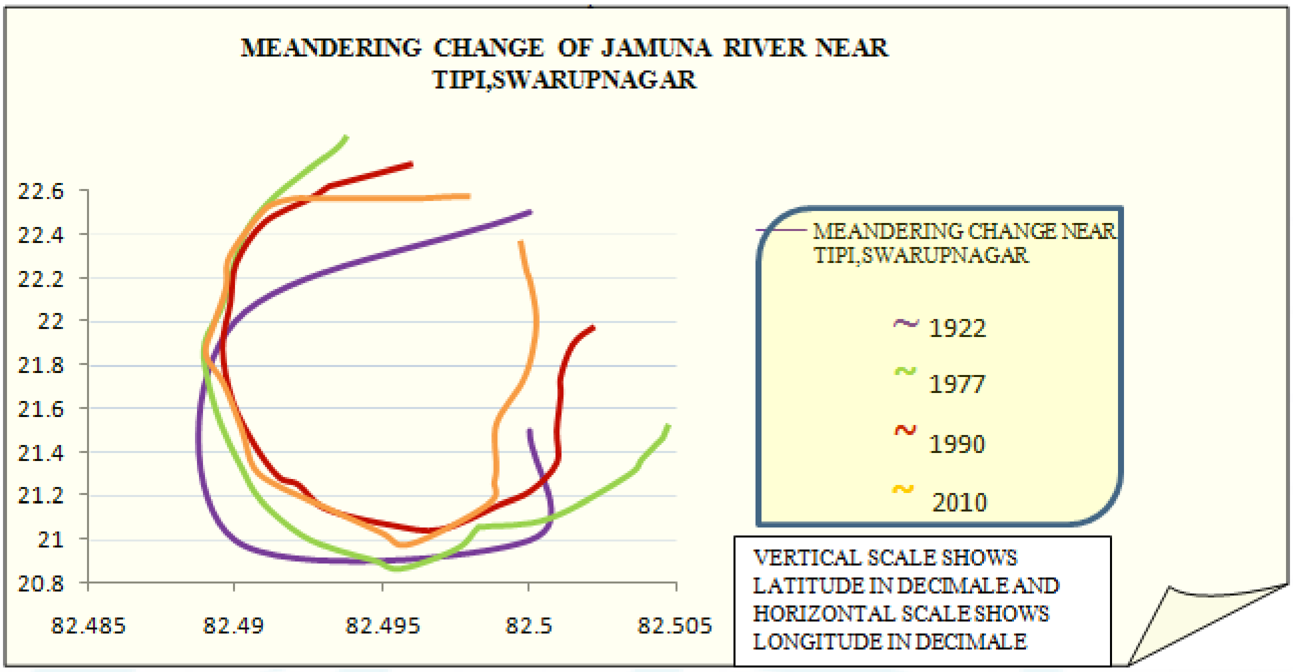

Figure 4: Meandering Change of River Jamuna

From the satellite images we can easily identified that the right bank of river Jamuna is mainly occupied by agricultural activity and the left bank of river Jamuna is mainly occupied by settlement and some artificial pond and plantation. The 1st image is from the year of 1977 and there we can easily identify that that the width of the river is quite wide than the other 2 images and the surrounding area of the river is covered by wetland or the water bodies. In the month of February rabi cultivation was very prominent at there. Some fallow lands are also recognized. The total amount of settlement area is very low comparatively the other image. Thus we can conclude that at the year of 1977 due to less human interference the depth and width of the river is bigger than the other. In the 2nd image which is on 1990, month of November. So the rain water is still flow in the river channel and for some extent in the upper region due to increase of human interference the width of the river is very narrow rather than the lower part where the tidal action is very prominent. Here we can see that the wet lands are become transformed into land where settlement takes place and mainly house orchard settlement are found at this place. In the last image of 2010 in the month of February here the rabi cultivation is very active in the bed of the river near Chowberia Nadia. The river is mostly dried up and the width of the river is very narrow. This drainage channel has been degenerated due to increase of human interference. Less of water bodies and increase of human settlement area is the major feature in that image. From the satellite images channel geometry has been computed. There is a profound effect of channel geometry on bank erosion of the Jamuna river in the present study area. The elements of the channel geometry are width (w), depth (d), height of the bank (H), angle of the bank, radius of curvature (Rc), meander weave length (λ) etc. When the ratio between Rc and w equals to 2, the channel is considered to be stable or is in equilibrium (Hickin, 1974). Most of the data which are collected from the Jamuna River show that the ratio between Rc and w is below. So, the Jamuna River is unstable in character in its lower course especially near Tipi. The bank profile of each station shows that there are several segments of slope elements on both side of bank profile. These segments ultimately form an irregular bank profile on both sides of the river channel, and these irregular slope angles create turbulences in the flow at local level. The turbulences enhance the river bank erosion. Because it is noticed generally that the current of water flows parallel to a straight river bank, the molecules of water roll over the surface of the river bank in the same manner as a wheel, the velocity of the rim of the molecule in touch with the surface of the bank being for that movement zero. So, there can be no erosion of the bank material. When there are inequalities on the bank surface, the local turbulence or eddies are formed (Roy, 1954).

The GPS survey in the lower portion of river Jamuna was conducted on 22.03.2015. Total 13 points are taken. In the starting point near bridge Gobardanga Kalibari the latitude is 22°52.101''N and the longitude is 88°45.821'E and the last point was taken near Labangola and latitude and longitude are 22°50.265"N and 88°48.063"E respectively. The maximum altitude is 9.12metres and the lowest altitude of that area is 4.25metres. At the 1st point the river is quite wide 55metres. But in the last point the river is mostly 13.2 metre.

Table 3: Channel Geometry of the Jamuna River

Locations	Width (W) in m	Height of Concave Bank (H) in m	Angle of River Bank(in degree)		RC (m)	RC: W
			Concave	Convex		
Labangola	4	7.5	1st segment 46 2nd segment 56	1st segment 6 2nd segment 7	76.80	19.2
Diara	3.5	6.5	1st segment 65 2nd segment 59	1st segment 4 2nd segment 5	112.50	32.14
Molladanga	4.5	8.2	1st segment 36 2nd segment 39	1st segment 8 2nd segment 9	85.45	18.99
Source: Calculated by the author based on SOI maps and field survey						

8. Water Quality Scenario of the Study Area

Table 4: Specific Energy and Froude No. at Labangola, SwarupnagarC.D. Block

Stations	Depth(m)	Mean Velocity (m/s)	Froude No. (fd)	Specific Energy(Es)
Molladanga	1	0.10	0.0387	1.00
	2	0.15	0.0290	1.00
	3	0.15	0.0190	1.00
	4	0.40	0.0386	4.01
Source: Field survey and Calculated by the author				

i. The average depth has been found to be in the range of 3.5 to 5.0 m.
ii. The velocity variation in the range of 0.10-0.40 m/s obtained by plotting the mean velocity at each cross section against the longitudinal distance along the stretch of the river. The huge variation of velocity may be principally due to fish trap structure (e.g. komor, vessel, nets etc.) constructed along the stretch and also high rate of siltation at various different sections. The velocity fluctuations can also be attributed to water influx and efflux through streamlets at certain different cross sections.
iii. From the velocity profile graph we can see that the maximum velocity is achieved near about the 60% of total depth from the bed of the river, which is matching the characteristics of velocity profile in case of open channel uniform flow.
iv. In the cross section wise it can be seen that the river velocity is maximum in the dredging zone and if we go towards the banks, the velocity decreases. The maximum velocity occurs where the depth is found as maximum below the water surface.
v. The salinity of the river water increases progressively as we move from upstream towards downstream as observed from the results.
vi. The pH of the river water remains more or less constant with sudden dip observed around 2.5 km and 9 km downstream, indicating a corresponding rise in salinity of the river water as observed from the results.
vii. The TDS in the river water shows a gradual increase due to an increase in the amount of dissolved solid present in the river water as we move downstream which is a result of the river gradually moves into its lower course siltation occurs as its sediment carrying capacity decreases.
viii. The conductivity increases correspondingly with the increase in TDS as expected.

9. Findings

The findings of the present study can be pointed out as below:

1) The economy of the area is agriculture and fishing based. Both the small and medium farmers practice extracting huge amount of groundwater, mainly in the dry season to grow boro-paddy. Hence, groundwater table is getting lower day by day.
2) The peasants use chemical fertilizers and pesticides in agricultural land. These materials make the soil sterile.
3) The river water gets polluted by dumping of domestic wastes on the river bank and also by mixing of the chemical components used in agricultural purposes.
4) When heavy rain occurs in the monsoon period, the area of lower portion of river Jamuna basin becomes flooded and normal life of the inhabitants is disrupted.
5) The width and the depth of the river are become very narrow in the middle portion than the upper and lower portion.
6) After analyzing the satellite images the landform and channel has been changed due to human interference over the 33 years (1977-2010).

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