FINAL DETAILED PROJECT REPORT (DPR) OF NATIONAL WATERWAY NO. 97
SUNDERBANS WATERWAYS
RIVER: HARIBHANGA RIVER (STATE OF WEST BENGAL)
(15.827KM)
(Volume – I: Main Report)
(Volume – II: Drawings)
Submission Date: 31/08/2020




Inland Waterways Authority of India

FINAL DETAILED PROJECT REPORT

REVISION - 0

AUGUST 2020

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(Volume – I: Main Report)
(Volume – II: Drawings)
Submission Date: 31/08/2020

Project: Consultancy Services for preparation of Two Stage Detailed Project Report (DPR) of Cluster 1 National Waterways

Owner: IWAI, Ministry of Shipping

Consultant: Egis India Consulting Engineers

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0	For Submission	August 2020	Team	A Khullar	JK Panigrahi
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LIST OF VOLUMES

VOLUME – I	**:**	**MAIN REPORT**
VOLUME – II	**:**	**DRAWINGS**
VOLUME – III A	**:**	**HYDROGRAPHIC SURVEY REPORT**
VOLUME – III B	**:**	**HYDROGRAPHIC SURVEY CHARTS**

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Egis India Consulting Engineers Pvt Ltd (EIPL) expresses their gratitude to ***Dr. Amita Prasad, IAS, Chairperson,*** *for spending her valuable time and guidance for completing this "Final Detailed Project Report (DPR) of Haribhanga River, Sunderbans Waterways (National Waterway 97)". EIPL would also like to thank* ***Shri Pravir Pandey, Vice Chairman IA&AS, Shri Alok Ranjan, Member (Finance) ICAS, Shri S.K. Gangwar, Member (Technical)*** *for their valuable support during the execution of project.*

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LIST OF ABBREVIATIONS

IWAI	Inland Waterways Authority of India
IWT	Inland Water Transportation
MOS	Ministry of Shipping
NW	National Waterway
DPR	Detailed Project Report
WW	Waterway
AtoN	Aid to Navigation
VC	Vertical Clearance
HC	Horizontal Clearance
CD	Chart Datum
SD	Sounding Datum
MSL	Mean Sea Level
DGPS	Differential Global Positioning System
RTK	Real Time Kinematic
GPS	Global Positioning System
SBES	Single Beam Echo Sounder
TS	Total Station
CRP	Common Reference Point
SBAS	Satellite-based augmentation systems
DGLL	Directorate General of Light House & Light ships
UTM	Universal Transverse Mercator
WGS	World Geodetic System
MT	Metric Ton
GNSS	Global Navigation Satellite System
BM	Bench Mark
TBM	Temporary Bench Mark
HAD	Haldia Development Authority
WBSTC	West Bengal Surface Transport Corporation Ltd.
WBTIDC	West Bengal Transport Infrastructre Development Corporation Ltd.
HNJPSS	Hooghly Nadi Jalpath Paribahan Samabai Samity Ltd.
IMO	International Maritime Organisation
VHF	Very High Frequency
RIS	River Information System

SALIENT FEATURES OF HARIBHANGA RIVER
(SUNDERBANS WATERWAYS (NW 97)

Sr. No.	Particulars	Details		
A.	**GENERAL**			
1.	***Location***			
a)	Cluster	3		
b)	State(s)	West Bengal		
c)	Co-ordinates & Name of Place	**Start**	**End**	
	Place	-	-	
	Latitude	21°53'18.81"N	21°58'24.96"N	
	Longitude	89°01'23.61"E	88°55'9.66"E	
B.	**TECHNICAL**			
1.	***Waterway***			
a)	National Waterway Number	97		
b)	Class	VII		
c)	Type (Tidal/Non-Tidal)	Tidal		
	Length (Km.)	**Total**	**Tidal**	**Non-Tidal**
		15.827 km	15.827 km	0 Km
d)	Sounding Datum			
	Description/Basis	Sounding Datum was transferred at all the newly established BM's using Gangra values. Standard method was adopted for transfer of datum for tidal reaches areas as per Admiralty Manual.		
	Value w.r.t MSL (m)	0 – 5 km	5 – 10 km	10 – 15.827 km
		-2.82	-2.82	-2.82
e)	LAD Status (w.r.t. SD)			
		Sub -Stretch 1	**Sub -Stretch 1**	**Sub -Stretch 1**
	Stretch Km (From……To……)	**0 – 5 km**	**5 – 10 km**	**10 – 15.827 km**
	Length with LAD < 1.2 m	0	0	0
	With LAD from 1.2-1.4 m	0	0	0
	With LAD from 1.5-1.7 m	0	0	0
	With LAD from 1.8-2.0 m	0	0	0

Sr. No.	Particulars	Details			
	With LAD > 2.0 m	5	5	5.827	
	Total	5	5	5.827	
f)	Target Depth of Proposed Fairway (m)				
g)	Conservancy Works Required				
	Type of Work	**0 – 5 km**	**5 – 10 km**	**10 – 15.827 km**	**Total (km)**
	Dredging Required (M. Cum.)				Nil
	Bandalling				Nil
	Barrages & Locks				Nil
	River Training (Km.)				Nil
	Bank Protection (Km.)				Nil
h)	Existing Cross Structures				
	Name of Structure	**Type**	**Nos.**	**Range of Horizontal Clearance**	**Range of Vertical Clearance w.r.t. MHWS**
	Dams/Barrages/Weirs/Aqueducts etc.	Nil	Nil	Nil	Nil
	Bridges	Nil	Nil	Nil	Nil
	HT/Tele-communication lines	Nil	Nil	Nil	Nil
	Pipelines, underwater cables, etc.	Nil	Nil	Nil	Nil
2.	***Traffic***				
a)	At present there are no IWT operations.	At present there are no IWT operations.			
b)	Major industries in the hinterland (i.e. within 25 km. on either side)	There is no big industries exist near to the survey area. Survey area lies in Sundarban Tiger Reserve.			
c)	Connectivity of major industries with Rail/Road network (Distances/Nearest Railway Stations etc.)	As the Survey area lies in Tiger Reserve forest so no rail and road network exist near the Haribhanga River.			
d)	Commodities	**In-bound**		**Out-bound**	

Sr. No.	Particulars	Details				
		Not Available			Not Available	
e)	Existing and Future Potential					
	Name of Commodity	**Existing**	**5 years**	**10 years**	**15 years**	**20 years**
	Passengers (nos.)	Not Available				
3.	***Terminals/Jetties***	Not Recommended				
4.	***Design Vessel***	Not Recommended				
5.	***Navigation Aids***	Not Required				
C.	**FINANCIAL**	Not Applicable				

EXECUTIVE SUMMARY

1.0 INTRODUCTION

Inland Waterways Authority of India appointed M/s Egis India for providing Consultancy Services for preparation of Two Stage Detailed Project Report (DPR) of Cluster 3 National Waterways. Haribhanga River is one of the 13 rivers clubbed in Cluster 3.

This detailed project report of 15.827 km stretch of Haribhanga River waterway is prepared on the basis of recommendations from feasibility report, detailed survey & investigations, preliminary engineering and design and suggestions from IWAI.

2.0 WATERWAY/DETAILED HYDROGRAPHIC SURVEY

The 15.827 km stretch of Haribhanga National waterway proposed for DPR study lies from Lat 21°53'18.81"N and Long 89°01'23.61"E to Lat 21°58'24.96"N and Long 88°55'9.66"E. Whole stretch of Haribhanga waterway is having tidal influence of 4.43 m.

River width in the waterway stretch varies from 1.86 km to 2.92 km. Average flow velocity in the waterway varies from 1.66 m/sec to 1.68 m/sec.

3.0 FAIRWAY DEVELOPMENT

As obtained from the results of hydrographic survey, by taking into advantage of tidal window, sufficient LAD is available in the complete 15.827 km stretch of waterway, which suggests that waterway, is viable for throughout the year navigation. However, on the basis of traffic study (detailed in Chapter - 4), it is concluded that no traffic is available in Haribhanga River, which can be considered for the development of waterway.

Hence, the river is considered as technically non-viable for further development and studies.

4.0 TRAFFIC STUDY

On the basis of detailed traffic survey and study done during DPR stage, following conclusions are made:

a) There is no big industries exist near to the survey area.

b) Survey area lies in Sundarban Tiger Reserve.
c) At present Haribhanga river has no IWT operations.

In view of the above observations, the waterway is declared as technically non-viable for further development and studies.

5.0 TERMINALS

At present no terminal is located in the river stretch.

In view of the above, also as concluded in Chapter 4, no jetty or terminal structure is proposed in this DPR of Haribhanga Waterway.

6.0 ENVIRONMENTAL & SOCIAL ASPECTS

The major objective of this study is to establish present environmental condition along the Haribhanga River through available data /information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. The study basically includes:

- Establishment of the present environmental scenario
- Study of the specific activities related to the project
- Evaluation of the probable environmental impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan

The entire study stretch is in South 24-Parganas district. South 24 Parganas district lies between $22^0$12'13"N and $22^0$46'55"N latitude and its longitudes are $87^0$58'45"E and $88^0$22'10"E covering an area of 9,960 sq. km. Alipore is the district headquarters of South 24 Parganas. It is the largest district of West Bengal in terms of area with a very small proportion of urban settlements. A large portion of the district is included in the Forests of Sundarbans

The project falls under the lies in Earthquake high damage risk zone-IV as defined by the Indian Standard (IS) 2002 seismic zoning classification system, i.e. a zone of relative stability. The maximum temperature as recorded is 37°C and the minimum is 9°C.

As no activities have been proposed for the waterway development in the DPR, no Environmental & Social Impact is foreseen for the Haribhanga Waterway.

7.0 CONCLUSION

On the basis of studies done in this DPR following conclusions are made:

a) By taking into advantage of tidal window, sufficient LAD is available in the complete 15.827 km. stretch of waterway, which suggests that waterway, is viable for throughout the year navigation.
b) River stretch lies in the restricted Tiger Reserve Forest area.
c) No passenger or cargo traffic is available along the stretch.

In view of the above observations, the waterway is declared as technically non-viable for further development and studies.

1.0 INTRODUCTION

Inland Waterways Authority of India (IWAI), an undertaking of Ministry of Shipping, Government of India intends to develop 106 new National Waterways in addition to the exiting 5 National waterways. The National waterways are proposed to be developed as a composite and integrated water transport system with the existing rail and road infrastructure across the country.

In view of this, IWAI invited online bids for "Consultancy Services for preparation of Two Stage Detailed Project Report of the 106 National Waterways in a set of eight clusters. Each waterway is to be explored for the potential of year round commercial navigation during Stage-1 (Feasibility Studies) of the project. The second stage comprises of preparation of techno-commercial detailed project report of the river/stretches approved by IWAI for stage -2 studies. Egis India Consulting Engineers Pvt. Ltd (EICEPL) was awarded the work for two stage DPR studies of two out of eight clusters respectively. Haribhanga River was clubbed under Cluster -3 for the two stage DPR studies.

This detailed project report of 15.827 km stretch of Haribhanga waterway is prepared on the basis of recommendations from feasibility report, detailed survey & investigations, preliminary engineering and design and suggestions from IWAI. The report is prepared in accordance with detailed ToR as per the agreement **(Refer Annexure 1)**.

1.1 PROJECT BACKGROUND AND SUMMARY OF PREVIOUS STUDY

Haribhanga River (under Sunderbans Waterways) is declared as National Waterway-97 as per "The National Waterway Act, 2016", No. 17 of 2016, published in the Gazette of India, Part – II-Section 1 no. 18, New Delhi, Saturday, March 26/2016/Chaitra 6, 1938 (Saka), by Ministry of Law and Justice (Legislative Department).

As per the Gazette notification, total 13 rivers (including Haribhanga River) was covered in the Sunderbans waterways (NW-97). Following section of the Haribhanga River is declared as National Waterway and recommended for feasibility studies by IWAI:

Length	Co-ordinate at Start	Start Location	Co-ordinate at End	End Location
15.827 km	21°53'18.81"N 89°01'23.61"E	-	21°58'24.96"N 88°55'9.66"E	-

A single feasibility report was prepared for all the 13 rivers covered under Sunderbans Waterways. Following conclusions were made for Haribhanga River in the feasibility report.

- The waterway is a tidal river having year round navigational possibility.
- The river can be recommended for DPR studies.

The above conclusions were made on the basis of findings during the feasibility study stage. Detailed survey and investigations are done including preliminary engineering studies as per the scope of work defined in the ToR to validate above conclusions and to identify the development works required for making a techno-economically viable IWT in Haribhanga WW.

Based on the above conclusions/observations done during feasibility studies i.e. first stage of the studies, IWAI recommended following stretch of Haribhanga River for second stage of the studies i.e. for detailed project report.

Length	Co-ordinate at Start	Start Location	Co-ordinate at End	End Location
15.827 km	21°53'18.81"N 89°01'23.61"E	-	21°58'24.96"N 88°55'9.66"E	-

1.2 PROJECT LOCATION / DETAILS OF STUDY AREA

Complete 15.827 km stretch of Haribhanga waterway is located in South 24 Parganas district of West Bengal. As observed during the feasibility studies, complete stretch of waterway is having tidal influence. Locally operated jetties/ferry ghats are also available at various locations all along the river stretch.

Haribhanga waterway project location as per DPR is shown in **Figure 1**. The detailed layout plan of waterway is provided in Drawing attached as **Volume-II**.

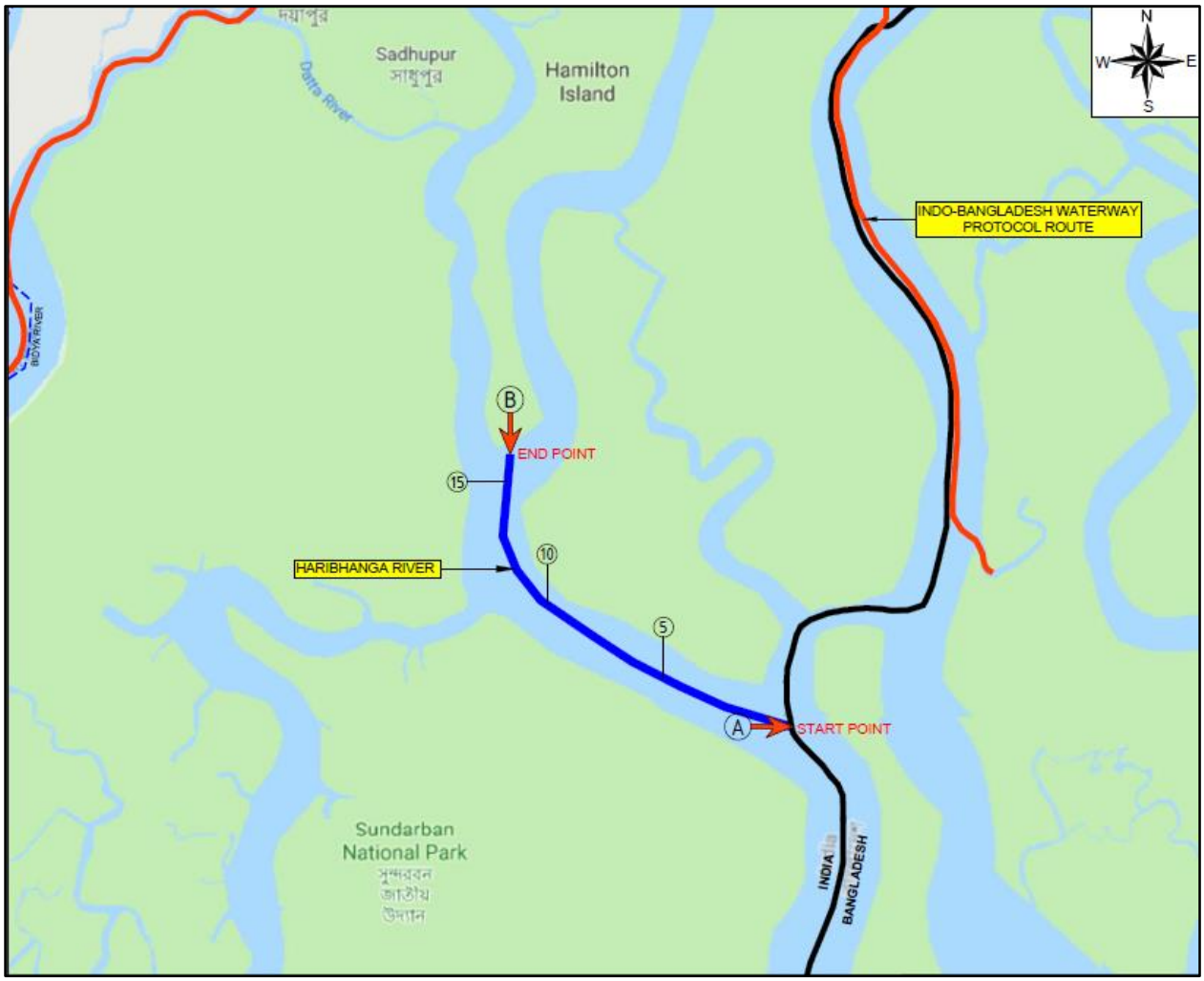


Figure 1: Haribhanga National Waterway Project Location

1.3 INDO–BANGLADESH WATERWAY PROTOCOL ROUTE

An Inland water transit and trade protocol exists between India and Bangladesh under which inland vessels of one country can transit through the specified routes of the other country. The existing protocol routes are (i) Kolkata-Pandu-Kolkata, (ii) Kolkata-Karimganj - Kolkata, (iii) Rajshahi-Dhulian-Rajshahi and (iv) Pandu-Karimganj-Pandu. For inter-country trade, four ports of call have been designated in each country namely; Haldia, Kolkata, Pandu and Karimganj in India and Narayanganj, Khulna, Mongla and Sirajganj in Bangladesh. Under the Protocol, 50:50 cargo sharing by Indian and Bangladeshi vessels is permitted both for transit and inter country trade.

IWAI is the Competent Authority on Indian side w.e.f. 8th September 2003 vide Ministry's Order No. WTC-15014/2/2001-IWT dated 29.08.03 and is responsible for maintenance of routes including conservancy and pilotage.

As shown in Figure 1 above, Haribhanga waterway stretch of 15.827 Km does not lies along the Indo-Bangladesh Protocol Route.

1.4 BRIEF SCOPE OF WORK AND COMPLIANCE STATEMENT

The brief scope of work for the project comprises of:

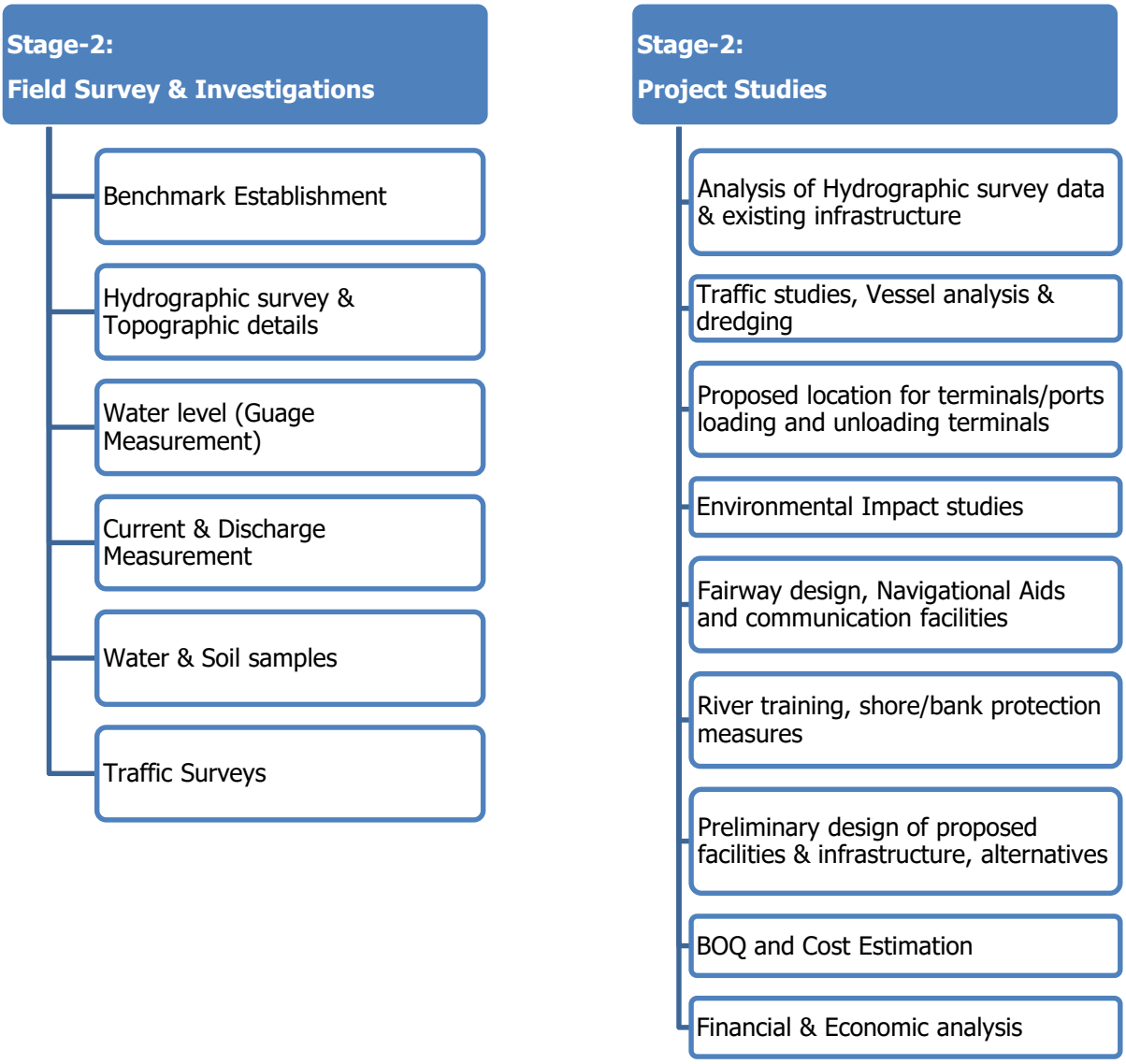
a) Hydrographic and Hydro-morphological Survey and Investigations
   i. Installation of bench mark pillars
   ii. Installation of water level gauges and observations as per TOR
   iii. Bathymetric & Topographic Survey
   iv. Current velocity and discharge measurements
   v. Collection of water & bottom samples and analysis as per TOR
   vi. Collection of Topographical features.
   vii. Survey chart preparation
b) Traffic Survey
c) Geotechnical investigations
d) Environmental & social impact assessment
e) Analysis of collected data and preliminary engineering design
f) Scheduling and costing
g) Economic & Financial analysis for assessment of techno economic feasibility
h) Conclusion and recommendations.

The scope of work mentioned above, under Hydrographic and hydro-morphological survey was covered in the Hydrographic Survey Charts and Report, submitted as part of first deliverable under Stage-II of the project. The compliance statement of detailed project report covering the remaining scope of work as per TOR is provided as below:

Sr. No.	Section – 6 Terms of Reference Clause No. 1.2	Covered under Chapter No./ Title
1.0	Assessment of Hydrographic Survey Report	Chapter 2: Waterway/Detailed Hydrographic Survey

Sr. No.	Section – 6 Terms of Reference Clause No. 1.2	Covered under Chapter No./ Title
2.0	Traffic Survey	Chapter 4: Traffic Study
3.0	Geotechnical investigations	Chapter 5: Terminals
4.0	Environmental & Social impact assessment	Chapter 9: Environmental and Social Aspects
5.0	Analysis of collected data and preliminary engineering design	Chapter 6: Preliminary engineering Designs
6.0	Scheduling and costing	Chapter 11: Project Costing Chapter 12: Implementation Schedule
7.0	Economic & Financial analysis for assessment of techno economic feasibility	Chapter 13: Economic and Financial Analysis
8.0	Conclusion and recommendations.	Chapter 14: Conclusion and Recommendations

The above scope of works shall be executed as per the framework shown below;



1.5 BRIEF METHODOLOGY & APPROACH

The stretch of waterway, recommended for DPR studies is surveyed and studied in detail for techno-economic development of IWT along the proposed stretch.

Detailed hydrographic, hydro-morphological survey and investigations, traffic, environment and social survey is done out along the stretch. The data collected from survey is further analysed in detail for design of waterway, estimating of dredging quantity and finalising location and type of jetties/terminals required along the waterway. On the basis of DPR level design and drawings, cost estimate, financial and economic evaluation is done. The techno-economic viability of IWT development along the proposed stretch is assessed and concluded in the report.

DPR studies have been construed as a means to establish the techno-commercial viability of the development of waterway, and accordingly have been taken–up in two stages:

Stage-I: Establishment of Technical Viability

Stage-II: Assessment of Financial/Economic viability, in case the technical viability is established.

A detailed DPR methodology and the expected outcome in fulfilling the assignment are presented as below:

Stage-I: Establishment of Technical Viability

Technical viability has been established on the survey & investigations, as per Volume-III of this report. Following of two major parameters have been considered to establish the technical viability:

- Availability of LAD (Least Available Depth) & dredging quantity for proposed Class of waterway
- Availability of Traffic (cargo/RO-RO/passenger)

In case, the traffic is available, all technical possibilities shall be explored to ensure the required LAD and further studies for assessment of financial viability (Stage-II) shall be performed to assess the complete techno-commercial viability.

However, in case, no traffic is available, the development of waterway in the specific reach of the river shall be considered as "Technically Not-Viable" and stage –II studies are not warranted.

Stage-II: Assessment of Financial/Economic Viability

Stage-II studies shall comprise of the following:

a) Design, Analysis and Costing

- Fairway Development
- Terminal
- Vessel
- Environmental and Social Studies

- Navigation and Communication Facilities
- Institutional Requirement
- Project Costing
- Implementation Schedule

b) <u>Commercial Viability</u>

- Estimation of economic and financial Returns

For Commercially viable project, the DPR will be concluded with providing recommendations for development.

For Commercially non-viable project, the DPR will be concluded declaring the project as commercially non-viable.

Above methodology is also presented as a flow chart in **Figure 2** as below:

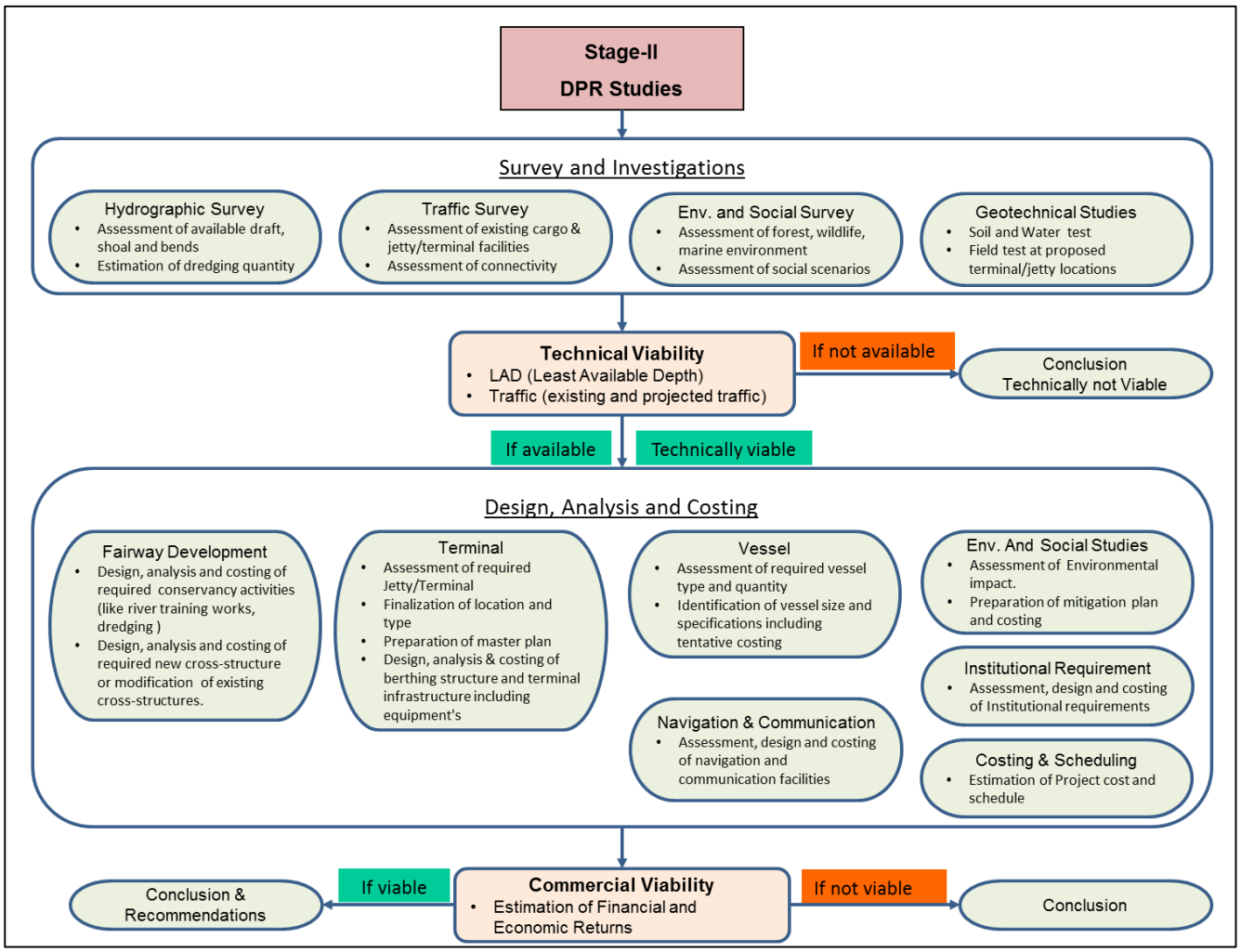


Figure 2: DPR Approach and Methodology Flow Chart

1.5.1 Classification of Waterways

For safe plying of self- propelled vessels up to 2000 tonne Dead Weight Tonnage (DWT) and tug-barge formation in push tow units of carrying capacity up to 8000 tonne, National waterways can be classified in the following categories as suggested by IWAI:

Table 1: Classification of National Waterway -Rivers

Class of Waterway	Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance Between Piers (m)	Self propelled vessel Carrying Capacity
CLASS-I	1.2	30	300	4	30	100 tonne Dead Weight Tonnage (approx. size 32m overall length, 5m moulded breadth and 1.0m loaded draft or one tug and two barges combination of 200 tonne Dead Weight Tonnage (approx. size 80m overall length, 5m moulded breadth and 1.0m loaded draft).
CLASS-II	1.4	40	500	5	40	300 tonne Dead Weight Tonnage (approx. size 45m overall length, 8m moulded breadth and 1.2m loaded draft or one tug and two barges combination of 600 tonne Dead Weight Tonnage (approx. size 110m overall length, 8m moulded breadth and 1.2m loaded draft).
CLASS-III	1.7	50	700	6	50	500 tonne Dead Weight Tonnage (approx. size 58m overall length, 9m moulded breadth and 1.5m loaded draft or one tug and two barges combination of 1000 tonne Dead Weight Tonnage (approx. size 141m overall length, 9m moulded breadth and 1.5m loaded draft).
CLASS-IV	2.0	50	800	8	50	1000 tonne Dead Weight Tonnage (approx. size 70m overall length, 12m moulded

Class of Waterway	Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance Between Piers (m)	Self propelled vessel Carrying Capacity
						breadth and 1.8m loaded draft or one tug and two barges combination of 2000 tonne Dead Weight Tonnage (approx. size 170m overall length, 12m moulded breadth and 1.8m loaded draft).
CLASS-V	2.0	80	800	8	80	1000 tonne Dead Weight Tonnage (approx. size 70m overall length, 12m moulded breadth and 1.8m loaded draft or one tug and two barges combination of 4000 tonne Dead Weight Tonnage (approx. size 170m overall length, 24m moulded breadth and 1.8m loaded draft).
CLASS-VI	2.75	80	900	10	80	2000 tonne Dead Weight Tonnage (approx. size 86m overall length, 14m moulded breadth and 2.5m loaded draft or one tug and two barges combination of 4000 tonne Dead Weight Tonnage (approx. size 210m overall length, 14m moulded breadth and 2.5m loaded draft).
CLASS-VII	2.75	100	900	10	100	2000 tonne Dead Weight Tonnage (approx. size 86m overall length, 14m moulded breadth and 2.5m loaded draft or one tug and two barges combination of 8000 tonne Dead Weight Tonnage (approx. size 210m overall length, 28m moulded breadth and 2.5m loaded draft or with higher dims).

In addition to the above, IWAI also given guidelines regarding vertical clearances with respect to transmission lines for National waterways as below:

Type of Transmission Lines	Vertical Clearance
Low voltage transmission lines including telephone lines	16.5
High voltage transmission lines, not exceeding 110 kilo volt	19.0
High voltage transmission lines, exceeding 110 kilo volt	19.0
	+1 centimetres extra for each additional 1 kilovolt

Also:

a) Waterway side slopes should be kept as 1(V): 5(H);
b) Minimum depth of channel should normally be available for about 330 days of the year;
c) Vertical clearance at cross structure over the waterway should be available at least in central 75% portion of each of the spans in entire width of the waterway;
d) For rivers, vertical clearance should be kept over Navigational High Flood Level (NHFL), which is the highest flood level at a frequency of 5% in any year over a period of last twenty years.

1.5.2 Measures to Improve the Depth

The basic parameters considered for the fairway design are:

- Depth
- Width
- Side slopes
- Bends

As explained above, as the classification of waterways in India is based on the experience gained in various waterways, the characteristic features of the design waterways based on studies carried out by IWAI are furnished below and the same shall be followed.

Fairway Design

The fairway depth should be good enough to ensure steerability of the vessel and to prevent bottom feel. To meet this requirement, the minimum depth that is needed in a channel would commonly be the sum of the draught (draft) of the vessel and other tolerance factors. The tolerance factors to be considered are listed as:

- Factor of keel clearance to avoid touching of the vessel to the ground and minimum free water below the keel for maintaining control on manoeuvring,
- Wave tolerance for the heaving and pitching of the vessel due to wave motion,
- Squat, increase of draft due to ship motion,
- Tolerance for siltation and dredging,
- Increase of draught due to trim and heaving due to unequal loading and steering manoeuvre respectively, and
- Tolerance for the change of draught during the transition from salt water to fresh water.

The keel clearance factor is the prime concern of the all tolerance factors considered. As per the standards laid down by German Code of practice (EAU 80), a 0.3 m layer of water column below the keel of the loaded ship is sufficient for free manoeuvrability of the vessel.

IWAI's experience in inland waterways in India and sub-continent (Bangladesh and Myanmar) shows that the under keel clearance for free manoeuvrability of the vessel varies between 0.2 and 0.5 m depending upon the soil characteristics of the channel bed and other parameters.

Width of a Channel

The total width of a navigation waterway (W) in general is expressed in terms of a beam of a vessel (B). The design width for the proposed two-way navigation can be obtained as:

$$W = BM + BM1 + C + 2C1$$

Where: W = Navigation channel width for two-way navigation.

BM = Maneuvering zone for the design vessel which takes into account the directional stability of vessel.

BM1 = Maneuvering zone for the upcoming vessel which takes into account the directional stability of vessel.

C = Width of separating zone.

C1 = Width of the security area, between the maneuvering zone and the channel side which is accounted for environmental and human factors including bank suction.

Values recommended by various authorities for the above equation vary within wide limits. Some of the recommended values are presented here:

BM = 1.3 B to 3.0 B
BM = BM1
C = 0.5 B to 1.0 B
C1 = 0.3 B to 1.5 B
Where, B = Beam of a design vessel.

Based on the experience and recommendations of experts on Inland Waterways, the factors considered for the present design are:

BM = 1.8 B
BM = BM1
C = 0.5 B
C1 = 0.5 B

The designed channel width = 1.8B+1.8B+0.5B+2x0.5B for two way navigation at draft level = 5.1B. The bottom width of the channel for two-way navigation for the design vessel can generally be considered as 5 x B.

Slopes

The selection of slope is in accordance with the soil characteristics of the bed and banks, width of the waterway etc. The adopted channel slope shall be 1:5

Width Allowance at Bends

In bends, the width of the fairway should be more than the width of the canal that is designed for a straight reach to allow for a drift of the vessel in a curved portion of the waterway. It means that the vessel occupies a greater width in bends than in a straight stretch of the waterway. The drift of the vessel depends on the radius of the bend, the speed of the vessel, wind forces, the flow pattern and the loading of the vessel. The drift angle is larger for vessels traveling in the downstream than the

upstream direction. The drift angle is inversely proportional to the bend radius 'R', that is, the larger the radius the smaller the value of drift angle. Unloaded ships normally subjected to more drift and consequently take up a greater width in bends than loaded ships and therefore the proposed allowance at the keel level of the unloaded ships is larger than the loaded ships.

Dredging of Navigational Channel

The dredging quantities for the above design channel shall be worked out based on the bathymetric surveys carried out. The system and different type of navigation marks shall be proposed in the DPR are given as follows:

- Lateral marks, to mark the left and right sides of the navigation route to be followed by navigator;
- Bifurcation marks, to mark the middle ground between the navigation channel, bifurcated channel and isolated dangers in the middle of the navigational channel;
- Shore marks;
- Bank wise marks, to indicate the channel at point where it approaches a bank;
- Crossing marks, to indicated crossing and alignment of the channel from one bank to another;
- Marks of prohibited areas, to indicate no permission of entry;
- Sound signal marks, to indicate use of horning or other sound signals;
- Marks for traffic control, to control up bound or down bound vessel in one way or sequence passage or to prohibit navigation;
- Marks on bridges, to indicate the passage through bridges;
- Depth indicator marks, to indicate shallow areas ahead in the navigation channel;
- Width indicator marks, to indicate the narrow stretches ahead in the navigational channel;
- River training marks, to indicate the ongoing river training works in the river to the navigators.

1.5.3 Identification of IWT Terminals

Site selection is the most important as it decides the investment for establishing the terminal facilities. Hence, proper consideration has to be given to select the most optimum location which will minimise the capital investment and other recurring cost during operation. The selection of suitable site shall be carried out with the view of following considerations:

- Water availability near the terminal land throughout the year especially during lean season;

- Stable river channel with sufficient depth;
- Favourable hydraulic conditions for berthing and cargo handling;
- Availability of terminal land for infrastructure, cargo storage and handling;
- Traffic potential and cargo characteristics; and
- Navigational safety.

The proposed IWT Terminals shall be planned with the following infrastructure facilities for operation:

i) Steel Gangway resting on a floating pontoon. The detailed engineering & design of gangway arrangement shall be carried out during the construction stage. The preliminary layout drawing shall be proposed in the DPR;
ii) Administration Building and Bank protection arrangement;
iii) Covered Storage Shed/Transit Shed;
iv) Open storage area;
v) Security Shed;
vi) Forklift Trucks, Pay loaders & Dumper tracks; and
vii) Weigh Bridge, Watch and ward, Compound wall, Firefighting arrangement, Electrical & PH Facilities including DG.

The terminal shall be proposed with suitable mooring facilities, firefighting water line, water supply pipeline, power line for shore connection to barges, fenders etc. Preliminary planning and master plan shall be prepared in the DPR stage as per the relevant IS codes. It is envisaged and proposed that to the extent possible, all shore/river bank based buildings / godown are prefabricated, pre-engineered type conforming to the best standards in vogue in logistic / supply chain industry.

Other Alternatives to Improve for Navigation

Based on our earlier study for Ganga River between the reach from Allahabad to Ghazipur, there are many methods available to improve river navigation. Bandalling work – it has to follow closely falling stage of river, closing minor channels and diverting river flow in single channel to increase depth in the navigable channel in mainly due done by bandalling. In some reaches this method becomes successful but some river stretches remain shallow and need other training measures including dredging. Channelization of river and Construction of barrages at suitable locations, creating ponding conditions with required depth and navigational locks for ships and vessel movement shall be studied. The examination of various options/measures to improve the water depth shall be studied. The most suitable method for development shall be identified with consideration on the likely morphological,

sediment transport, and dredging aspects of different options. This task is expected to be fed back into from the financial and economic analysis providing refinement to the proposed development until a recommended solution is reached. The most appropriate type of river development including drudging option along the river shall be identified and likely impacts of these developments on river flow depths as well as sedimentation and morphology shall be investigated. This analysis will constitute an iterative process in which problems relating to LAD will be addressed to find more successful solutions where necessary. This will however, not be an open-ended process as the assessment of techno-economic feasibility updation only requires an indication of the likely costs of building and maintaining the structures which are shown to support achievement of LAD as intended.

1.5.4 Concept Design and Cost Estimates

Preliminary Design shall be performed for all the structures /developmental works proposed as per the above analysis and mathematical model studies carried out conforming to relevant IS Codes. Design drawings shall be prepared and submitted based on the preliminary design. Bill of quantities and cost estimates shall be prepared for all the proposed structures / developmental works. Based on the cargo potential and other considerations necessary for locating an IWT terminal, extent of land required for setting up of IWT terminals and other suitable locations shall be identified. Preliminary topographic survey shall be carried out and layout plan for all suggested locations shall be prepared clearly indicating all facilities e.g. jetty, approach to jetty, bank protection, covered and open storage, roads, office, sentry hut, boundary wall, bank protection, bunkering facility, water facility, turning circle for IWT vessels location of depth contours of 2m and 2.5m in the river near the terminal sites. Preliminary engineering design and drawings for setting up of terminals with related facilities including mechanical loading/ unloading at the proposed sites shall be prepared. Also inter modal cargo transfer facilities required at these terminals shall be indicated.

1.5.5 Financial and Economic Analysis

Financial and economic analysis through FIRR and EIRR of the project including SWOT analysis shall be carried out for the project. For the Financial Internal Rate of Return shall be computed as follows:

- Costs shall be calculated as total capital investment for the Project components, net rate of interest charges during construction and operations & maintenance costs for the Project;
- Income flows shall be calculated based on gross revenues of projected goods to be transported through private operators with permissible assumptions such as project life etc.;
- Economic Internal Rate of Return shall be computed taking into account the following factors;

- The assumed life of the project as per norms;
- Costs shall be calculated as Government contribution and other sources. A standard conversion factor shall be used to reduce financial costs to economic costs;
- Benefits shall be estimated as Government revenues, calculated as net profit share, royalties and tax;
- Social Benefits like fuel saving, reduction in environment pollution and carbon emission, accident reduction, decongestion of rail and roads, etc.

The financial viability and sustainability of this project depend upon the adaptation to the prevailing context in which they operate. In working out the Financial Viability and sustainability, the following factors shall be considered.

- budgeting and cost accounting systems,
- resource mobilization for capital investments,
- cost recovery and operational financing,
- cost reduction and control.

The Profitability projections and financial analysis for each of the project components shall be worked out in detail and presented in the report. The financial statements shall be prepared on the basis of the suitable assumptions. The cost benefit analysis for the proposed project shall be calculated. IRR and preliminary expenses shall be suitably considered and estimated. Break-even analysis shall be performed and presented in the report.

2.0 WATERWAY / DETAILED HYDROGRAPHIC SURVEY

2.1 HYDROGRAPHIC SURVEY

As detailed above, the National Waterway stretch of Haribhanga river under DPR study is from Lat 21°53'18.81"N and Long 89°01'23.61"E to Lat 21°58'24.96"N and Long 88°55'9.66"E. The total length of this stretch is about 15.827 km. The scope of the work to conduct hydrographic and topographic survey of this stretch of Haribhanga waterway comprises of:

- Undertake bathymetric and topographic survey of proposed waterway
- Establishing horizontal and vertical control stations.
- Construction of benchmark pillars and establishing its reduced level w.r.to Mean Sea Level.
- Transfer of sounding Datum.
- Setting up and deployment of water level gauges.
- Current velocity and discharge measurements.
- Collection and analysis of water and bottom samples.
- Collection of topographic features including existing cross structures.
- Preparation of inventory of industries in the project influence area (PIA).
- Analysis of survey data, including assessment of water availability for navigation.
- Preparation of survey charts and report.

2.1.1 Waterway in General and Hydro-Morphological Characteristics

The Haribhanga River is a tidal estuarine river in the Sunderbans Tiger Reserve area, West Bengal, India. Haribhanga River starts from the boarder of Satkhira District of Bangladesh. It follows the international boundary between India and Bangladesh. The river flow in to the Bay of Bengal with a wide mouth after traversing about 25 kilometers. There are no sharp curves in the river stream.

The proposed 15.827 Km stretch of waterway is located in the South 24 Parganas district of West Bengal. Whole stretch of Haribhanga waterway is having tidal influence of 4.43 m.

Average flow velocity in the waterway varies from 1.66 m/sec to 1.68 m/sec. Reduced depth at every 1 Km intervals for full stretch of the river is provided in **Chapter 3**.

2.1.2 Existing Hydrological / Topographical Reference levels

There is no existing GTS Station within the Haribhanga River survey area. Its Topographical composition does not allow establishing any Bench Mark within the survey area as the entire river

covers by Tiger reserves. Therefore the established Bench Mark RM -01 at Hemnagar has been used for Tidal Observations.

The final accepted WGS 84 coordinates and details of Benchmarks established during the conduct of survey are provided in **Table 2**.

Table 2: Description of Bench Marks

BM	Location	Chainage	Latitude (N)	Longitude (E)	Easting (m)	Northing (m)	Height above SD (m)	Height above MSL (m)
RM-01	Hemnagar		N22°12'23.74"	E88°58'58.98"	704423.789	2457031.798	3.514	6.334

2.1.3 Sounding Datum and Reduction details

Sounding datum was transferred from Gangra. Standard method was adopted for transfer of datum for tidal reaches areas as per Admiralty Manual. Details of Sounding Datum (SD) and reduction details are provided in **Table 3** as below:

Table 3: Details of Sounding Datum

Sl. No	Location of Bench Mark / tide gauges	Chainage (Km)	Stretch for corrected soundings and topo levels (Km)	Established Sounding Datum w.r.t. MSL (m) at col. A.	Sounding Datum of Tide Gauge w.r.t. MSL (m)	Correction in WL data for Bathymetric survey (m)	Topo level data to be converted as depth for volume calculation wrt SD (m)
	A	B	C	D (+ve indicates above MSL, -ve indicates below MSL)	E	F = (E-WL data in MSL)	G = ((E-topo levels in MSL)
1	Hemnagar	-	15.827	-2.82	-2.82	Tidal Area	2.82

2.2 EXISTING CROSS STRUCTURES

2.2.1 Bridges

There was no bridge/cross structure exists in the survey area.

2.2.2 Electric Lines / Communication Lines

There is no High tension line in this river stretch.

2.2.3 Pipe Lines / Cables

No cross-structures, pipe lines, underwater cables are located along the entire stretch of waterway.

2.2.4 Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

No dams, barrage, weir or any other cross structure are located along the entire stretch of waterway.

2.3 BENDS

No sharp bend is located along the entire stretch of waterway:

2.4 VELOCITY AND DISCHARGE DETAILS

Current meter observation was carried out at each location at required depths using virtual ware Current meter. The observations were carried out at the deepest route of the channels. Discharge calculations are from the observed data. The current meter and discharge details are provided in **Table 4**.

Table 4: Current Meter and Discharge Details

S t r	Ch in	Position	Obs	Velocity (m/sec.)	ve ag e	Are (S q	Dis ch rg e

		Latitude	Longitude	Easting (m)	Northing (m)		Surface	0.5 D	0.8 D			
1	0	21°53'33.3533" N	089°00'34.6581"E	707622.2	2422297.2	14.7	1.72	1.70	1.61	1.68	38369.7	64461.1
2	15	21°58'16.6983" N	088°55'06.2883"E	698086.9	2430891.9	8	1.70	1.69	1.60	1.66	30721.9	50998.3

2.5 WATERWAY DESCRIPTION

The total 15.827 km stretch of Haribhanga Waterway under DPR study, can be broadly divided in to three (3) stretches. **Table 5** below provides the details of sub-stretches of Haribhanga waterway.

Table 5: Sub-Stretches of Haribhanga Waterway

Sub-Stretch No.	Chainage	
	From	To
1	0 Km	5 km
2	5 Km	10 km
3	10 Km	15.827 km

Detail descriptions of each sub-stretch are provided in below sections.

2.5.1 Sub Stretch 1: (0 km to 5 km)

Bathymetric Survey was carried out for this stretch between 0 to 5 km chainage of the Haribhanga River. It is the downstream portion of the Haribhanga River where it confluence with the Bangladesh Border. This stretch is about 2.3 KM wide with no portion of the river bank protected. Sufficient

depths are available for all time navigation. Both the banks are covered with Tiger Reserve Forest. Following are the observations made during survey of Sub-stretch 1 (Chainage 0 Km to 5 Km)

- There are no overhead obstructions/crossovers.
- There are no prominent dams & Barrage available in this stretch.
- The tidal range is 4.43 m in this stretch.
- There is no hindrance or encroachment in this stretch.

The details of current and discharge at different depths is placed at **Table 4**.

Figure 3 above shows the alignment of Sub-stretch 1 (Ch. 0.0 Km to 5.0 Km) of Haribhanga Waterway. **Figure 4** shows the observed and reduced bed profile of sub-stretch 1.

Figure 3: Google Image showing Sub-Stretch -1

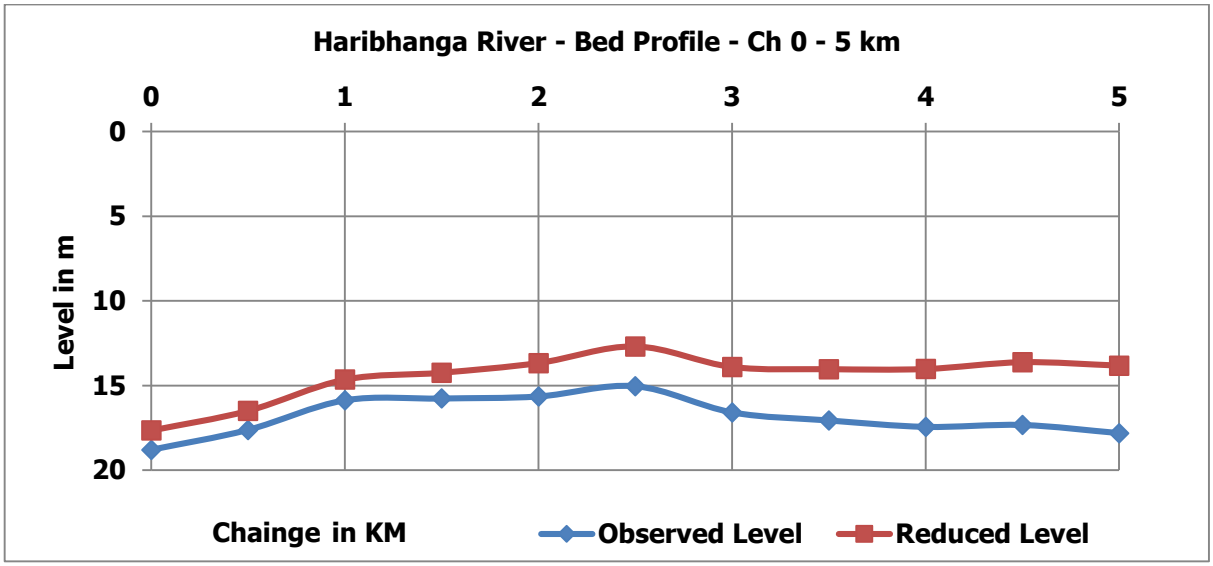


Figure 4: Bed Profile of Waterway Sub-Stretch 1 (Chainage 0km – 5 km)

Figure 5: Photographs of Sub-Stretch 1

2.5.2 Sub Stretch 2: (5km to 10km)

Bathymetric Survey was carried out for this stretch between 5 to 10 km chainage of the Haribhanga River. This stretch is also about 2.5 KM wide with no portion of the river bank protected. Sufficient depths are available for all time navigation. Both the banks are covered with Tiger Reserve Forest. The details of current and discharge at different depths is placed at **Table 4**.

Following are the observations made during survey of Sub-stretch 1: (Chainage 5 km to 10 km)

- There are no overhead obstructions/crossovers.
- There are no prominent dams & Barrage available in this stretch.

- The tidal range is 4.43 m in this stretch.
- There is no hindrance or encroachment in this stretch.

Figure 6: Google Image showing Sub-Stretch -2 of Waterway

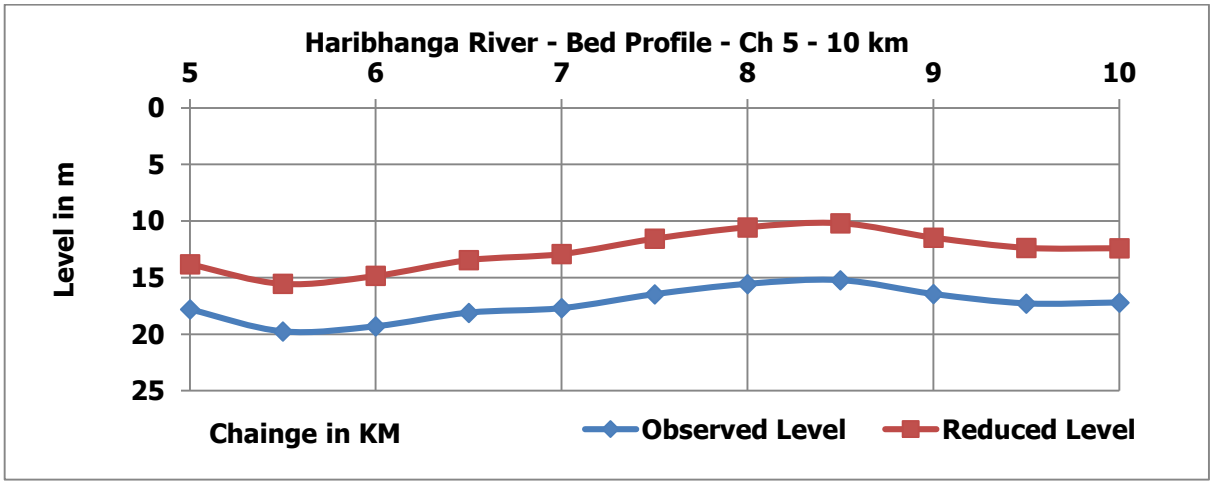


Figure 7: Bed Profile of Waterway Sub-stretch 2 (Chainage 5 km – 10 km)

Figure 8: Photographs of Sub-stretch 2

2.5.3 Sub Stretch 3: (Chainage 10 Km to 15.827 Km)

Bathymetric Survey was carried out for this stretch between 10 to 15.83 km chainage of the Haribhanga River. This stretch is also about 2.0 KM wide with no portion of the river bank protected. Sufficient depths are available for all time navigation. Both the banks are covered with Tiger Reserve Forest. The details of current and discharge at different depths is placed at **Table 4**.

- There are no overhead obstructions/crossovers.
- There are no prominent dams & Barrage available in this stretch.
- The tidal range is 4.43 m in this stretch.
- There is no hindrance or encroachment in this stretch.

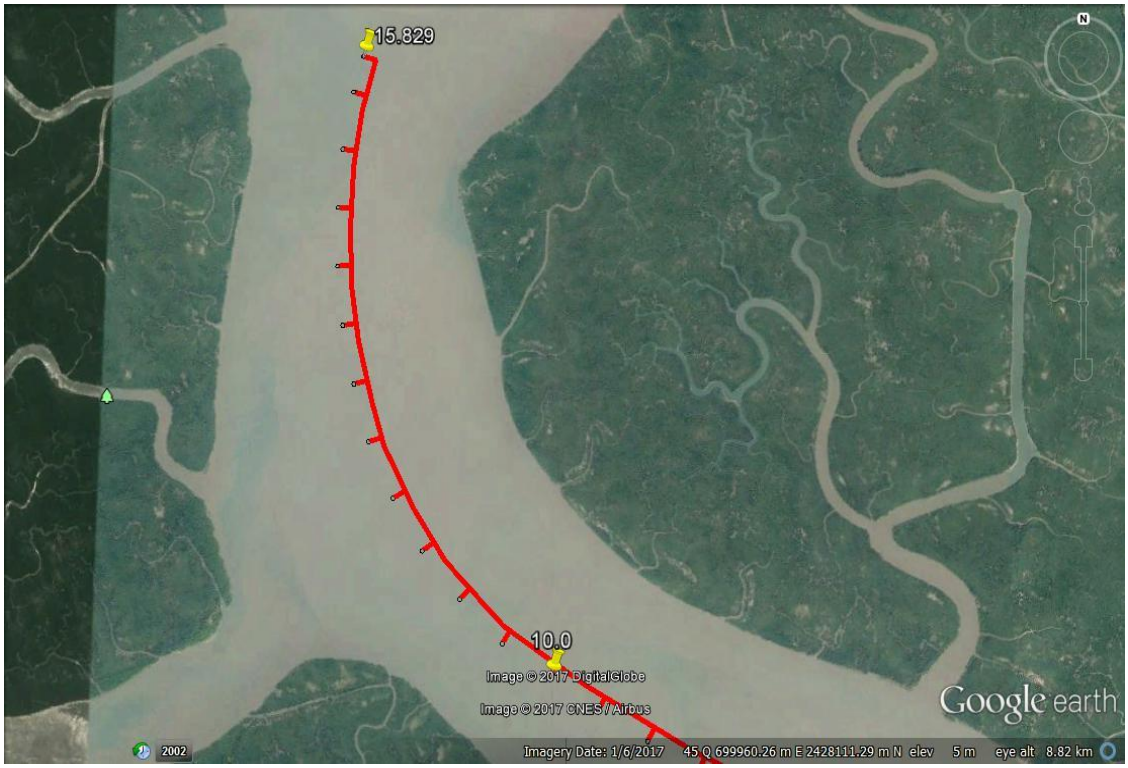


Figure 9: Google Image showing Sub-Stretch -3 of Waterway

Figure 9 above shows the alignment of sub-stretch 3 (Ch. 20.0 km to 30 km) of Waterway. **Figure 10** shows the observed and reduced bed profile of sub-stretch 3.

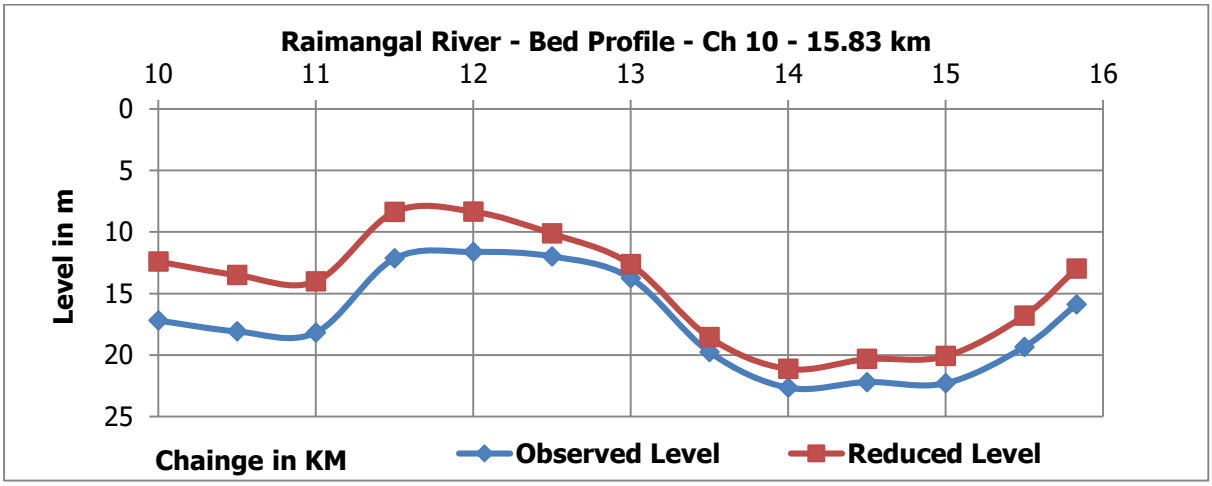


Figure 10: Bed Profile of Waterway Sub-stretch 3 (Chainage 10 km – 15.827 km)

Figure 11: Photograph along Sub-Stretch 3

2.6 SOIL AND WATER SAMPLES ANALYSIS AND RESULTS

Waterway bed soil and water samples were collected using Vanveen Grab & Niskin type water sampler at respective locations. One sample were collected at each location in the river stretches. The location and depth of the collected samples are appended in **Table 6.**

Table 6: Soil & Water Sample Locations

Sample No	Chainage (KM)	Latitude	Longitude	Easting (m)	Northing (m)	Depth (m)
1	0	21°53'33.3533"N	089°00'34.6581"E	707622.2	2422297.2	14.7
2	15	21°58'16.6983"N	088°55'06.2883"E	698086.9	2430891.9	8

The collected soil & water samples were analyzed for the following properties:-

Soil Samples

- Grain size
- Specific gravity
- PH Value
- Cu, Cc
- Clay Silt percentage

Water samples

- Sediment Concentration

Test result of samples is provided in **Figure 12**.

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54A, Pratapaditya Road, Kolkata - 700026

CERTIFICATE OF ANALYSIS ON SOIL & WATER SAMPLES

Table No. : 2

Project : Laboratory Analysis of Soil & Water Samples

River : Haribanga

Job No. : 6154 H

Sample Reference				Test Results on SOIL SAMPLES								Test Results on WATER SAMPLES	
				Particle Size Analysis								Sediment Concentration Test	
				By Sieve Analysis		By Hydrometer Analysis							
Serial No.	Sample Ref. No.	Name of Sample	Chainage	Observed Depth (m)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Specific Gravity	pH Value	Cohesive Strength of Uniformity (Cu)	Cohesive Strength of Curvature (Cc)	Total Solid (mg/lit)
1	HB-1	Soil	0	14.70	0	6	39	55	2.64	8.02	6.00	1.50	-
2	HB-2	Soil	15	8.00	0	9	45	46	2.65	8.28	6.00	1.50	-
3	HB-1	Water	0	14.70	-	-	-	-	-	-	-	-	29252
4	HB-2	Water	15	8.00	-	-	-	-	-	-	-	-	30510

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Figure 12: Soil and Water Sample Test Results

3.0 FAIRWAY DEVELOPMENT

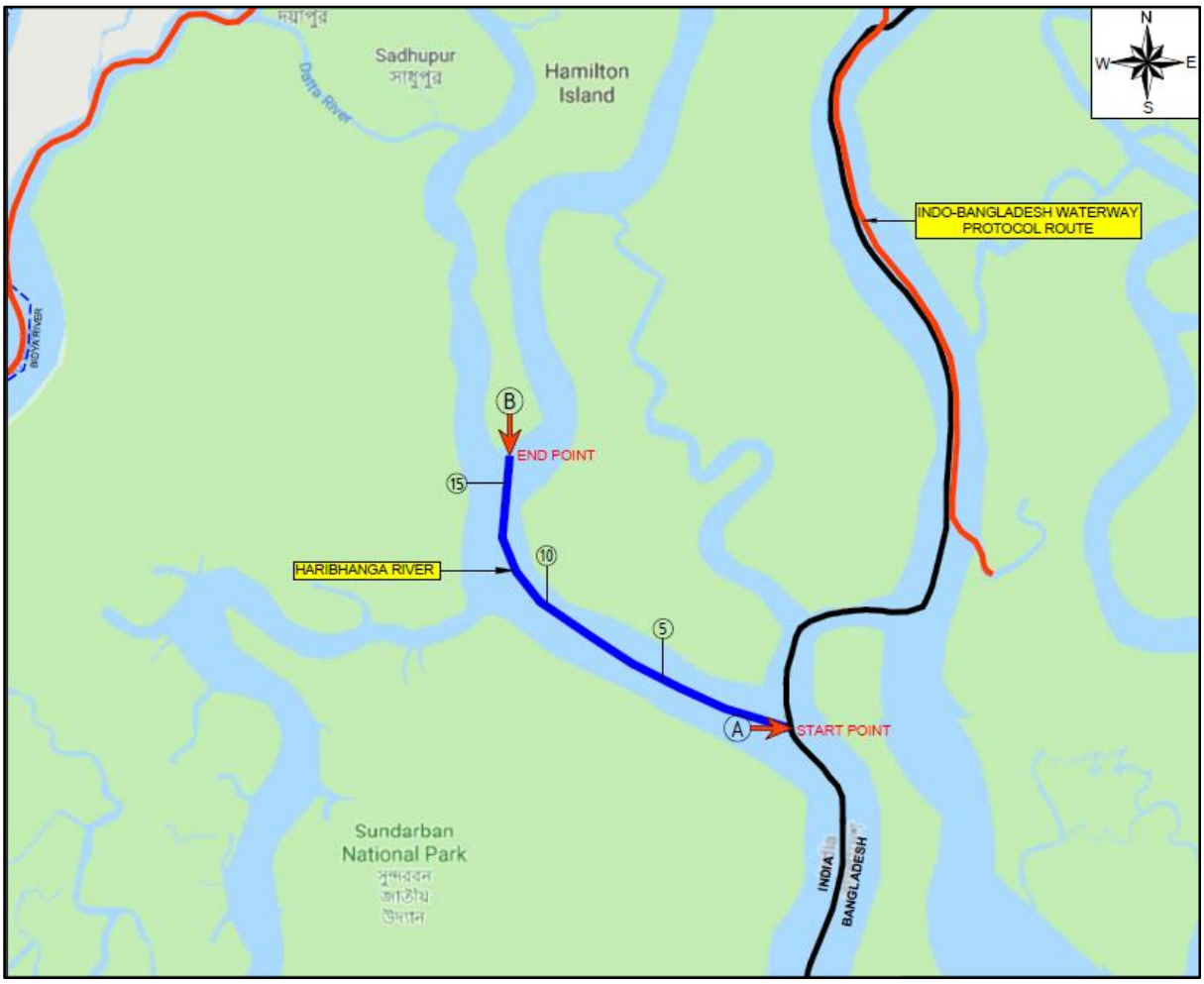
In most of the countries where inland navigation is developed, such as in Europe, China, Russia etc., the waterways have been classified in different classes depending on their physical characteristics and development potential in future. Generally, with larger waterway dimensions bigger IWT vessels can operate resulting in lower shipping cost per tonne of cargo as compared to the shipping cost of smaller vessels. One of the important factors contributing to lower shipping cost by operation of bigger vessels is the improvement in power to load ratio, i.e. capacity of cargo carrying per unit of engine power. Hence, every waterway should be developed to larger dimensions (depth and width of navigation channel) subject to the physical characteristics of the waterway. However, for developing a waterway to larger dimensions (in other wards waterway of higher class) additional investment would be required. Therefore, there would be an optimum waterway class for a particular waterway whereby total cost to the system (i.e., increase in cost due to development work vis-a-vis reduction in shipping cost) is minimum. This optimum solution is required for each waterway and for this purpose classification of waterways would facilitate planning for the optimum class of the waterway and its development.

3.1 PROPOSED CLASS / TYPE OF WATERWAY

IWAI gives a classification of waterways on the basis of width and depth of rivers/canals, radius of bends, vertical clearance, horizontal clearance between bridge piers and self-propelled vessel carrying capacity of vessels. On the basis of these criteria's, classification of waterways was done by IWAI as detailed in Paragraph **1.1.1** and **Table 1**.

From the detailed hydrographic survey, following observations are made on the proposed fairway:

a) No dams, barrage and any other cross-structure is located along the proposed fairway stretch.
b) Reduced depth of waterway varies from 7.7 m to 22.8 m w.r.t sounding datum.
c) Tidal influence of 4.43 m.
d) Width of river varies from 1.86 km to 2.92 km.


Sadhupur
সাধুপুর
Hamilton
Island
Datta River
N
W
E
S
INDO-BANGLADESH WATERWAY
PROTOCOL ROUTE
B
END POINT
15
10
HARIBHANGA RIVER
5
A
START POINT
Sundarban
National Park
সুন্দরবন
জাতীয়
উদ্যান
INDIA
BANGLADESH

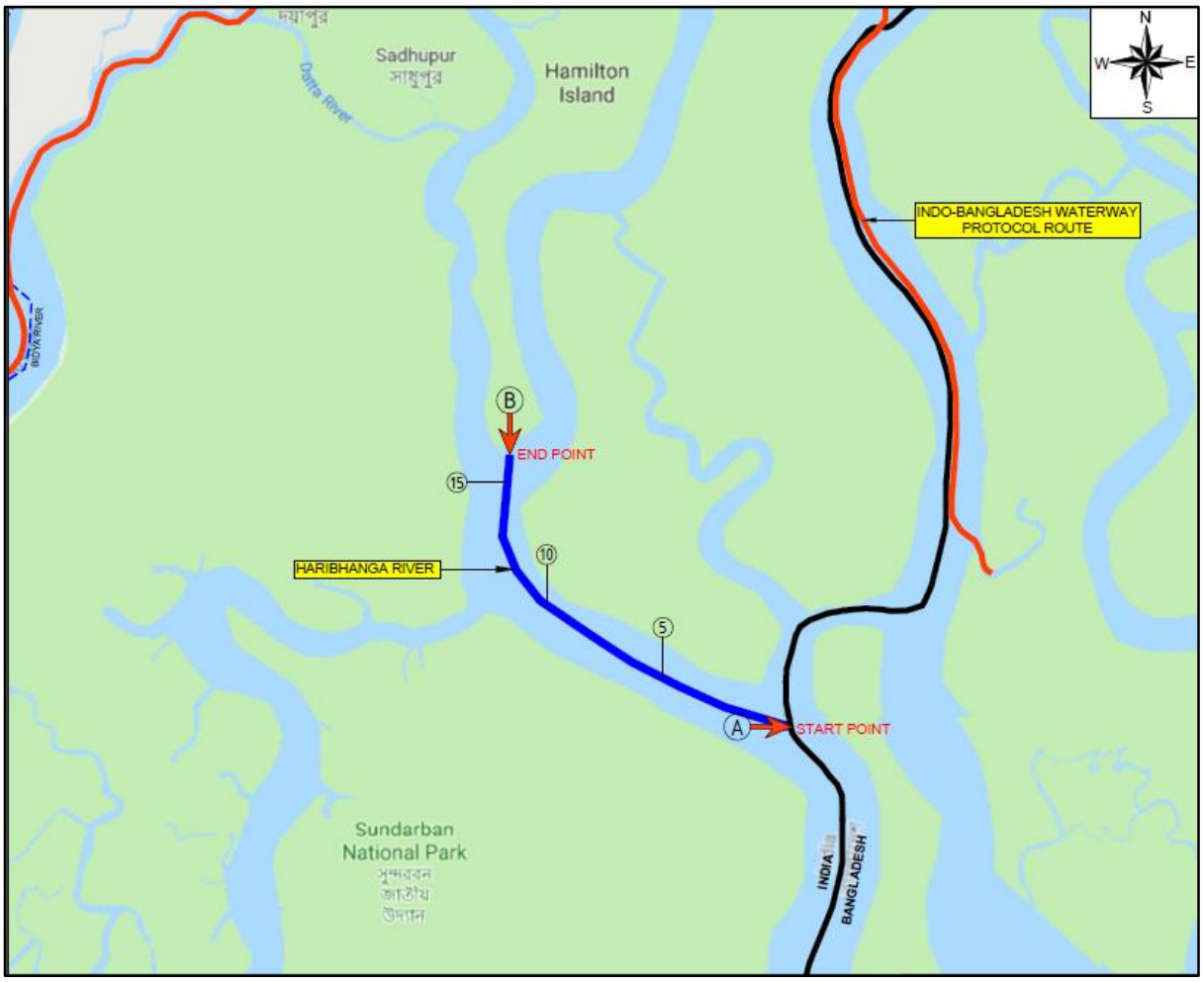
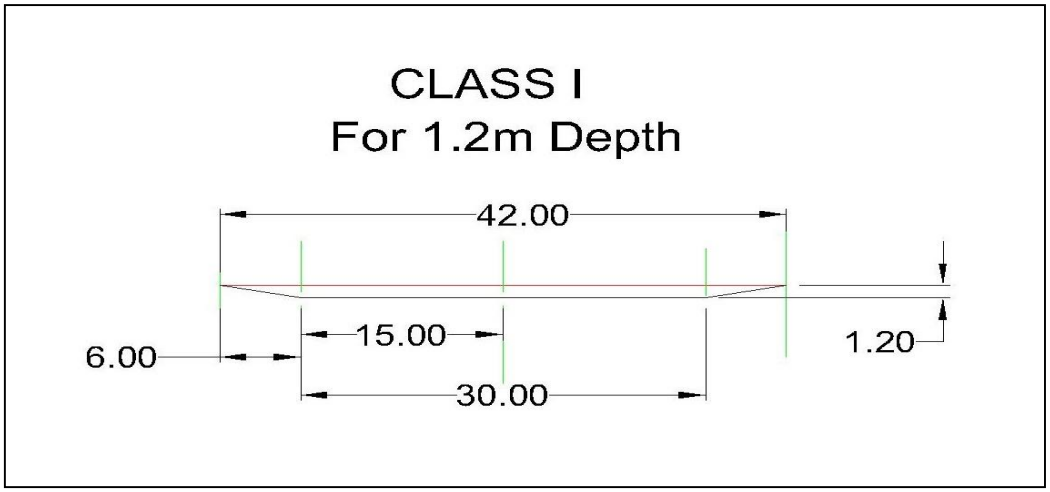


Figure 13: Proposed alignment of Haribhanga Waterway

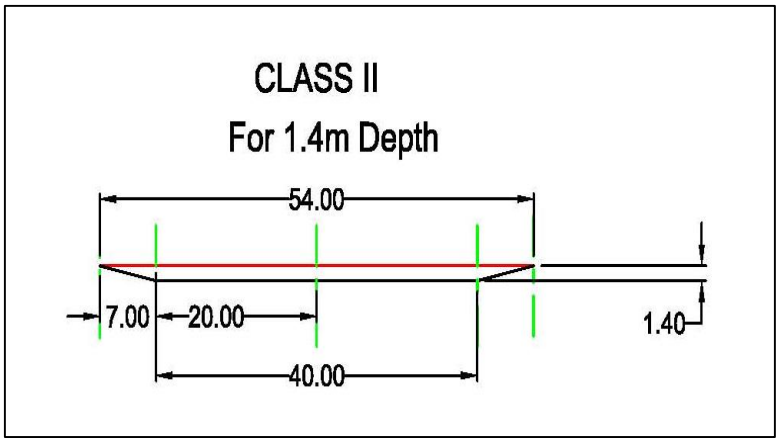
The classification of waterway and its type is based on the availability of LAD and Vessel proposed to be deployed for the required traffic. As per the hydro-graphic studies provided in Volume-III of submitted DPR, by taking into advantage of tidal window, sufficient LAD is available in the complete 15.827 km stretch of waterway, which suggest that waterway is viable for throughout the year navigation. However, dredging quantities have also been worked out for different classes of waterways. The details are as follows:

Class I



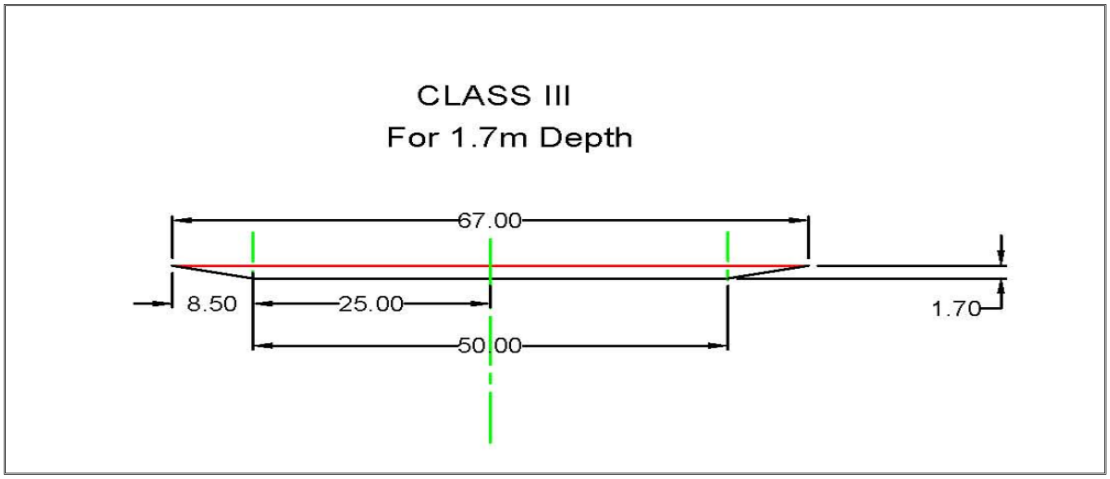
Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				14	17.6	0.00	0.00	0.00
1	2					13.7	14	0.00	0.00	0.00
2	3					12.3	14.1	0.00	0.00	0.00
3	4					13.1	14.4	0.00	0.00	0.00
4	5					12.9	14.1	0.00	0.00	0.00
5	6					14.6	15.6	0.00	0.00	0.00
6	7					12.9	14.1	0.00	0.00	0.00
7	8					10.55	13.8	0.00	0.00	0.00
8	9					9.6	11.7	0.00	0.00	0.00
9	10					11.5	13.3	0.00	0.00	0.00
10	11					12.5	14	0.00	0.00	0.00
11	12					8.1	13	0.00	0.00	0.00
12	13					8.26	12.39	0.00	0.00	0.00
13	14					12.5	21.7	0.00	0.00	0.00
14	15					19.4	22.8	0.00	0.00	0.00
15	15.830					12.8	19.4	0.00	0.00	0.00
				Total	**0.00**			**Total**	**0.00**	

Class II



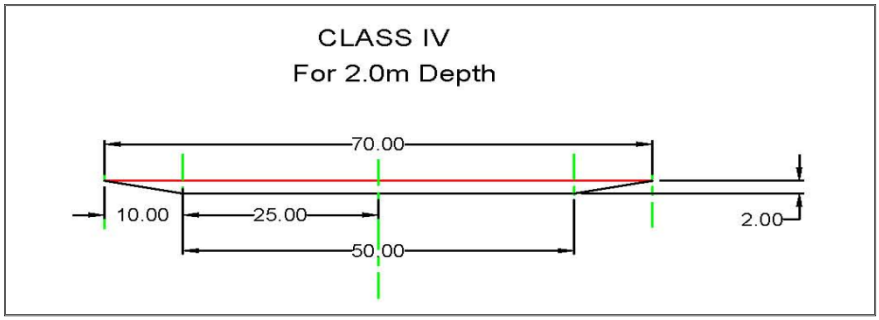
Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				13.9	17.6	0.00	0.00	0.00
1	2					13.7	14	0.00	0.00	0.00
2	3					12.3	14.1	0.00	0.00	0.00
3	4					13.1	14.4	0.00	0.00	0.00
4	5					12.9	14.1	0.00	0.00	0.00
5	6					14.2	15.6	0.00	0.00	0.00
6	7					12.8	14.1	0.00	0.00	0.00
7	8					10.55	13.8	0.00	0.00	0.00
8	9					9.6	11.7	0.00	0.00	0.00
9	10					11.5	13.3	0.00	0.00	0.00
10	11					12.4	14	0.00	0.00	0.00
11	12					8	13.1	0.00	0.00	0.00
12	13					8.26	12.39	0.00	0.00	0.00
13	14					12.5	21.7	0.00	0.00	0.00
14	15					19.2	22.8	0.00	0.00	0.00
15	15.830					12.8	19.6	0.00	0.00	0.00
				Total				**Total**	**0.00**	

Class III



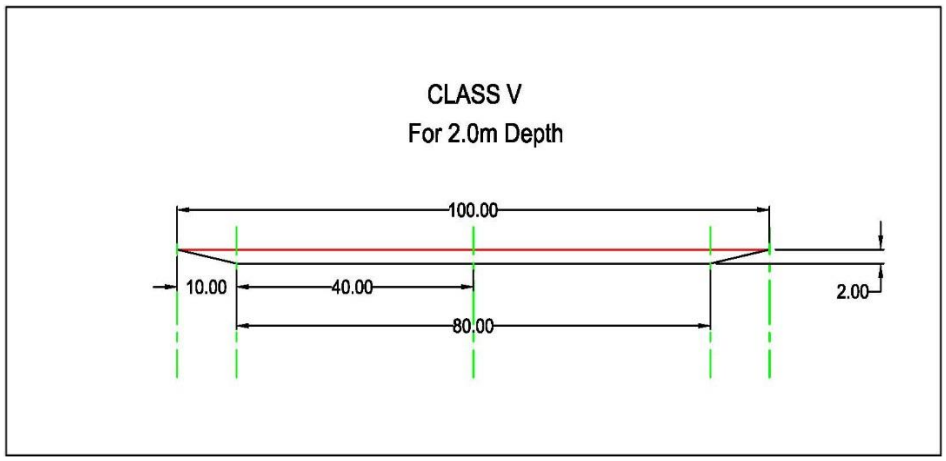
Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				13.9	17.6	0.00	0.00	0.00
1	2					13.65	14	0.00	0.00	0.00
2	3					12.3	14.1	0.00	0.00	0.00
3	4					13.1	14.4	0.00	0.00	0.00
4	5					12.9	14.1	0.00	0.00	0.00
5	6					14.2	15.6	0.00	0.00	0.00
6	7					12.8	14.1	0.00	0.00	0.00
7	8					10.55	13.8	0.00	0.00	0.00
8	9					9.6	11.7	0.00	0.00	0.00
9	10					11.5	13.3	0.00	0.00	0.00
10	11					12.4	14.1	0.00	0.00	0.00
11	12					7.7	13.2	0.00	0.00	0.00
12	13					8.26	12.39	0.00	0.00	0.00
13	14					12.5	21.7	0.00	0.00	0.00
14	15					18.9	22.8	0.00	0.00	0.00
15	15.830					12.8	20	0.00	0.00	0.00
				Total				**Total**	**0.00**	

Class IV



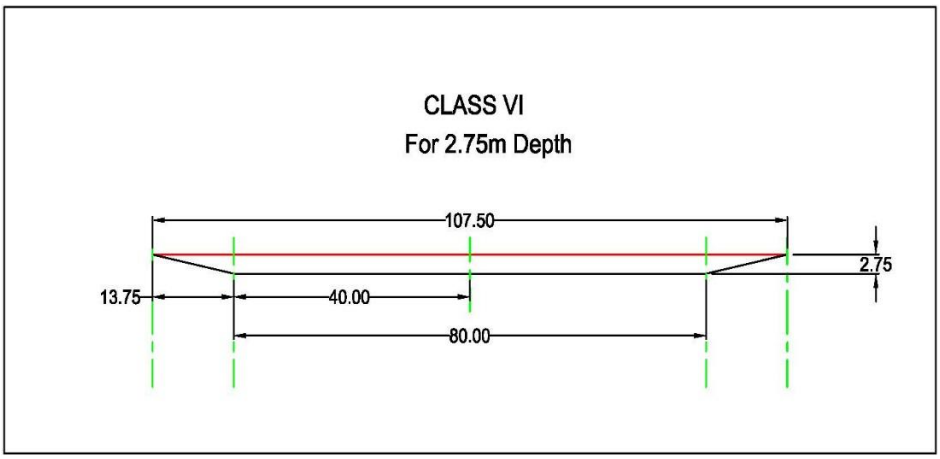
Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				13.9	17.6	0.00	0.00	0.00
1	2					13.65	14	0.00	0.00	0.00
2	3					12.3	14.1	0.00	0.00	0.00
3	4					13.1	14.4	0.00	0.00	0.00
4	5					12.9	14.1	0.00	0.00	0.00
5	6					14.2	15.6	0.00	0.00	0.00
6	7					12.8	14.1	0.00	0.00	0.00
7	8					10.55	13.8	0.00	0.00	0.00
8	9					9.6	11.7	0.00	0.00	0.00
9	10					11.5	13.3	0.00	0.00	0.00
10	11					12.4	14.1	0.00	0.00	0.00
11	12					7.7	13.2	0.00	0.00	0.00
12	13					8.26	12.39	0.00	0.00	0.00
13	14					12.5	21.7	0.00	0.00	0.00
14	15					18.9	22.8	0.00	0.00	0.00
15	15.830					12.8	20	0.00	0.00	0.00
				Total				**Total**	**0.00**	

Class V



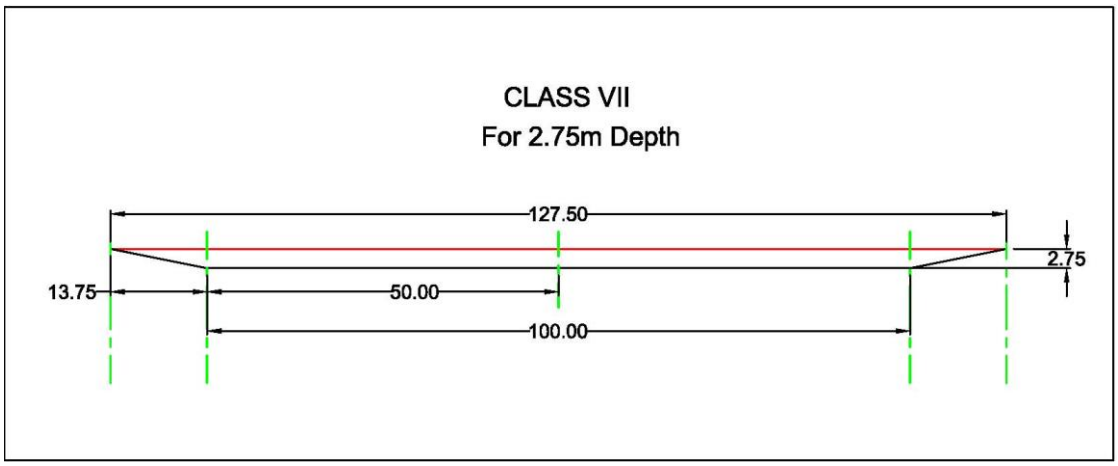
Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				13.74	18.05	0.00	0.00	0.00
1	2					13.65	14.61	0.00	0.00	0.00
2	3					12.28	14.2	0.00	0.00	0.00
3	4					13.02	14.41	0.00	0.00	0.00
4	5					12.9	14.4	0.00	0.00	0.00
5	6					14.19	15.6	0.00	0.00	0.00
6	7					12.8	14.11	0.00	0.00	0.00
7	8					10.54	13.81	0.00	0.00	0.00
8	9					9.6	11.7	0.00	0.00	0.00
9	10					11.5	13.3	0.00	0.00	0.00
10	11					12.38	14.1	0.00	0.00	0.00
11	12					7.7	13.96	0.00	0.00	0.00
12	13					8.24	12.39	0.00	0.00	0.00
13	14					12.5	21.75	0.00	0.00	0.00
14	15					18.05	23.1	0.00	0.00	0.00
15	15.830					12.8	20.06	0.00	0.00	0.00
				Total				**Total**	**0.00**	

Class VI



Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				13.7	18.06	0.00	0.00	0.00
1	2					13.65	14.62	0.00	0.00	0.00
2	3					12.26	14.3	0.00	0.00	0.00
3	4					13.02	14.41	0.00	0.00	0.00
4	5					12.9	14.7	0.00	0.00	0.00
5	6					14.11	15.6	0.00	0.00	0.00
6	7					12.8	14.11	0.00	0.00	0.00
7	8					10.53	13.82	0.00	0.00	0.00
8	9					9.6	11.72	0.00	0.00	0.00
9	10					11.43	13.3	0.00	0.00	0.00
10	11					12.37	14.1	0.00	0.00	0.00
11	12					7.7	13.96	0.00	0.00	0.00
12	13					8.24	12.44	0.00	0.00	0.00
13	14					12.5	21.78	0.00	0.00	0.00
14	15					18.03	23.1	0.00	0.00	0.00
15	15.830					12.8	20.12	0.00	0.00	0.00
				Total				**Total**	**0.00**	

Class VII



Chainage (km)		Observed				Reduced w.r.t. Sounding Datum				
From	To	Min. depth (m)	Max. depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Min. Depth (m)	Max. Depth (m)	Length of Shoal (m)	Dredging Qty. (cu.m.)	Accumulative Dredging Qty.
0	1	Not Applicable (Tidal Zone)				13.65	18.08	0.00	0.00	0.00
1	2					13.65	14.63	0.00	0.00	0.00
2	3					12.26	14.6	0.00	0.00	0.00
3	4					13.02	14.41	0.00	0.00	0.00
4	5					12.87	14.7	0.00	0.00	0.00
5	6					13.94	15.6	0.00	0.00	0.00
6	7					12.74	14.33	0.00	0.00	0.00
7	8					10.53	13.88	0.00	0.00	0.00
8	9					9.6	11.72	0.00	0.00	0.00
9	10					11.27	13.33	0.00	0.00	0.00
10	11					12.35	14.05	0.00	0.00	0.00
11	12					7.7	13.97	0.00	0.00	0.00
12	13					8.23	12.55	0.00	0.00	0.00
13	14					12.5	22	0.00	0.00	0.00
14	15					17.87	23.2	0.00	0.00	0.00
15	15.830					12.8	20.25	0.00	0.00	0.00
				Total				**Total**	**0.00**	

It is proposed to develop Haribhanga Waterway as Class VII waterway.

4.0 TRAFFIC STUDY

4.1 GENERAL

South 24 Parganas is a district in the Indian State of West Bengal, headquartered in Alipore. It is the largest district of West Bengal state by area and second largest by population. It is the sixth most populous district in India (out of 640). On one side is the urban fringe of Kolkata and on the other, the remote riverine villages in the Sundarbans.

The district has 5 Sub-divisions namely (i) Alipore Sadar (ii) Baruipur (iii) Canning (iv) Diamond Harbour, and (v) Kakdwip. The South 24 Parganas district highlights as per 2011 census[1]

- South 24 Parganas District comprises of 29 C.D. Blocks and 7 Statutory Towns.
- There are total 2,042 villages and 111 Census Towns in the District.
- South 24 Parganas District 2nd most populated district.
- The percentage of urban share of Population of South 24 Parganas District has expanded from 15.7% (2001 Census) to 25.6% (2011 Census) of total Population of respective Census.
- South 24 Parganas District ranks 4th in decadal Population growth rate among the Districts with 18.2%.
- The density of Population (Population per square km) of the district is 819 per square km which makes its rank 12th in the State.
- There are 75 (seventy five) Villages having Population 10,000 and above.
- South 24 Parganas District has the highest area (9960.00 sq km) in the State.
- A large portion in the southern part of the district is covered with thick Mangrove forests of created in the riverine delta created in the confluence of the rivers Ganga, Brahmaputra, Padma known as the Sundarban Reserve Forest which is included in the UNESCO World Heritage Site. Sundarban is a prominent National Park, Tiger Reserve and Biosphere Reserve in the country and in the world.

4.2 INFLUENCE AREA / HINTERLAND

Haribhanga river flows through one (1) CD block of South 24 Parganas disctrict, namely, Gosaba. The Project Influence Area (PIA), considering existing and projected traffic for passenger ferry services,

[1] District Census Handbook, 2011

comprises of the following CD blocks and districts. Total influence area/hinterland extending on either side of waterway is provided in **Table 7**.

Table 7: Project Influence Area/ Hinterland

State	District	Area (Km^2)	C.D. Block	Area (Km^2)	Total Hinterland area (Km^2)
West Bengal	South 24 Parganas	9,960	Gosaba	296.72	296.72

4.2.1 Population of Hinterland area

Population of hinterland area for proposed IWT in Haribhanga waterway is provided in **Table 8** below:

Table 8: Population of Hinterland[2]

State	District	Population (Nos.)	C.D. Block	Population (Nos.)	Total Hinterland Population (Nos)
West Bengal	South 24 Parganas	81,61,961	Gosaba	58,197	58,197

4.2.2 Existing and proposed Industries

No industries are located or proposed along the entire stretch of river

4.3 HINTERLAND CONNECTIVITY

There is no road, rail and waterway network in the entire river. Also no Mobile network is available in the area.

4.4 COMMODITY COMPOSITION / CATEGORIZATION

Both the banks are covered with Tiger Reserve forest. Being forest, no commodity/ cargo/ passenger traffic is located along the entire river stretch.

[2] District Census Handbook, 2011

4.5 TOURISM TRAFFIC

No tourism traffic is located along the waterway.

4.6 GROWTH TREND

As per district census statistics, the decadal population growth rate of South 24 Parganas is 18.2%.

However, as Haribhanga river does not have its passenger and cargo traffic, traffc forecast can not be done.

4.7 CONSLUSION

Following conclusions are made from the traffic studies done above:

a) River stretch lies in the restricted Tiger Reserve Forest area.
b) No passenger or cargo is available along the stretch.

In view of the above observations, the waterway is declared as technically non-viable for further development and studies.

5.0 TERMINALS

The terminal planning and design includes selection of suitable sites in the vicinity of traffic potential considering all the relevant technical variables such as choosing the type of berthing facility and providing of waiting and parking areas and other ancillary facilities required for efficient terminal operation. Based on the projected traffic, the selection of various facilities will be planned.

There is no ferry terminal in the river stretch. Haribhanga River is divided into 3 stretches on the basis of gradient. Navigation is possible in the entire river at all times as sufficient depth is available for navigation.

As as concluded in Chapter 4, no passenger/cargo traffic is avalable along the stretch, as such no jetty or terminal structure is proposed in this DPR of Haribhanga Waterway.

6.0 PRELIMINARY ENGINEERING DESIGNS

The main objective of preliminary engineering is to ascertain quantitatively the feasibility of engineering works. Preliminary engineering is carried out to arrive at the preliminary sizing of all major facilities required at the terminal and waterway for safe navigation. As concluded in Chapters 3 and 4, no development activity is proposed in the Haribhanga Waterway in this DPR.

7.0 VESSEL DESIGN

Waterway lies in the tiger reserve forest area, as such vessel movement is not allowed in the river stretch. No additional vessels are proposed in this DPR for Haribhanga waterway.

8.0 NAVIGATION AND COMMUNICATION SYSTEM

As no development is proposed in the waterway, navigation and communication system are not considered in the DPR.

9.0 ENVIRONMENTAL AND SOCIAL ASPECTS

9.1 OBJECTIVE OF ENVIRONMENTAL AND SOCIAL STUDIES

Inland Waterway Authority of India (IWAI), Ministry of Shipping, Government of India intends to explore the potential of additional waterways across the country for year round commercial navigation, and recommending the possibility of Composite and Integrated development of National waterways to achieve navigation and to develop water transport facilities across India.

The section of Haribhanga River from Km 0.000 to Km 15.827 falling in South 24 Parganas District of West Bengal State is also considered for Sunderban waterways and declared as National Waterway No. 97 (NW-97).

The Haribhanga river is a tidal estuarine river in the Sunderbans Tiger Reserve Area, West Bengal, India. Haribhanga river starts from the border of Satkhira district of Bangladesh. It follows the international boundary between India and Bangladesh.

The river flows in to the Bay of Bengal with a wide mouth after traversing 25 Kilometers. Haribhanga river has several tributaries/creeks on its bank. The details of the creeks are given in **Table 9.**

Table 9: List of Creeks

Sl No	Creek	Chainage	Length(Km)
1	Creek 1	4.887	4.653
2	Creek 2	6.165	2.791
3	Creek 3	8.907	1.136
4	Creek 4	9.03	1.985
5	Creek 5	9.812	1.248
6	Creek 6	10.965	4.191
7	Creek 7	11.029	1.093
8	Creek 8	11.731	1.075
9	Creek 9	12.428	1.145
10	Creek 10	12.81	4.269
11	Creek 11	13.625	1.018
12	Creek 12	14.611	2.047

The major objective of this study is to establish present environmental condition along the project corridor through available data /information supported by field studies to evaluate the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to minimize / reduce adverse impacts and to prepare an Environmental Management Plan (EMP) for timely implementation of the mitigation measures to make the project environmentally sound and sustainable. The study basically includes:

- Establishment of the present environmental and social scenario
- Study of the specific activities related to the project
- Evaluation of the probable environmental and social impacts
- Recommendations of necessary environmental control measures.
- Preparation of Environmental Management Plan
- To identify the requirement of various regulatory clearances, NoCs

9.2 ENVIRONMENTAL SETTING IN THE PROJECT AREA

9.2.1 Physiographic

The entire study stretch is in South 24-Parganas district. South 24 Parganas district lies between $22^0$12'13"N and $22^0$46'55"N latitude and its longitudes are $87^0$58'45"E and $88^0$22'10"E covering an area of 9,960 sq. km. Alipore is the district headquarters of South 24 Parganas. It is the largest district of West Bengal in terms of area with a very small proportion of urban settlements. A large portion of the district is included in the Forests of Sundarbans.

Geographically, district South 24 Parganas lies in the lowest course of river Ganga at the Southern-most part of Gangetic West Bengal. The entire drainage pattern of the district is heavily incumbent upon the tidal forces of Bay of Bengal. There are numerous mudflats, coastal wetlands, lagoons, creeks and estuaries of large rivers in the district. The most important rivers of the district are Hooghly (the final course of Ganga), Bidyadhari, Matla, Piyali, Raymangal, Thakuran, Raidighi, Bidya, Saptamukhi (owing to its seven channels), Hataniya-Doaniya etc. There are many streams and rivulets known as Khal and forested Swamps and marshy wetlands known as Bil (also spelt asBeel). Most of the rivers are joined with each other through these channels, naturally or erected by human, and forms a web like river-network spread over the larger share of the district. Due to tidal activity in the Bay of Bengal, most of these rivers changes theirs paths often and forms small water bodies through-out the district. The sea water can enter as far as 100 km. from the coastal lines through these river streams. There are many other small rivers passing through the district, most of them are directly connected to the Bay of Bengal and are influenced by the Tidal waves.

The physiograhiy of the entire district is situated in the Gangetic delta. A large every area in the southern part of the district is covered with the dense jungle of Sundarban with numerous rivers and its tributaries in between. Numerous islands are thus found in this area. Some of these islands remain totally sub-merged under water. In the northern part of the district we find the Baruipur-Jaynagar Plain and Kulpi-Diamond Harbour Plain which is 5-6 meters above the sea level. Here the process of land making process is still going on.The district could be divided into 4 sub-micro regions viz. (a) South Hugli Flats (b) South Bidyadhari Plain (c) Hooghly Delta, and (d) Sundarbans.

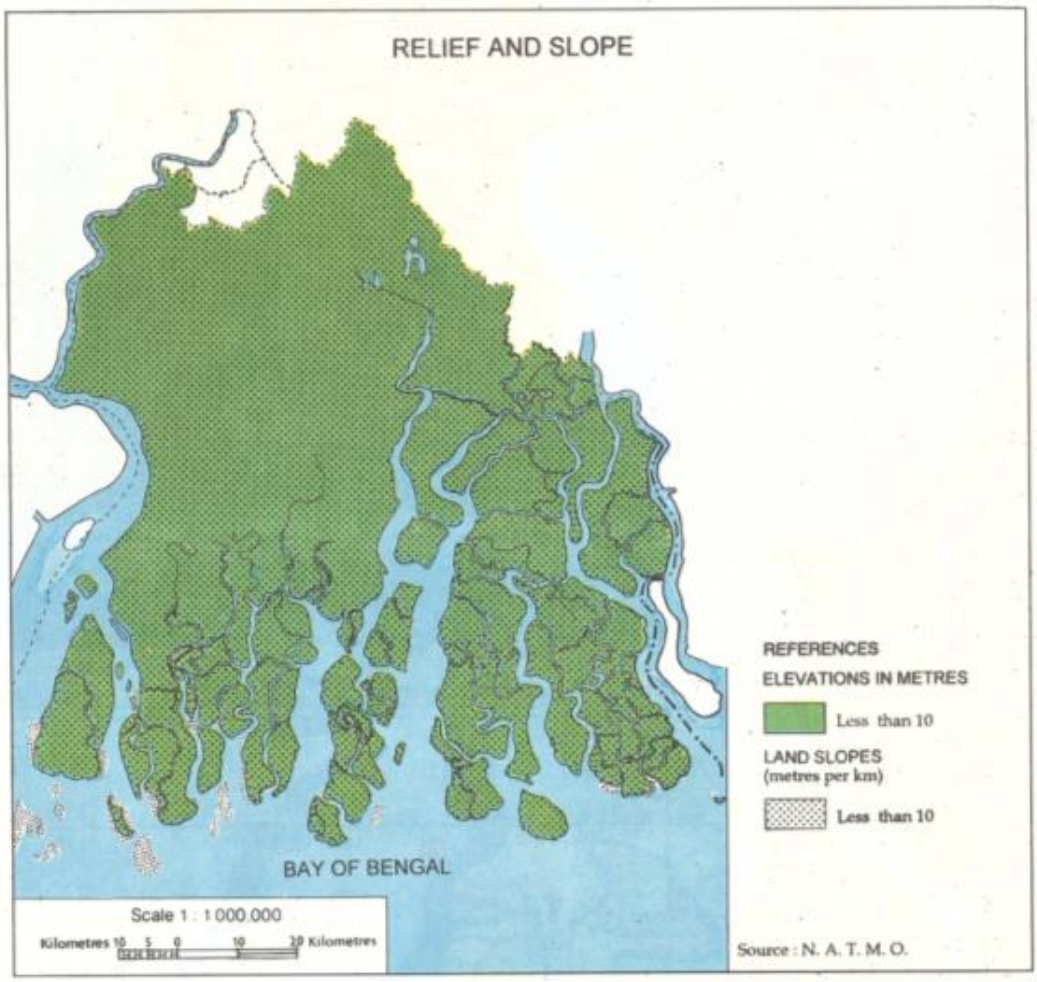
South Hugli Flats: From the northern boundary of the district (Kolkata) to Diamond Harbour in the south, this is a narrow flat alluvial land along the river of Hooghly which also forms the district boundary in the west. Flowing south-west, Hooghly receives the Rupnarayan River in the Hugli point and then turns east for about 12 km. until it reach Diamond Harbour. From there it again turns southwards and falls into Bay of Bengal. The Hugli is a navigable river and ships reach Kolkata Port through this river during high tides.

South Bidyadhari Plain: This plain area has its general slope towards the south. Situated in the northern part of the district, river Matla is the most prominent river of this plain. There are many streams and water channels which are locally known as khals.

Hooghly Delta: Lying in the south-western part of the district, the Hooghly river forms the district boundary in the west. The river falls into the Bay of Bengal and has a southern slop. Before falling into Bay of Bengal, it bifurcates into two channels. The main channel is passing to the west and the other called Baratala to the east of Sagar Island. The southern part of the Hugli Delta has numerous channels and islands of which Henry's Island, Sagar Island, Frederick Island and Fraserganj Island are some of the worth mentioning islands. It is a land of strong tides and tides sometimes reaches a height of 3 to 5 metres.

Sundarbans: Almost the entire area under Indian part of Sundarban is contained in district South Twenty Four Parganas. A dense mangrove forest amongst numerous rivers and streams, thousands of islands, rich flora and fauna along with human presence has made Sundarbans world famous. The area is known for the Royal Bengal Tiger (Pantheratigris tigris), as well as numerous fauna including species of birds, spotted deer, crocodiles and snakes. The fertile soil of Sundarbans helps intensive agriculture. Rightly designated as among the 'new seven wonders of nature', Sundarbans functions as a protective barrier for millions of inhabitants living in the southern part of the district.

Sundarbans is stretched between India and Bangladesh with India's share is only 19 percent. The Bay of Bengal lies in the southern part of Sundarbans and the rivers of the region falls there. Thus it has become a region of transition between the fresh water of the rivers and the saline water of the Bay of Bengal. Relief and Slope Map of South 24 Parganas District are furnished in **Figure 14**.



Source : NATMO

Figure 14: Relief and Slope Map of South 24 Parganas District

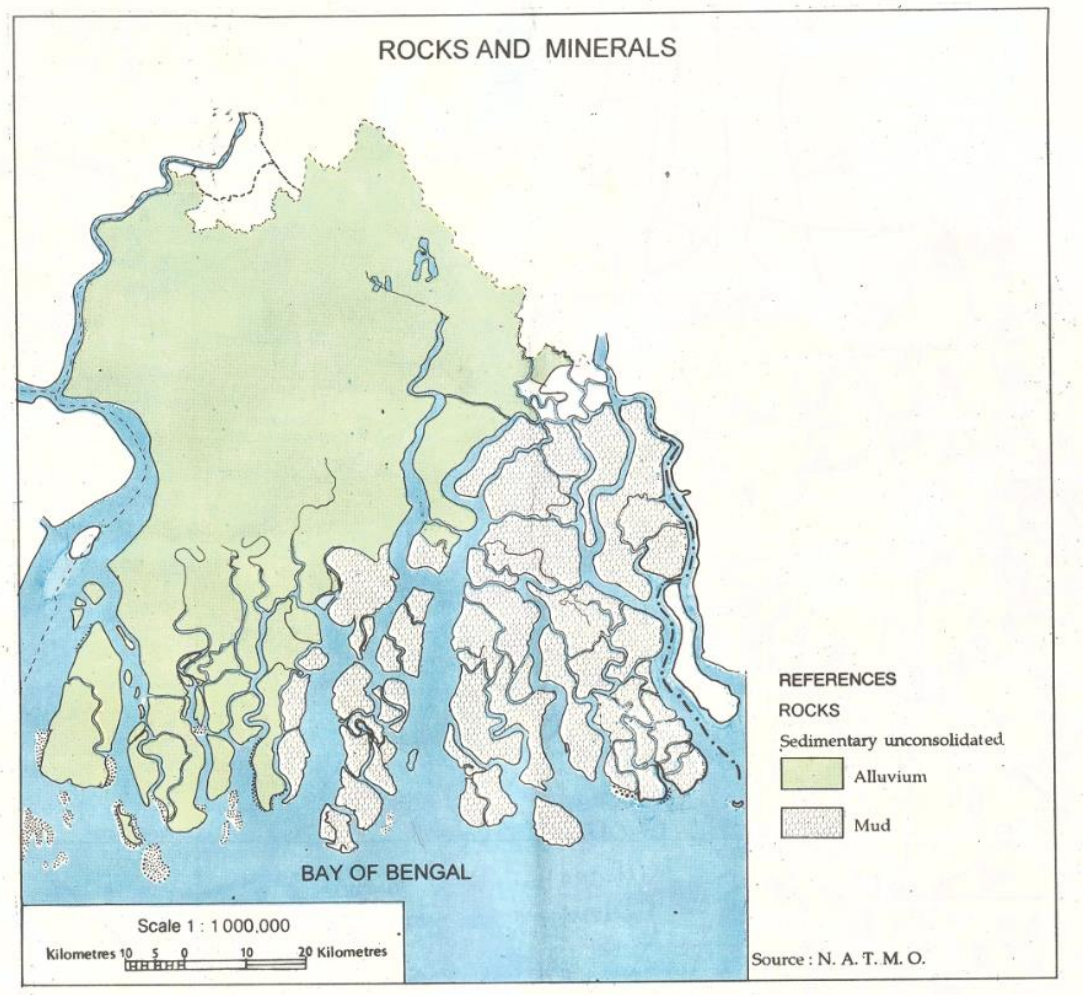
9.2.2 Geology and Seismicity

Geology:

The district of South 24-Parganas is covered with recent alluvium, which is of great depth. Once a boring was conducted near Akra Road, Garden Reach which found no signs of rocky bottom or marine

beds even when dug at a depth of 1,306 feet. In the eastern and central parts, the surface soil is chiefly a clayey loam with some peaty patches in the marshy areas. Surface soil in the Sundarbans area is heavy clay impregnated with salt. The borings conducted in the region indicate that the alluvium of the area consists of alterations of clay, sand and silt. Kankar (very tiny pieces of stone) is mixed with sands and clays. Even the stumps of sundri trees have been found at Sealdah in Kolkata at various levels down to a depth of thirty feet.

The Rock and Mineral Map of South 24 Parganas District is presented in **Figure 15**.

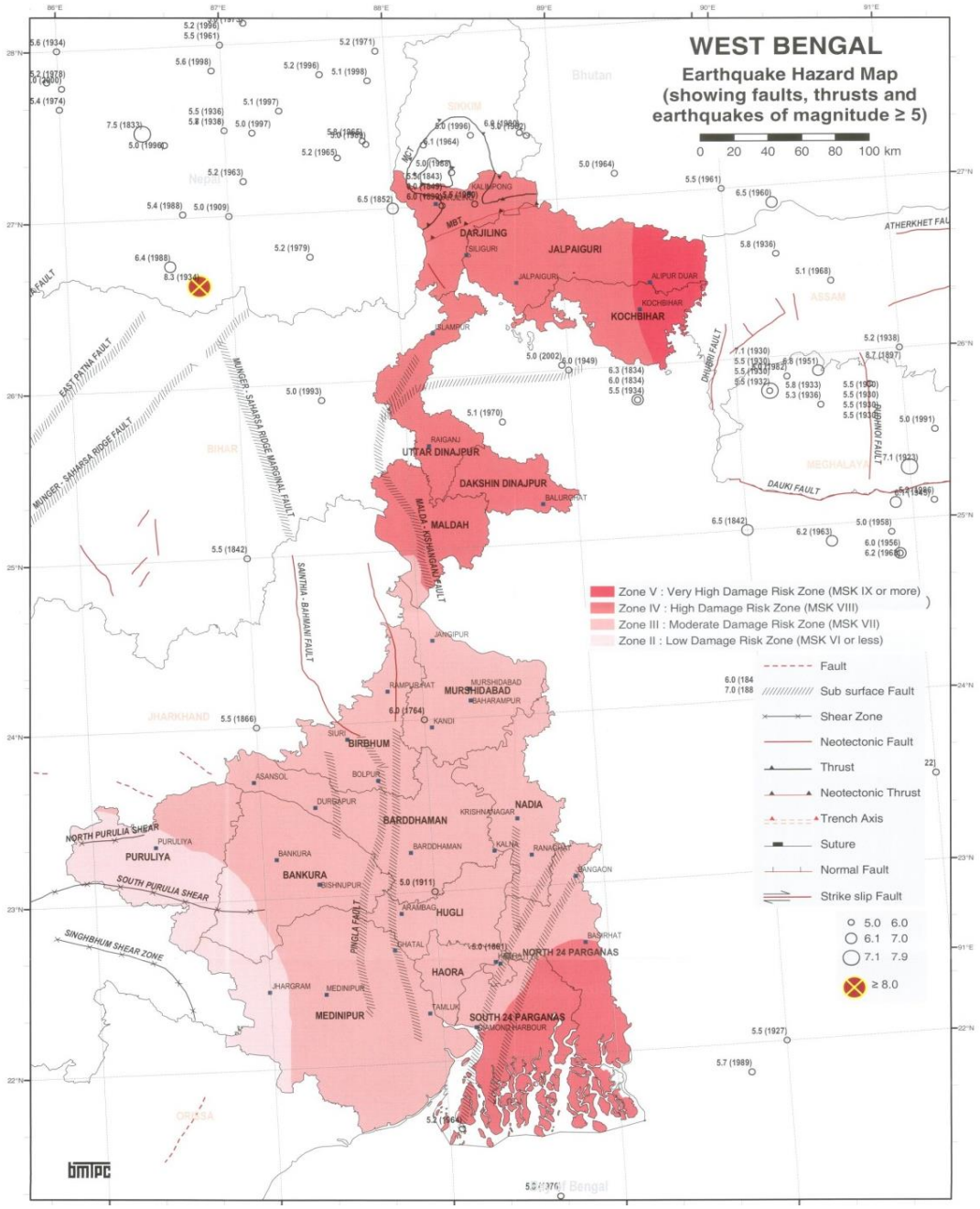


Source : NATMO

Figure 15: Rock and Mineral Map of South 24 Parganas District

Seismicity:

As defined by the Indian Standard (IS) 2002 seismic zoning classification system, the seismicity is measured on a scale from II to V where zone II is most stable and Zone V is considered to be least stable. According to West Bengal Disaster Management Department (WBDMD) western sections of the northern districts of Jalpaiguri and Kooch Bihar lie in Zone V. The remaining parts of these two districts, along with the districts of Darjeeling, Uttar Dinajpur, Dakshin Dinajpur, Maldah, 24 North Parganas and 24 South Parganas lie in Zone IV. The rest of the state along with the city of Kolkata lies in Zone III. The project stretch lies in Earthquake high damage risk zone-IV. The Eartquake zoning map of West Bengal state is shown in **Figure 16**.



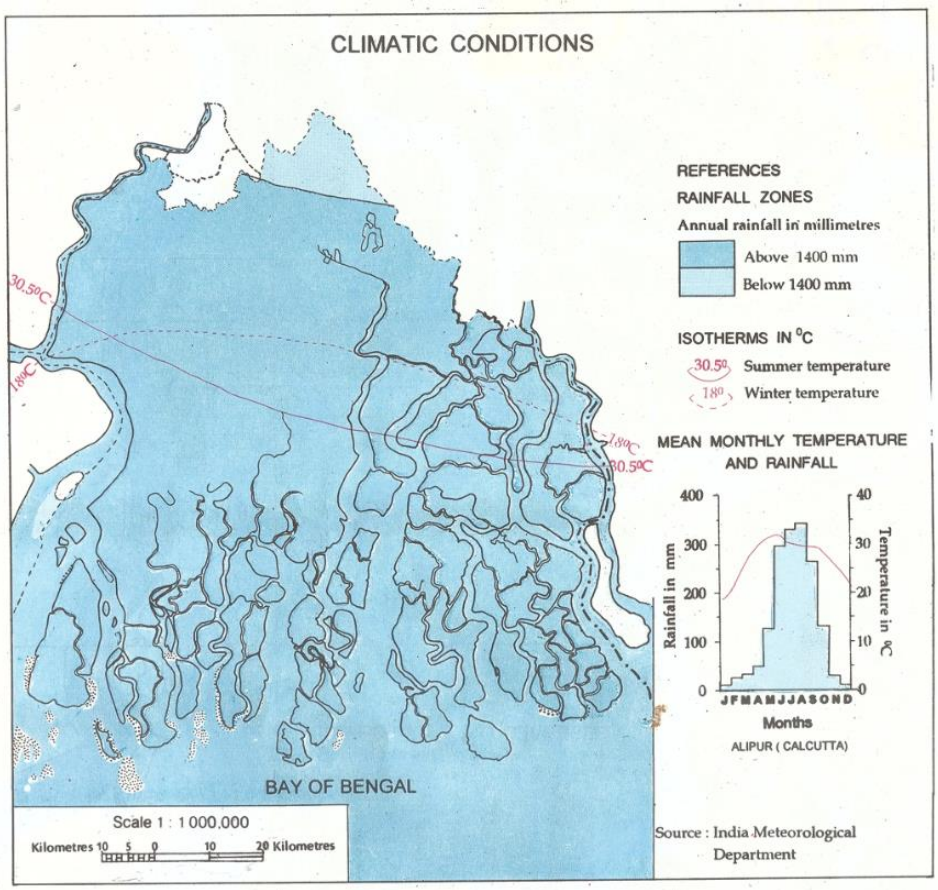
Source : West Bengal Disaster Management Department

Figure 16: Earthquake Zoning map of West Bengal

9.2.3 Climate

The normal climate of the district is hot and humid throughout the year with well distributed rainfall during the monsoon season. The maximum temperature as recorded is 37°C and the minimum is 9°C.

It may be noted that the skies are moderately clouded in May, heavily clouded in monsoon season and clear or lightly clouded during rest of the year. Winds are generally stronger in Sundarbans and its surroundings. Nor'westers from March to May and the Bay cyclones during the monsoon ravage the land every year. The climatic condition of the district is shown in **Figure 17**.



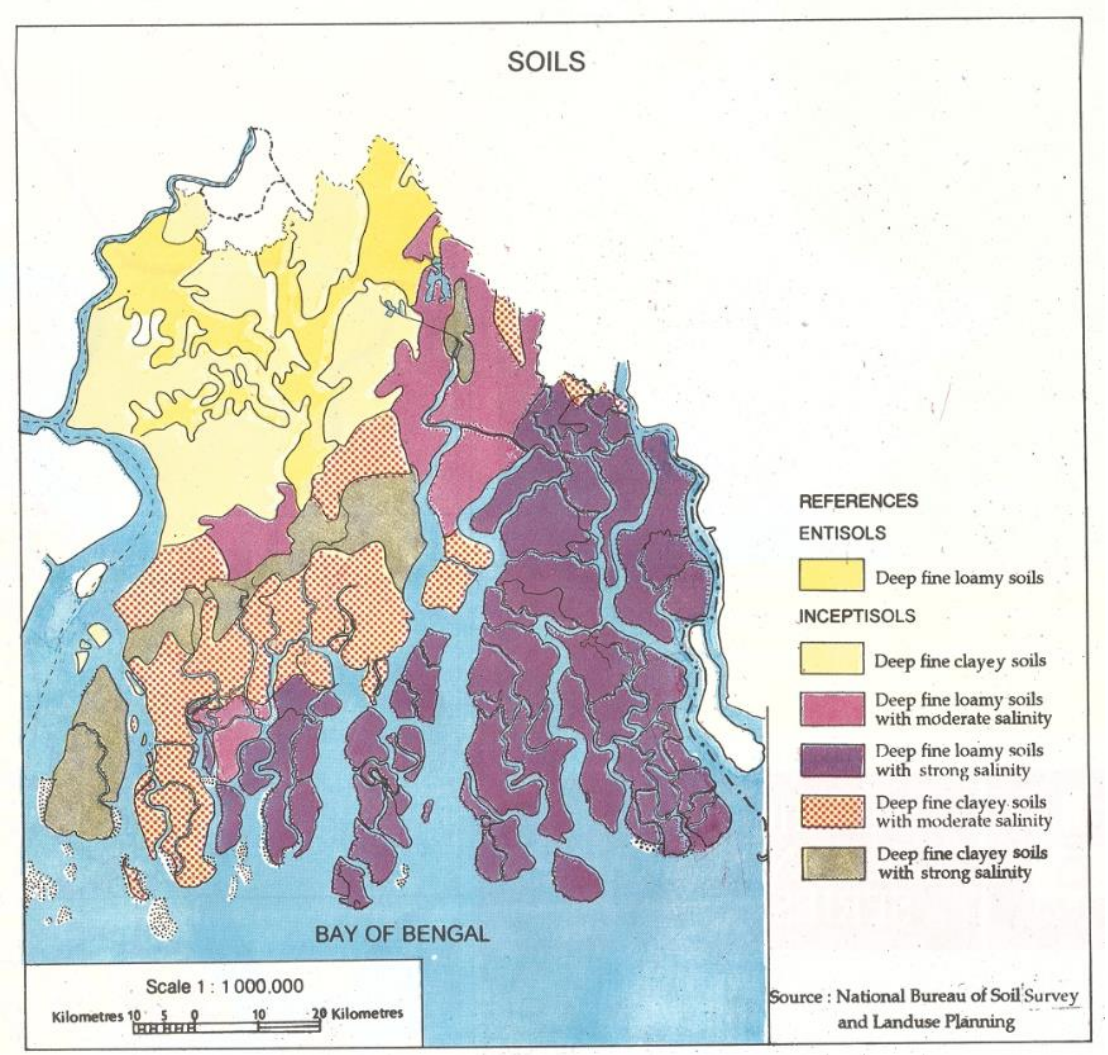
Source : NATMO

Figure 17: Climatic condition of South 24 Parganas District

9.2.4 Soil

The presence of numerous rivers, khals and bils with Bay of Bengal covering almost the whole of the south has divided the soil of the district into two broad categories viz. non-saline soils and coastal soils of tidal origin. The direct deposits of Ganga alluvium is salt free and rich in calcium or magnesium and thus rich in nutrients. The indirect deposits of Ganga alluvium is formed by the water going to sea, getting salty and re-entering the main land through tides.

Costal soils in the district of south 24 parganas are distributed over the police sation of Gosaba, basanti, Canning, Bhangar, Mograhat, Diamond Harbour, Falta, Mandir Bazar, Joymagar, Kultali, Mathurapur, Kulpi , Patharpratima, Namkhana and Sagar. Considering the trends in the soil salinity fluctuations , ground water table condition, natural vegetation, cropping practices, watershed areas draining into costal water and other features relevant to costal agro ecosystem. The soil map of the district is given in **Figure 18**.



Source : NATMO

Figure 18: Soil Map of South 24 Parganas District

9.2.5 Land Use Pattern

Both the banks of Haribhanga waterway are covered with Tiger Reserve forest. Being forest, no commodity/ cargo/ passenger traffic is located along the entire river stretch.

Land use pattern of the project influenced district is presented in

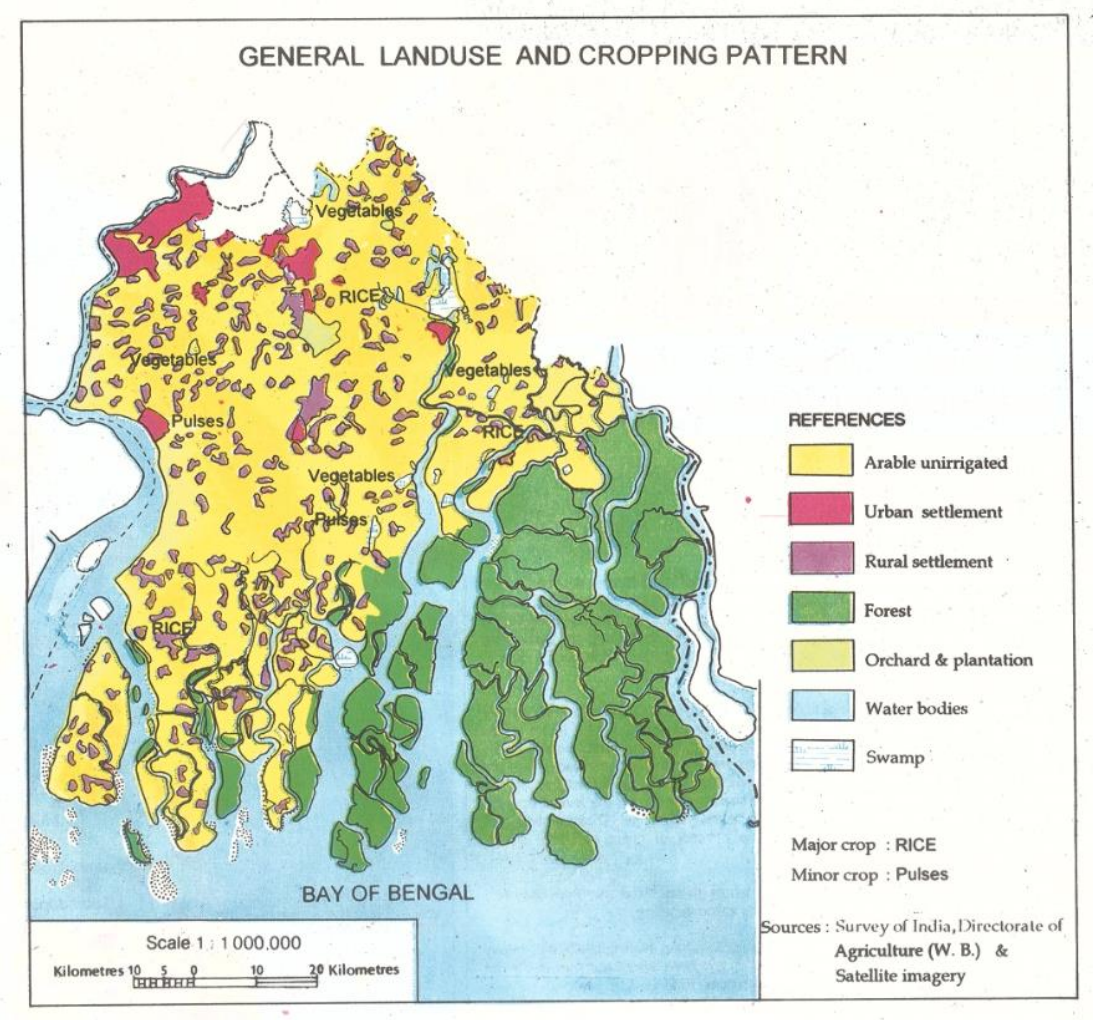
Table 10.

Table 10: Land Utilization Pattern of the South 24-Parganas district (Area in '000 ha.)

Year	Reporting Area	Forest Area (C)	Area under Non-agricultural use	Barren & unculturable land	Permanent pastures & other grazing land	Land under misc. tree groves not included in Net area sown	Culturable waste land	Fallow land other than current fallow	Current fallow	Net area sown
2006-07	948.71	426.36	136.15	0.40	0.01	2.09	0.74	0.09	10.08	372.79
2007-08	948.71	426.30	138.30	0.44	0.05	2.94	0.04	0.18	8.16	372.30
2008-09	948.71	426.30	140.06	0.44	0.04	2.86	0.50	0.20	4.63	373.66
2009-10	948.71	426.30	141.30	0.47	-	2.69	1.47	0.03	18.91	357.54
2010-11	948.71	426.30	143.32	0.07	0.02	2.56	1.34	0.01	16.69	358.40

Source: - District Statistical Hand Book, South 24 Parganas, 2010-11

The district is situated in the Proper Delta of Lower Ganga Plain. It is little higher above the flood level and the physical features are similar to deltaic land of the country. The northern inland tract is fairly well raised delta and the southern portion is a low lying Sundarbans towards the seaboard. The Sundarbans are a network of tidal channels, river creeks and islands. There are some swampy marshes covered with low forest and scrub wood. The low land gradually declines towards the coast. The land use pattern of the district is given in **Figure 19**.



Source: NATMO

Figure 19 : Land Use Map of South 24 Parganas District

9.2.6 Ambient Air Quality

During the reconnaissance survey, it was the found that the Air quality along the study area of Haribhanga River was free from dust. However, it was also confirmed from the local people that there is no problem caused due to Air pollution. Also there is no major industrial development along the waterway stretch. The Ambient Air quality near Kakdwip Area is given in **Table 11**.

Table 11: Ambient Air Quality near Kakdwip Area

Location	Parameters				
	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	SO_2 µg/m³	NO_2 µg/m³	CO mg/m³
Kakdwip Area, near KoPT Jetty	73.88	38.13	7.02	25.11	0.29

Source : EIA STUDY OF BSL'S MARINE INDUSTRIAL CLUSTER AT KULPI, August 2017

9.2.7 Ambient Noise Level

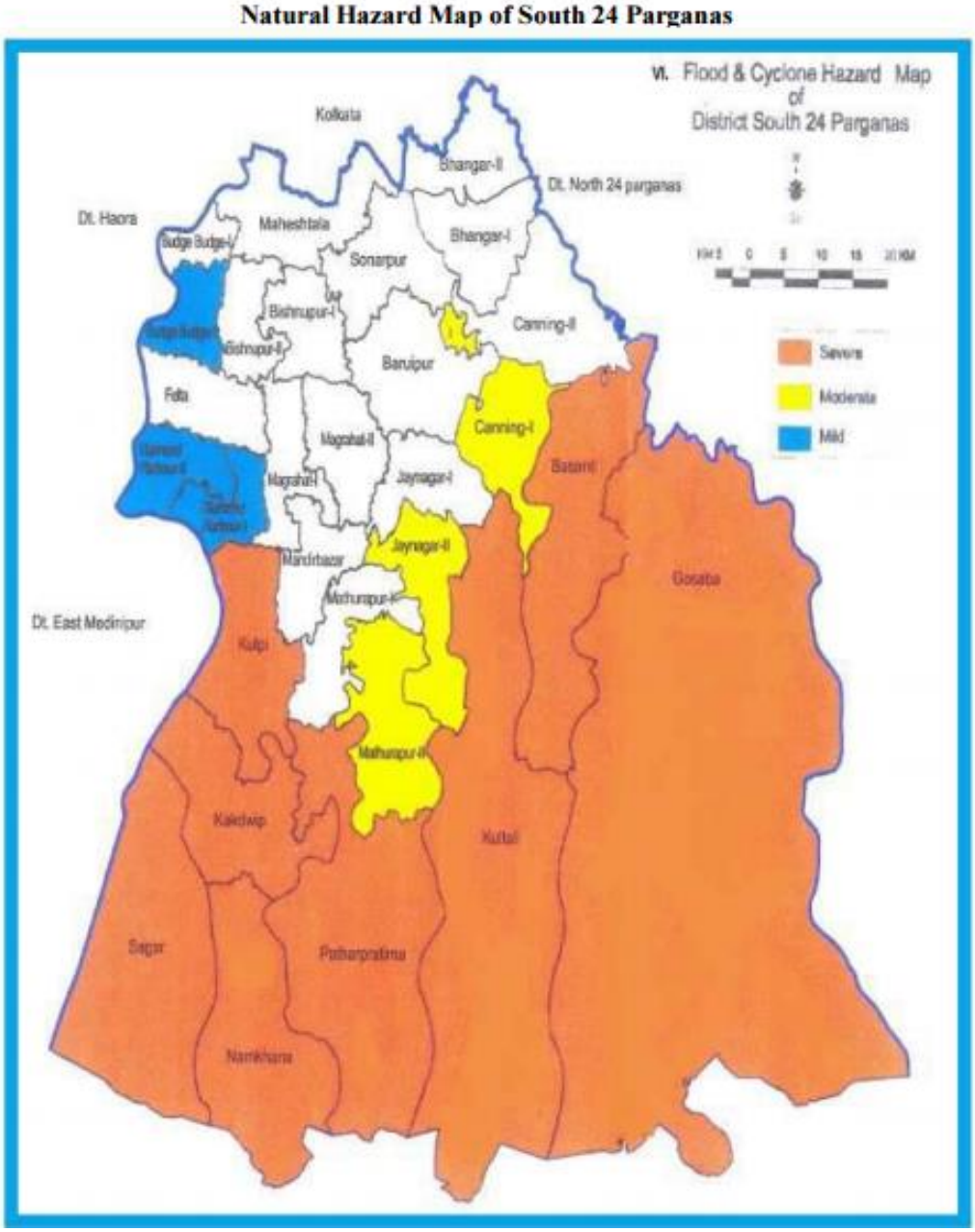
During the reconnaissance survey, it was the found Noise is not big issues in the surrounding areas of Haribhanga River. There are not any noises generating sources in the nearby areas.

9.2.8 Susceptibility to Natural Hazards

West Bengal is vulnerable to multiple disasters. Due to its sub-tropical littoral location, the state is prone to tropical cyclones, storm surges and tsunamis. In past, this district was hit by natural hazards in many occasions. The hazards include Cyclone, Storm Surge, Flood, Earthquake etc. of medium to large intensities. Susceptibility to various kinds of Natural Hazards are elaborated in the following sections-

- **Susceptibility to floods**

River and coastal flooding are the most frequently occurring natural disaster and are increasing in occurrence more rapidly than any other disaster. Urbanization and deforestation reduce the capability of the earth to hold excess water. As asphalt- and concrete-covered surfaces expand and open spaces disappear at the edges of metropolitan areas, it takes less rain to flood communities as water running over the pavement collects quickly and easily disrupts storm drain systems. Those areas which are most at risk for floods include low-lying areas, coastal regions and communities on rivers downstream from dams. Flood waters are extremely dangerous; a mere six inches of swiftly moving water can knock people off their feet.



Source: District Disaster Management Plan, South 24 Parganas 2017

Figure 20: Natural Hazard Map of South 24 Parganas

- **Susceptibility to Earth Quake**

Earthquakes are one of the most powerful natural forces on earth and regularly affect people around the world. Earthquakes can have a range of magnitudes with the strongest having devastating

consequences for the areas where they are centered, nearby areas, and even some far away in the case of earthquake-generated tsunamis.

Most earthquakes are quite small but are not readily felt. Larger and more violent earthquakes are those that occur in a release of energy as the plates slide past or collide into one another.

Large earthquakes can focus on the boundaries where two plates meet, but they are not limited to these areas. As the plates move, fractures in the earth's crust develop and earthquakes are often located on them. These fractures are referred to as faults, and all generate earthquakes when they move.

The impacts of earthquakes vary based on their energy and intensity. The strongest earthquakes that occur can result in ground rupture, causing damage to bridges, dams, roads, railroad tracks, and the foundations of buildings. They can also cause landslides and avalanches as a result of the shaking. Intense shaking can also cause liquification of ground built on landfill when water mains break. The shaking of an earthquake is increased in areas of landfill.

South 24 Parganas fall under Zone IV of the Seismic Zone of India. On 15th April 1964, largest instrumented Earthquake occurred in Sagar Island with Magnitude 5.2.

- **Susceptibility to Wind and Cyclones**

Cyclones are natural events, which cannot be prevented. Cyclones form in certain favourable atmospheric and oceanic conditions. There are marked seasonal variations in their places of origin, tracks and attainment of intensities. These behaviours help in predicting their movements. Pre and Post monsoon storms are more violent than the storms of the monsoon season. The coastal stretch of West Bengal, especially in South 24 Parganas is necessarily highly vulnerable to cyclone. The phenomenal storm surge in coastal West Bengal is due to its peculiar bathymetry and nature of coastal belt. As a result when a very severe cyclonic storm or a hurricane approaches the coast, the enormous storm surge generated by the wind pressure submerges the coastal belt at the time of the storm crossing the belt. The frequency of storms crossing this belt is also high. Another peculiar characteristic of this coast is that it is crisscrossed by innumerable rivers and rivulets, with the elevation of the islands about 4 to 5 meters. The seadykes and embankment are not strong enough to resist strong wind-driven waves and naturally cave in during depression / cyclonic storm situation.

A heavy cyclone accompanied by a sea wave, is the worst kind of disaster which may occur in this delta. Disasters of this kind have caused appalling mortality in the past and will possibly do so again.

Practically, nothing can be done to avoid them but fortunately they are not frequent. They are most likely to occur at the beginning or at the end of rains, i.e., either before the winter paddy is planted or at a time when it is almost ripe. Under such circumstances the damage to crops may be small in comparison with the mortality among men and cattle which may be enormous. The maritime districts of West Bengal are liable to storm waves but South 24 Parganas has suffered most severely.

The district experiences two Cyclone seasons – pre-monsoon and post-monsoon cyclone during April-May and Nov-Dec, respectively. Pre-monsoon cyclone, which causes wide spread hailstorm and it is traditionally called as Kalbaishaki. The district is located in very high damage risk zone (V=50m/s) with respect to Cyclone. The historical Records of devastating cyclone are given in **Table 12**.

Table 12: **Historical records of most devastating cyclones in South 24-Pargana district**

S. No.	Date	Cyclone	Description
1.	**7-12 October, 1737**	Super Cyclone*	Crossed West Bengal coast over Sunderbans **Surge height:** 12 m **Loss of life:** 300,000
2.	**2-5 October, 1864**	Very Severe Cyclonic Storm	Cross the coast near Contai, West Bengal Surge Height: The wave in many places rose to 9 m The Maximum height of the waves reached 12 m. At Sagar Island it was 5 m above land level. At Diamond Harbour, the wave was 3 m **Loss and Damage:** People Killed=**50,000** (mostly due to drowning), and **30,000** (due to diseases as a result of inundation)
3.	**23-26 May, 2009**	Severe Cyclonic Storm	Crossed close to the east of Sagar Island **Surge Height:** 3-5 m **Loss and Damage:** People Killed=137, Cattle heads Killed= 50,000

9.2.9 Estuary and Coastal Zone

The District is interspersed with innumerable drainage channelsincluding some important rivers, creeks, cross - channels and several man-made drainage-cum-irrigation canals. More particularly in the south and south-eastern parts of the District, this drainage network has attained a complex pattern due to the presence of numerous crosschannels which ultimately join the major tidal creeks. They have given rise to a large number of islands of various shapes and sizes. These deltaic and tidal streams have their off-take points further upstream either in the Ganga or in the Padma River. To the west of the District, the Bhagirathi - Hooghly is the most important stream of this system. The lower tidal portion of this stream is called as the Hooghly, while the upper non-tidal portion is known as the Bhagirathi.

Coastal ecosystem" includes estuaries and coastal waters and lands located at the lower end of drainage basins, where streams and river systems meet the sea and are mixed by tides. The coastal ecosystem includes saline, brackish (mixed saline and fresh) and fresh waters, as well as coastlines and the adjacent lands. All these water and landforms interact as integrated ecological units. Shore-lands, dunes, sandbars, offshore islands, headlands, and freshwater wetlands within estuarine drainages are included in the definition since these interrelated features are crucial to coastal fish and wildlife and their habitats. Mangroves are located all along estuarine areas, deltas, tidal creeks, mud flats, salt marshes and extend over 4871 sq. km (about 7% of world's mangrove areas). Impact of global warming- induced sea level rise due to thermal expansion is more pronounced in the Bay of Bengal due to the shallowness of the waters. The entire coastal ecosystem in general and the eastern coast in particular are highly vulnerable due to flat and low terrain, high population density, over exploitation of natural resources, high rate of environmental degradation on account of pollution and non-sustainable development. On many occasions, the livelihood requirements of people are detrimental to maintaining the delicate balance of the fragile coastal ecosystem. Degradation of the eco-system not only affects the environment adversely, but also makes the people living in the coastal areas more vulnerable.

In general, these rivers show a north-south trend, but some of them maintain south-easterly course as well. Besides variations in local slopes, existence of pockets of depressions or raised grounds also influences the alignments of local drainage system. These channels ultimately find their ways to the Bay of Bengal through any one of the principal estuaries, starting from the Hooghly estuary forming the western-most boundary of the District to the Raimangal in the east. Other principal estuaries are the Baratala (a distributary of the Hooghly), the Saptamukhi, the Thakuran, the Matla and the Gosaba. Amongst these, the Hooghly in the extreme west and the Ichamati - Kalindi- Raimangal

system receive some fresh water supply from their upstream zones. The supply of fresh water increases during monsoon rain. All other estuaries are beheaded and have become entirely tidal. These estuaries were the lower courses of the Ganga off-shoots in different phases of recent past. Though the upper courses of these rivers are totally disconnected from fresh water supply due to heavy siltation in their feeder channels, their lower courses still remain active owing to regular tidal flow. All these estuaries are inter-connected by intricate network of cross-channels which are generally developed at right angles to the main estuaries.

The estuaries in the western part of the District with the exception of the Hooghly are smaller in length compared to those in the eastern part. The Muriganga or Baratala estuary along Namkhana - Kakdwip area is only 15 Kms. long while the Raimangal stretches via the Kalindi and the Ichamati for about 60 Kms. near Hasnabad - Hingalganj area. The inland extensions of active cross channels are rather constricted in the western part than in the east.

The drainage regime can be divided distinctly into two parts taking the Matla River as the axis. The Matla is a very wide estuary comparable with the Hooghly near the sea face. It becomes very turbulent during the monsoon months. But the upper course of the Matla from Canning to Basanti is seriously affected by excessive silt deposition. The Bidyadhari, the Karati and the Atrabeki have drained into the Matla at Canning. This section has been completely silted up. The Atrabeki, which was once a connecting channel between Matla and the north-western channel of Raimangal has now ceased to be active. The upper courses of Harinbhanga – Jhilla - Raimangal have become hydrologically more efficient due to increased tidal activities. Even in the Haroagang, flow tides are progressing via Jhilla-Raimangal creek. The tract lying in between Saptamukhi and Harinbhanga, to the south of the embanked area is truely in active phase where continuous deposition is in progress.

The section of waterway starts near Kakdwip at Lat 22°39'6.71"N, Long 88°55'33.35"E and ends at Kalanchi at Lat 22°53'53.79"N, Long 88°53'53.94"E. The start point is nearest to Dampier-Hodges Line and located at a distance of 4.5 km north from the Dampier-Hodges Line. It is an imaginary line, passing through 24 Parganas South and North districts, which roughly indicates the northern-most limits of estuarine zone affected by tidal fluctuations. However, tidal influence is observed in the stretch of waterway.

9.2.10 Archaeological and Heritage Locations

Jatar deul temple is an archaeological site located in the stony alluvial and bushy landscape of the western Sundarbans.

Sunderbans Biosphere Reserve, a World Heritage Site and International Biosphere Reserve declared by UNESCO is located in the district.

9.2.11 Flora

It is easily understood that from the above discussion that this area is rich in flora. Practically the whole district is covered with mature and active parts of Gangetic Delta. The southern plains surround the mature delta, the Sundarbans surrounds the active parts of Gangetic Delta. In the mature delta, cultivated crops have replaced the natural cover. Various kinds of vegetables, cereals, pulses, fibre plants, oil seed crops and other food accessories are found in the region. Rice is the most important cereal of the district. Exotic varieties of fruit trees, bamboo groves, flowers and scrubs are also found.

In a comprehensive study performed by David Prain in 1903 it is seen that Sundarbans have a total of 245 genera and 334 plant species. The Sundarbans flora is characterised by the abundance of Sundari (*Heritiera fomes*), gewa (*Excoecaria agallocha*), goran (*Ceriops decandra*) and keora (*Sonneratia apetala*) all of which occur prominently throughout the area. There is abundance of dhundul or passur (*Xylocarpus granatum*) and kankra (*Bruguiera gymnorrhiza*) though distribution is discontinuous. Among palms *Poresia coaractata*, *Myriostachya wightiana* and golpata (*Nypa fruticans*), and among grasses spear grass (*Imperata cylindrica*) and khagra (*Phragmites karka*) are well distributed.

9.2.12 Fauna

The Sundarbans provides a unique ecosystem and a rich wildlife habitat. According to the latest Tiger Census, the Sundarbans have about 270 tigers (*Panthera tigris tigris*). But the encouraging fact is that the number of this endangered species is increasing. The Royal Bengal Tiger of Sundarban is one of the most majestic animals of the world.

Apart from tiger, there is much more wildlife. Most importantly, mangroves are a transition from the marine to freshwater and terrestrial systems and provide critical habitat for numerous species of small fish, crabs, shrimps and other crustaceans that adapt to feed and shelter, and reproduce among the tangled mass of roots, known as *pneumatophores*, which grow upward from the anaerobic mud to get the supply of oxygen. Animals like leopard (*Panthera pardus fusca*) and several other smaller predators such as the jungle cats (*Felis chaus*), fishing cats (*Prionailurus viverrinus*) and leopard cats (*Prionailurus bengalensis*) are also found in this jungle. Also chital deer (*axis axis*), Indian muntjacs (*Muntiacus muntjak*), wild boars (*Sus scrofa*), rhesus macaque (*Macaca mulatta*) and about 30,000 spotted deer are found in the area. Sundarbans supports diverse biological resources which include at

least 150 species of commercially important fish, 270 species of birds, 42 species of mammals, 35 reptiles and 8 amphibian species. This region is an important wintering area for migrant water birds also and is an area suitable for watching and studying avifauna. Some of the reptiles are predators too, including two species of crocodiles, the saltwater crocodile (*Crocodylus porosus*) and mugger crocodile (*Crocodylus palustris*), as well as the gharial (*Gavialis gangeticus*) and the water monitor lizards (*Varanus salvator*), all of which hunt on both land and water. Sharks and the Gangetic dolphins (*Platanista gangetica*) roam the waterways.

Avifauna: Sundarbans is the home of 170 species of bird life including the endemic brown-winged kingfishers (*Pelargopsis amauroptera*) and the globally threatened lesser adjutants (*Leptoptilos javanicus*) and masked finfoots (*Heliopais personata*) and birds of prey such as the ospreys (*Pandion haliaetus*), white-bellied sea eagles (*Haliaeetus leucogaster*) and grey-headed fish eagles (*Ichthyophaga ichthyaetus*). Other noteworthy birds found in this area are open billed storks (*Anastomus oscitans*), black-headed ibis (*Threskiornis melanocephalus*), water hens (*Amaurornis sp*), coots (*Fulica sp*), pheasant-tailed jacanas (*Hydrophasianus sp*), pariah kites (*Milvus migrans*), brahminy kites (*Haliastur indus*), marsh harriers (*Circus aeruginosus*), swamp partridges (*Francolinus gularis*), red jungle fowls, spotted doves(*Spilopelia chinensis*), common mynahs (*Acridotheres tristis*), jungle babblers (*Turdoides sp*), herring gulls (*Larus sp*), caspian terns (*Hydroprogne caspia*), gray herons (*Ardea cinerea*), brahminy ducks (*Tadorna ferruginea*), spot-billed pelicans (*Pelecanus philippensis*), great egrets (*Ardea alba*), night herons (*Nycticorax nycticorax*), common snipes (*Gallinago gallinago*), wood sandpipers (*Tringa glareola*), green pigeons (*Treron phoenicoptera*), rose-ringed parakeets (*Psittacula krameri*), paradise flycatchers (*Terpsiphone paradisi*), cormorants (*Phalacrocorax sp*), white-bellied sea eagles (*Haliaeetus leucogaster*), common kingfishers (*Alcedo atthis*), peregrine falcons (*Falco peregrinus*),various woodpeckers, whimbrels (*Numenius phaeopus*), black-tailed godwits (*Limosa limosa*), little stints (*Calidris minuta*), curlews (*Numenius sp*), golden plovers (*Pluvialis fulva*), pintails (*Anas acuta*), white-eyed pochards (*Aythya nyroca*), lesser whistling ducks (*Dendrocygna javanica*)etc.

Aqua fauna: Regarding the aqua fauna of the region silver carp (*Hypophthalmichthys molitrix*), barbs, river eels, starfish, king crab, fiddler crab (*Uca sp*), hermit crab, prawn, shrimps, Gangetic dolphins (*Platanista gangetica*), skipping frogs (*Euphlyctis sp*), common toads and tree frogs are found in abundance. One particularly interesting fish is the mudskipper.

Reptiles: An excellent number of reptiles are also found in Sundarbans. Some of the common ones are olive ridley turtles (*Lepidochelys olivacea*), sea snakes, dog faced water snakes (*Cerberus rynchops*), green turtles (*Chelonia mydas*), estuarine crocodiles (*Crocodylus porosus*), chameleons,

king cobras (*Naja naja*), salvator lizards (*Varanus salvator*), hard shelled batgun terrapins (*Melanochelys trijuga*), Russels vipers (*Daboia russelii*), monitor lizards (*Varanus bengalensis*), hawks bill turtles (*Eretmochelys imbricata*), pythons (*Python molurus*), common kraits (*Bungarus caeruleus*), green vine snake (*Ahaetulla nasuta*), checkered keelbacks (*Xenochrophis sp*) and rat snakes. The river terrapin (*Batagur baska*), Indian flap-shelled turtles (*Lissemys punctata*), peacock soft-shelled turtles (*Trionyx hurum*), yellow monitors (*Varanus flavescens*), water monitors (*Varanus salvator*) and Indian pythons (*Python molurus*) are some of the resident species.

The details lists of flora and fauna are given in **Annexure III.**

9.2.13 National Parks, Forests, Wildlife Sanctuaries and Reserves

According to India State Forest Report, 2015 the total forest cover of South 24 parganas district is 2782 Km^2 which is about 27.93 % of the district's total geographical area (9960 Km^2).

Out of 2782 Km^2, 977 Km^2 falls under very dense forest area category; whereas Moderately Dense Forest and Open Forest area covers 753 Km^2 and 1052 Km^2 areas respectively. The comparative statement showing forest cover of South 24 Parganas District and West Bengal state is presented in below **Table 13**. It is observed from the table that district's Forest Cover percentage in respect to total geographical area is higher than state's overall coverage.

Table 13: Forest Cover of South 24 Parganas District and West Bengal State

District / State	Forest Cover in Sq. Km					
	Geographical Area (GA)	Very Dense Forest	Moderately Dense Forest	Open Forest	Total	Percentage of GA
South 24 Parganas	9960	977	753	1052	2782	27.93
West Bengal	**88752**	**2948**	**4172**	**9708**	**16828**	**18.96**

Source : India State Forest Report, 2015

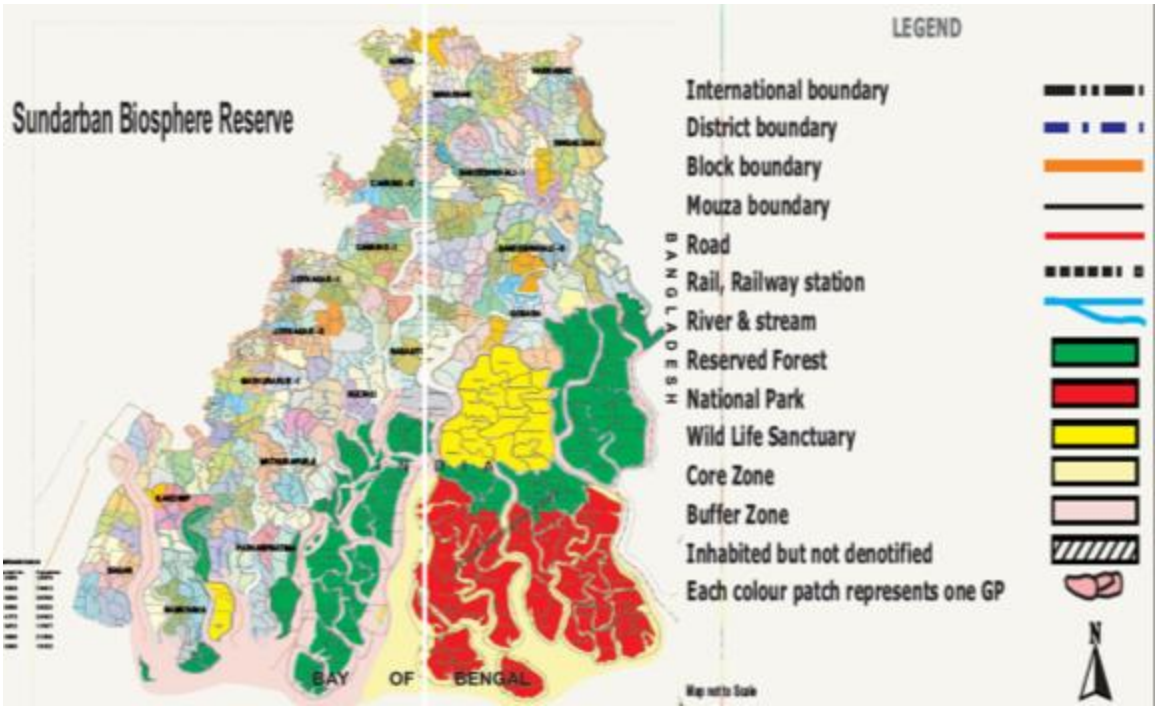
There are forest patches available along the proposed waterway stretch.

National Parks, Wildlife sanctuaries, Biosphere Reserve play a vital role in protecting the wildlife of a particular area and providing them their natural habitat.

The Sunderban Tiger Reserve is located in South 24 Paraganas, West Bengal and has a total geographical area of 2585 km2 with 1437.4 km2 consisting of populated areas and forest covering 1474 km2. The Sundarbans National Park is a National Park, Tiger Reserve, and a Biosphere Reserve in West Bengal, India. It is part of the Sundarbans on the Ganges Delta, and adjacent to the Sundarban Reserve Forest in Bangladesh. The delta is densely covered by mangrove forests, and is one of the largest reserves for the Bengal tiger. It is also home to a variety of bird, reptile and invertebrate species, including the salt-water crocodile. The present Sundarban National Park was declared as the core area of Sundarban Tiger Reserve in 1973 and a wildlife sanctuary in 1977. On 4th May 1984 it was declared a National Park. It is a UNESCO world heritage site inscripted in 1987. It is considered as a World Network of Biosphere Reserve (Man and Biosphere Reserve) in 2001.

Seven main rivers and innumerable watercourses form a network of channels at this estuarine delta. All the rivers have a southward course towards the sea. The eco-geography of this area is totally dependent on the tidal effect of two flow tides and two ebb tides occurring within 24 hours with a tidal range of 3–5 m and up to 8 m in normal spring tide, inundating the whole of Sunderban in varying depths. The tidal action deposits silts back on the channels and raising the bed, it forms new islands and creeks contributing to uncertain geomorphology. There is a great natural depression called "Swatch of No Ground" in the Bay of Bengal between 21°00' to 21°22' latitude where, the depth of water changes suddenly from 20 m to 500 m. This mysterious depression pushes back the silts towards south and/or further east to form new islands.

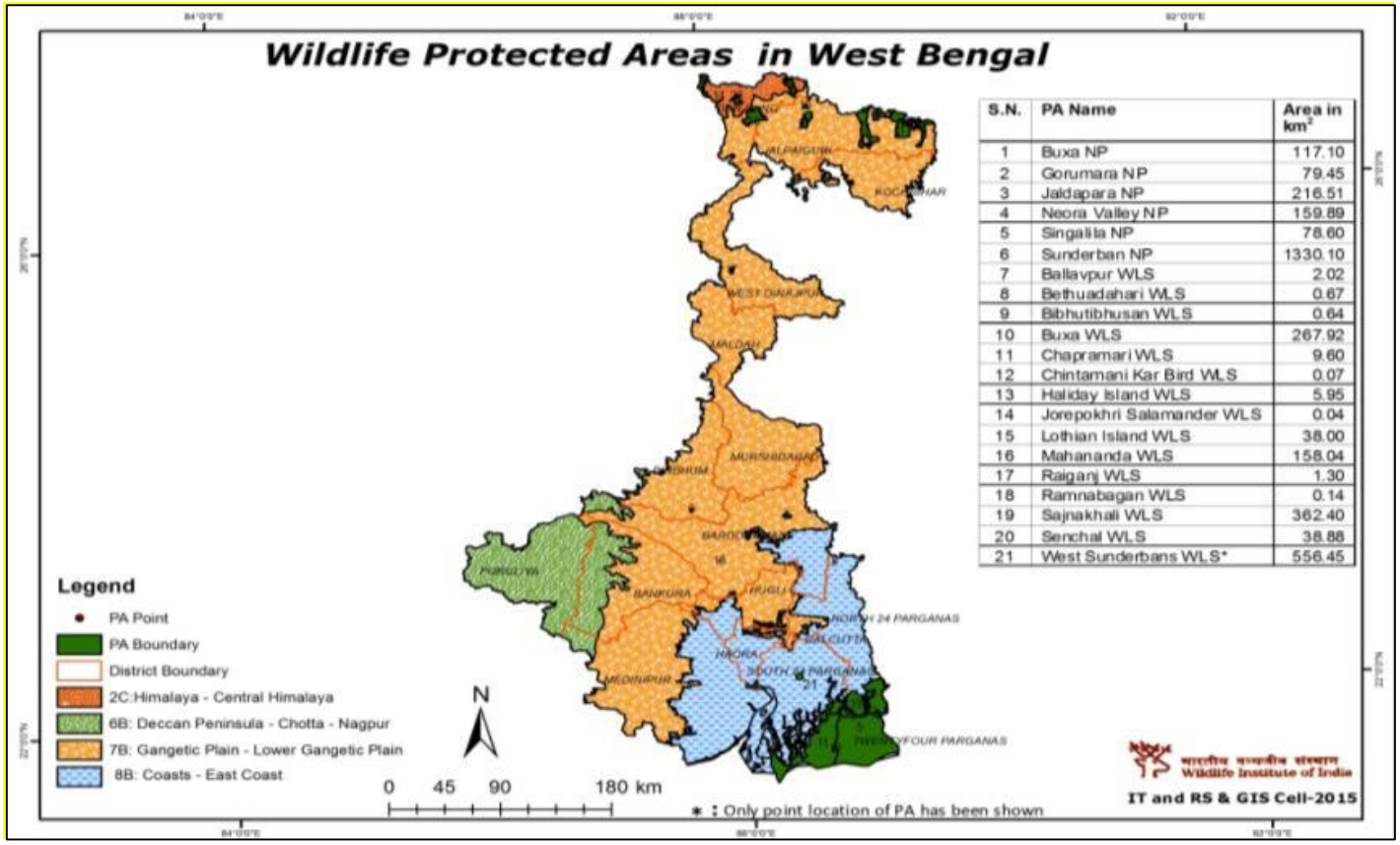
The Sunderban Biosphere Reserve is located at a distance of 30 Km from the start point of Waterway section. The Map of Sunderban Biosphere Reserve is furnished in **Figure 21**.



Source : WWF-India

Figure 21: Map of Sundarban Biosphere Reserve

Besides Sundarban, the other notified Protected Area (under Willdlife Act, 1972) in the district is also home to four wildlife sanctuaries. These are Haliday Island, Lothian Island, Narendrapur, and Sajnekhali. The details of various protected areas in West Bengal covered under purview of Wildlife Act, 1972 is given in **Figure 22**.



Source : Wildlife Institute of India

Figure 22: Wildlife Protected Area of West Bengal

9.2.14 Socio-Economic Profile

Social Profile

The distribution of population in rural and urban area in the district as per 2011 census shows that majority of the population i.e. 74.42% lives in rural areas of the district. The total population of the district is 81,61,961 (Male- 41,73,778; Female – 39,88,183). The literary rate and sex ratio being 77.51% and 956 respectively, the percentage of SC and ST was 30.19 and 1.19 respectively in the district. The district comprises of 5 nos. of sub-divisions, 7 nos. of municipalities along with 111 Census Towns and 2,042 villages. The demographic profile of the project district is presented in **Table 14**.

Table 14: **Demographic Profile of South 24 Parganas District**

Total Population	Male Population	Female Population	Literary Rate (%)	Sex Ratio	SC (%)	ST (%)
81,61,961	41,73,778	39,88,183	77.51	956	30.19	1.19

Source : Census of India, 2011

There are no settlements located along the section of Haribhanga River.

Economic Profile

Agriculture: South 24 Parganas is mainly an agricultural district. The main source of livelihood of the people is cultivation, but most of the agricultural lands in the district are mono-cropped owing to poor irrigation facilities and high salinity in water. Besides, the district being coastal, the agriculture of the district periodically suffers from setbacks like Storm, Cyclone, and Depression etc. The crops are also often subjected to attacks by various diseases, insects and pests owing to relatively high humidity (85.0 per cent). Rice is the most important food crop of the district. All the three well-known types of rice, Aus, Aman and Boro are cultivated in the district with Aman occupying the first place and outstripping the other two in both area of cultivation and production of grain.

Rice is the most important food crop in South 24 Parganas. Apart from rice, potato, pulses, gram, chilli etc. are also important food crops of the district. Jute is the most important cash crop. The topography of the Ganga riverine lands is plain with a mild slope towards the south and as such only rabi crops like potato, wheat and vegetables are irrigated from tanks and *bils*. The topography of the

Ganga low lands is basin shaped and it gets submerged partially by accumulated rain water. Crops are usually irrigated from *bils* in Ganga low lands. The clayey soil of the Ganga low lands is very good for Aman paddy. With the first rain, Jute is sown. In July and August Jute is harvested and is allowed to lie on the plots to shed their stems for rotting. The topography of the saline soils is plain and its characteristic is the constant interaction between Ganga alluvium and saline soils. During rainy season the area of saline soils goes under Aman paddy. Except in the bheris and fisheries the entire area presents a landscape of Aman paddy. The nature of saline alkaline soil being silty it contains lower organic matter and nitrogen content and is not suitable for growing of crop as the salt concentration increases in such type of soils. Non-saline alkaline soil undergoes such a natural process that it becomes salt and calcium carbonate free and becomes favourable for growing of jute and rabi pulses. Degraded saline soil is highly unfit for growing of paddy and cultivation is often considered uneconomical on this soil and thus abandoned.

Irrigation: Although excessive rainfall in the district South 24 Parganas is certainly a boon for cultivation of the Aman paddy, it is harmful for other crops, because, with the exception of the high land along the banks of the rivers, the country is low and swampy and tends to become water-logged whenever there is excessive rainfall. Irrigation from rivers, dams and canals too does not help much as the water in winter is saline.

Despite such constraints, the Irrigation Department in last two decades has constructed some sluice gates and dams. They resist inflow of the saline water to certain extent, though cyclones and high tides often damage them. Excavation of tanks and sinking of shallow tube wells in some areas and use of transported water of the Hooghly river through back-feeding process has enabled the district to gain some more cropped areas.

Incidentally, irrigation by private canals is the most important source of irrigation covering almost 85 per cent of the total irrigated area in the district.

Animal Husbandry: South 24 Parganas doesn't occupy any significant place in animal husbandry. There is very little pasturage and cattle usually graze in the fields after the crops have been reaped, having very little to eat in the open. The local cattle are usually of non-descript type, ill-fed in most cases. There is also a crisis of the land for raising fodder crops and the villages try to overcome the crisis by cultivating seasonal fodders.

Fishery: South 24 Parganas is extremely rich in fish fauna, courtesy Sundarbans by virtue of presence of numerous intertwined river channels, creeks and riverine estuaries of Sundarbans, fishery

has always been an important economic activity of the district of South 24 Parganas. Fresh water fishes as well as saline water fishes – both are available due to presence of rivers and sea. They are plentiful and found at all times of the year. While this is so, the supplies in the market are regrettably poor, still today there is no adequate arrangement for the preservation of fish. Thus the fishermen are compelled to sell their fishes in open market and naturally they do not receive adequate amount as they have to sell all the fishes afresh nor those will be wasted. Apart from rivers and seas, fishes are also available in ponds, lakes, *khals*, *bils* and *bheris*. Small fishermen use boats and to keep the fishes fresh and alive they keep their catches in bamboo cage in water tied to their boats. Big fishermen use motor boats and motor launches and use ice for preservation. The wholesale fish market is at Canning though there are a total eleven landing centres in South Twenty Four Parganas. They are Basanti, Kultali, Gosaba, Sandeshkhali, Namkhana, Kakdwip, Diamond Harbour, Kalinagar (P.S. Nadakhali), Raidighi and Port Canning.

Industry: Though the district shares common boundary with the State Capital of Kolkata, still the industrial sector is not much developed in South 24 Parganas district. The presence of dense jungle of Sundarbans, numerous islands and rivers, *khals* and *bils* had made a large part of the area non-accessible for development of industry. One serious reason may be lack of adequate electricity.

The industries found in the district are mainly of house hold industry type. The centres for manufacturing of cutlery and agricultural implements are located in some places. The pottery industry is located at Jaynagar, Baruipur and Budge Budge. The manufacture of *gur* (molasses) is mainly carried on in Jaynagar and also throughout the Diamond Harbour Sub-division. Areas nearer to Kolkata have few button making and manufacture of steel trunks units. Cotton handloom weaving, which is an old time industry, still manages to survive with the help of the co-operatives in Bhangar, Begampur, Deara, Kanyanagar etc.

The handicrafts of the district deserve special mention. The mats and asans (small sitting mats), earthen dolls and images, cane and bamboo products etc. are famous. Undivided South 24 Parganas were the home of jute industry. After the bifurcation of the district the jute industries that fall on this side are still running. But the market of jute is narrowed due to its high costing and launching of plastic bags as its substitute.

The industrialization of the district got a big blow during the last decade with the closer of big unit like Bata Shoe Industry. The only notable industry of the district is the Garden Reach Ship Builder & Engineers Ltd. which is a Government of India enterprise under the Ministry of Defence since 1960.

Solar energy is used in electrifying the areas of Sundarbans. The State Government has appointed West Bengal Renewable Energy Development Agency (WBREDA) for installing and utilizing solar power to illumine the area. They are acting as the nodal agency for its solar power project for the Sundarbans. West Bengal Electronics Industry Development Corporation Limited (WBEIDC) a Government of West Bengal enterprise has undertaken the challenging task of providing non-traditional electricity to the district. They have installed one SPV Power Plant in Gangasagar which is capable of generating 26 Kilowatts of power. Wind Farm at Bakkhali-Fraserganj produces 2 megawatts of electricity. Homes in various parts of Sundarbans receive this non- traditional electricity. Streets are lightened with solar lamps also. Besides Webel, some other private companies such as Agni Power, Tata, BP Solar, Geetanjali Solar, Exide etc. have also come forward and have installed their own Power Plants.

Trade and Commerce: Paddy, rice, jute, wheat, pulses, chillies, watermelon, coconut, varieties of vegetable etc. grows in the district due to the presence of abandon sweet water rivers. These are marketed at different points of the district. Presently paddy and rice marketing is done through Government run authorized agent i.e. the Food Corporation of India. Another Government run agency, the Jute Corporation of India controls raw jute trade. As for Government intervention, the farmers are ensured with minimum support price as fixed by the Government of India.

Among the vegetables, the most commonly grown and marketed vegetables are cabbage, cauliflower, tomato, radish, brinjal, patal, jhinga, ladies finger, sweet pumpkin, battle gourd, bitter gourd, papaya, spinach, carrot, beet and potato. The most important wholesale markets for vegetables in the district are Baruipur and Bhangar.Chilli and coconut are the most important cash crops of the districts. Chilli is marketed from Chhoto Mollakhali and Kakdwip while coconut is marketed from Amtala and Bhangar. Kakdwip, Diamond Harbour, Kolkata and its suburbs are assembling markets of Watermelon which is grown in Sundarbans in rotation with paddy and chillies. Pulses, sugar, gur (molasses), mustard seeds and oil, fruits, potato and onion are imported agricultural produce of the district.Both fresh water and salt water fishes are exported from the district in great qualities. The fish is also being sold locally.

Imported agricultural produce in the district are Pulses, Sugar, Gur, Mustard seeds and oil, Fruits, Potato and Onion. Export trade of the district mainly consists of jute and mesta, vegetables, chillis, fruits (especially guava, watermelon and coconut), fish and gur.

Transport: Due to abundance of waterways, the district got water transport from a very old time. Early trade and commerce of the district were performed by waterways only.

Road transport of the district is only a recent development. The total length of roads maintained by PWD is divided into four categories – National Highways, State Highways, District Roads and Village Roads.

9.3 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS AND THEIR MITIGATION MEASURES

As no activities have been proposed for the waterway development in the DPR, no Environmental & Social Impact is foreseen for the Waterway.

9.4 LEGAL AND REGULATORY FRAMEWORK

The increase of environmental concern also necessitated appropriate tools/actions to protect environment. During Stockholm Conference, first exclusive Environmental Protection Act was enacted in India in 1986. Prior to this umbrella act, Water (Pollution Prevention and Control) Act was enacted in India in 1974 & Air Pollution act, 1981. In accordance with EPA act (1986) Central and State Boards for Prevention and Control of Water Pollution were set up. Later these boards were renamed into Central Pollution Control Board and respective State Pollution Control Boards. Department of Environment was set up in 1980. Subsequently in 1985, it was upgraded to a full-fledged Ministry of Environment and Forests and Climate Change (MoEFCC) under Government of India to serve as the focal point in the administrative structure for the planning, promotion and coordination of environmental and forestry programmes. The name of MoEF has been revised in the year 2014 to Ministry of Environment, Forests and Climate Change (MOEFCC). This ministry has overall authority for the administration and implementation of government policies, laws and regulations related to the environment, including conservation, environmental assessment, sustainable development, forest conservation and pollution control. MOEFCC identifies the need to enact new laws and amend existing environmental legislation when required, in order to continue to conserve and protect the environment. At the state level, the MOEFCC authority is implemented by the Department of the Environment and the Department of Forests.

In 1976, the 42nd Constitutional Amendment created Article 48A and 51A, placing an obligation on every citizen of the country to attempt to conserve the environment. As a result, a number of laws related to environmental conservation were passed to strengthen existing legislation. Environment (Protection) Act, 1986 is the landmark legislation as it provides for the protection of environment and aims at plugging the loopholes in the other related acts and this Act is called as umbrella Act. Under this Umbrella Act all the environmental acts and rules have been formed.

The laws and regulation applicable under the progamme:

- Policy and Regulatory Framework of Government of India
- Environmental Policy of respective State Government
- Legislation applicable to construction activities

9.5 NEED FOR ENVIRONMENTAL CLEARANCE

The propsed project will not require Environmental Clearance as per EIA Notification 2006 and its further ammendments due to no activities are proposed.

9.6 MAJOR CLEARANCES / APPROVALS / PERMITS APPLICABLE TO THE PROJECT

No activities are proposed.

10.0 INSTITUTIONAL REQUIREMENTS

As no infrastructure development is proposed for Haribhanga Waterway, no need for separate institutional setup is foreseen for the project implementation.

11.0 PROJECT COSTING AND ECONOMIC & FINANCIAL ANALYSIS

No conservancy activity or infrastructure work is proposed for development of Haribhanga waterway. Hence, the costing and thereby financial and economic analysis is not worked out.

12.0 CONCLUSION

The viability of Island Water Transport project for introduction of navigation on any waterway can be judged by both technically and commercially. The technical viability of the project can be assessed based on availability of discharges to maintain navigable depth in a design channel suitable to ply design vessel and the availability of traffic (either existing or forecasted). The commercial viability of the project can be gauged based on its growth over the project period and return on investment made besides several others socio-economic benefits such as employment generation, poverty alleviation in rural areas and so on. The recommendation for implementation of the project is based on the trade-off between costs to be incurred and benefits derived.

On the basis of studies done in this DPR following conclusions are made:

a) By taking into advantage of tidal window, sufficient LAD is available in the complete 15.827 km. stretch of waterway, which suggests that waterway, is viable for throughout the year navigation.
b) River stretch lies in the restricted Tiger Reserve Forest area.
c) No passenger or cargo traffic is available along the stretch.

In view of the above observations, the waterway is declared as technically non-viable for further development and studies.

ANNEXURES

ANNEXURE 1: TOR OF THE AGREEMENT

ANNEXURE 2: ENVIRONMENTAL AND SOCIAL SCREENING TEMPLATE

Screening Question	Yes	No	Details / Remarks
1. Is the project located in whole or part in / near any of the following Environmentally Sensitive Area? If yes, please provide the name and distance from the project site.			
a) National Park		√	
b) Wildlife/ Bird Sanctuary	√		Lothian Island Wildlife Sanctuary. It is about 4.0 Km from the study stretch
c) Tiger or Elephant Reserve		√	
d) Biosphere Reserve	√		The entire river stretch is located within Sundarban Biosphere Reserve
e) Reserved / Protected Forest	√		Some Forest patches are available along the study stretch of the river
f) Wetland		√	
g) Important Bird Areas		√	
h) Mangroves Areas	√		Within the stretch mangrove species are present
i) Estuary with Mangroves	√		
j) Areas used by protected, important or sensitive species of fauna for breeding, nesting, foraging, resting, over wintering, migration	√		
k) World Heritage Sites	√		Sundarbans World Heritage site
l) Archeological monuments/ sites (under ASI's Central / State list)		√	
2. Is the project located in whole or part in /near any Critically Polluted Areas identified by CPCB?		√	
3. Is, there any defense installations near the project site?		√	
4. Whether there is any Government Order/ Policy relevant / relating to the site?		√	
5. Is the project involved clearance of existing land, vegetation and buildings?		√	No Activities are proposed
6. Is the project involved dredging?		√	
7. Is the project area susceptible to natural hazard (earthquakes, subsidence, erosion,	√		Prone to Flood, Cyclones and heavy winds

Screening Question	Yes	No	Details / Remarks
flooding, cyclone or extreme or adverse climatic conditions)			
8. Is the project located in whole or part within the Coastal Regulation Zone?	√		
9. Is the project involved any demolition of existing structure?		√	
10. Is the project activity requires acquisition of private land?		√	
11. Is the proposed project activity result in loss of direct livelihood / employment?		√	
12. Is the proposed project activity affect schedule tribe/ caste communities?		√	

S. N.	Result of Screening Exercise	(Yes / No)
1	Environment Impact Assessment is Required	No
2	CRZ Clearance is Required	No
3	Environmental Clearance is Required	No
4	Forest Clearance is required	No
5	Wildlife Clearance is required	No
6	NOC from SPCB is required	No
7	Social Impact Assessment is Required	No
8	Abbreviated RAP is required	No
9	Full RAP is required	No
10	Any other clearance is required	No

ANNEXURE 3: CHECKLIST FOR FLORA AND FAUNA OF THE DISTRICT

Floral Community of Sundarban

Checklist for Flora

Mangroves and associates			
Sl. no.	**Scientific name**	**Local name**	**Remarks**
1	*Nypa fruiticans*	Golpata	Mangrove
2	*Avicennia officinalis*	Jat baen	Mangrove
3	*Avicennia alba*	Kalo baen	Mangrove
4	*Avicennia marina*	Pyara baen	Mangrove
5	*Lumnitzera racemosa*	Kripa	Mangrove
6	*Exocoecaria agallocha*	Genwa	Mangrove
7	*Xylocarpus granatum*	Dhundul	Mangrove
8	*Xylocarpus mekongensis*	Passur	Mangrove
9	*Aegiceras corniculatum*	Khalsi	Mangrove
10	*Aegialitis rotundifolia*	Tora	Mangrove
11	*Rhizophora mucronata*	Garjan	Mangrove
12	*Rhizophora apiculata*	Garjan	Mangrove
13	*Bruguiera gymnorrhiza*	Kankra	Mangrove
14	*Bruguiera sexangula*	Kankra	Mangrove
15	*Bruguiera cylindrica*	Bakul kankra	Mangrove
16	*Bruguiera parviflora*	Bakul kankra	Mangrove
17	*Ceriops decandra*	Jhamti goran	Mangrove
18	*Ceriops tagal*	Math goran	Mangrove
19	*Kandelia candel*	Garia	Mangrove
20	*Scyphiphora hydrophyllacea*	Tagri bani	Mangrove
21	*Sonneratia apetala*	Keora	Mangrove
22	*Sonneratia griffithii*	Ora	Mangrove
23	*Sonneratia caseolaris*	Chak keora	Mangrove
24	*Sonneratia alba*		Mangrove
25	*Heritiera fomes*	Sundari	Mangrove associate
26	*Acanthus ilicifolius*	Hargoja	Mangrove associate
27	*Acanthus volubilis*	Lata hargoja	Mangrove associate
28	*Phoenix paludosa*	Hental	Mangrove associate
29	*Cynometra ramiflora*		Mangrove associate
30	*Caesalpinia bonduc*	Nata	Mangrove associate
31	*Caesalpinia crista*	Shingri lata	Mangrove associate
32	*Hibiscus tiliaceous*	Bhola	Mangrove associate
33	*Hibiscus tortuosus*	Bhola	Mangrove associate

Mangroves and associates			
Sl. no.	**Scientific name**	**Local name**	**Remarks**
34	*Thespesia populnea*	Paras	Mangrove associate
35	*Dalbergia spinosa*	Chulia kanta	Mangrove associate
36	*Derris scandens*	Noa lata	Mangrove associate
37	*Derris trifoliata*	Pan lata	Mangrove associate
38	*Derris indica*	Karanja	Mangrove associate
39	*Atalantia correa*	Ban Lebu	Mangrove associate
40	*Brownlowia tersa*	Lata Sundari	Mangrove associate
41	*Crinum defixum*	Sukha Darsan	Halophytes
42	*Cryptocorne ciliata*	Kerali	Halophytes
43	*Sesuvium portulacastrum*	Gada Bani	Halophytes
44	*Sarcolobus globosus*	Caw Phal	Halophytes
45	*Sarcolobus carinatus*	Baole Lata	Halophytes
46	*Pentatropis capensis*	Dudhi Lata	Halophytes
47	*Heliotropium curassavicum*	Nona Hatisnur	Halophytes
48	*Ipomoea pes-caprae*	Chhagal Knuri	Halophytes
49	*Hydrophylax maritima*		Halophytes
50	*Clerodendrum inerme*	Ban Jhampi	Halophytes
51	*Viscum orientale*	Manda	Halophytes
52	*Dendrophthoe falcata*	Bara Manda	Halophytes
53	*Porteresia coarctata*	Dhani Ghas	Halophytes
54	*Tamarix dioica*	Lal Jhau	Xerophytes
55	*Tamarix aphylla*	Lal Jhau	Xerophytes
56	*Tamarix troupii*	Nona Jhau	Xerophytes
57	*Solanum trilobatum*	Lala Gurbegun	Xerophytes
58	*Opuntia dillenii*	Fani mansa	Xerophytes
59	*Casuarina equisetifolia*		
60	*Viscum monoicum*	Manda	Epiphyte
61	*Dendrophthoe falcata*	Bara Manda	Epiphyte
62	*Premna corymbosa*		
63	*Holarrhana antidysenterica*		
64	*Cerbera manghas*	Dabur	Mangrove associate
65	*Launaea sermentosa*		
66	*Trianthema portulacastrum*		
67	*Ammannia baccifera*		
68	*Barringtonia asiatica*	Hijal	Fresh water Mangrove

Mangroves and associates			
Sl. no.	**Scientific name**	**Local name**	**Remarks**
69	*Barringtonia racemosa*	Hijal	Fresh water Mangrove
70	*Thespesia populneoides*	Paras	Mangrove associate

Source: West Bengal Forest Department

Bryophytes recorded from Sundarban		Pteridophytes Recorded from Sundarban	
S. No.	**Scientific name**	**S. No.**	**Scientific name**
1	*Pogonatum sp.*	1	*Acrostichum aureum*
2	*Polytrichum sp.*	2	*Adiantum caudatum*
3	*Porella sp.*	3	*Azolla pinnata*
4	*Marchantia sp*	4	*Ceratopteris thalictroides*
5	*Pogonatum sp.*	5	*Marsilea minuta*
		6	*Pteris vittata*
		7	*Salvinia cucullata*
		8	*Salvinia natans*

Faunal Community of Sundarban

Checklist for Mammals

Sl. No.	Name	Scientific Name	IUCN Status
1	Tiger	*Panthera tigris*	*Endangered*
2	Fishing Cat	*Prionailurus viverrinus*	*Vulnerable*
3	Rhesus Macaque	*Macaca mulatta*	*Least Concern*
4	Spotted Deer or Chita	*Axis axix*	*Least Concern*
5	Wild Pig	*Sus scrofa*	*Least Concern*
6	Finless Porpoise	*Neomeris phocaenoides*	*Vulnerable*
7	Gangetic Dolphin	*Platanista gangetica*	*Endangered*
8	Irrawady Dolphin	*Orcaella brevirostris*	*Vulnerable*
9	Smooth coated otter	*Lutrogale perspicillata*	*Vulnerable*
10	House Shrew	*Suncus marinua*	*Least Concern*
11	Common Jungle Cat	*Felis chaus*	*Least Concern*
12	Leopard Cat	*Prionailurus bengalensis*	*Least Concern*
13	Jackal	*Canis aureus*	*Least Concern*
14	Indian Fox	*Vulpes bengalensis*	*Least Concern*
15	Small Indian Civet	*Viverricula indica*	*Least Concern*
16	Common Grey Mongoose	*Herpestes edwardsii*	*Least Concern*
17	Five-striped Squirrel	*Funumbulas pennanti*	*Least Concern*
18	Field Mouse	*Mus booduga*	*Least Concern*
19	Large Bandicoot Rat	*Bandicota indica*	*Least Concern*
20	House Rat	*Rattus rattus*	*Least Concern*
21	House Mouse	*Mus musculus*	*Least Concern*
22	Indian Flying Fox	*Pteropus giganteus*	*Least Concern*
23	Short-nosed Fruit Bat	*Cynopterus sphinx*	*Least Concern*
24	Lesser Yellow Bat	*Scotophilus temmincki*	*Least Concern*
25	Greater False Vampire	*Megaderma lyra*	*Least Concern*
26	Lesser Rat-tailed Bat	*Rhinopoma hardwickli*	*Least Concern*
27	Bicoloured Leaf-nosed Bat	*Hipposideros bicolor*	*Least Concern*
28	Indian Pygmy Bat	*Pipistrellus tenuis*	*Least Concern*
29	Small clawed otter	*Amblonyx cinereus*	*Vulnerable*

Source: West Bengal Forest Department

Checklist for Reptiles

Sl. No.	Name	Scientific Name	IUCN Status
Order : Chelonia			
1	Common Batagur or river Terrapin	*Batagur baska*	*Critically Endangered*
2	Flap shell turtle	*Lissemys punctata*	*Least Concern*
3	Chitra Turtle	*Chitra indica*	*Endangered*
4	Indian roofed turtle	*Kachuga tecta*	*Least Concern*
5	Olive Ridley Turtle	*Lepidochelys olivacea*	*Vulnerable*
6	Green Turtle	*Chelonia mydas*	*Endangered*
7	Hawksbill Turtle	*Eretmochelys imbricata*	*Critically Endangered*
Order : Squamata			
8	Common Checkered Keelback	*Xenochrophis piscator*	*Least Concern*
9	Common smooth water snake	*Enhydris enhydris*	*Least Concern*
10	Dog faced Water Snake	*Cerberus rhynchops*	*Least Concern*
11	Wart Snake or file snake	*Acrochordus granulatus*	*Least Concern*
12	Glossy Marsh snake	*Gerarda prevostiana*	*Least Concern*
13	Sea-snake	*Enhylrina schistose*	*Least Concern*
14	Estuarine Sea-snake	*Hydrophis obscurus*	*Least Concern*
15	Black banded Sea-snake	*Hydrophis nigrocintus*	*Data Deficient*
16	Blue Sea-snake	*Hydrophis caerulescens*	*Least Concern*
17	Sea-snake	*Microcephalophis gracilis*	*Least Concern*
18	Sea-snake	*Microcephalophis cantoris*	*Data Deficient*
19	Estuarine Crocodile	*Crocodylus porosus*	*Least Concern*
20	Tokay gecko	*Gekko gecko*	-
21	Mouse Gecko	*Hemidactylus frinatas*	*Least Concern*
22	House Gecko	*Hemidactylus flaviridis*	*Least Concern*
23	Brook's House Gecko	*Hemidactylus brookii*	-
24	Indian Garden Lizard	*Calotes versicolor*	*Least Concern*
25	Indian Chameleon	*Chamaeleo zeylanicus*	*Least Concern*
26	Common Dotted Garden Skink	*Riopa punctata*	-
27	Water Monitor	*Varanus salavator*	*Least Concern*
28	Monitor Lizard	*Varanus flavescens*	*Least Concern*
29	Ornate Flying Snake or Gliding Snake	*Chrysopelea ornata*	-
30	Blind Snake	*Typhlops porrectus*	*Data Deficient*
31	Common Blind snake	*Typhlops braminus*	-
32	Indian Rock Python	*Python molurus*	*Vulnerable*

Sl. No.	Name	Scientific Name	IUCN Status
33	Common Sand Boa	*Gongylophis conicus*	-
34	Trinket Snake	*Elaphe helena*	-
35	Indian Rat Snake	*Ptyas mucosa*	-
36	Banded kukri Snake	*Oligodon arnensis*	-
38	Common vine snake	*Ahaetulla nasuta*	-
38	Common wolf snake	*Lycodon aulicus*	*Least Concern*
39	Striped Keelback	*Amphiesma stolatum*	-
40	Olivaceous Keelback	*Atretium schistosum*	*Least Concern*
41	Bronze-back	*Derdreluphis ahactulla*	-
42	Common Indian Bronzeback	*Dendrelaphis tristis*	*Data Deficient*
43	Common Indian Krait	*Bungarus caeruleus*	-
44	Banded Krait	*Bungarus fasciatus*	*Least Concern*
45	Indian Cobra	*Naja naja*	*Least Concern*
46	King Cobra	*Ophiophagus hannah*	*Vulnerable*
47	Rusell's viper	*Daboia russelli*	*Least Concern*
48	Spot tailed Pit Viper	*Trimeresurus erythrurus*	*Least Concern*

Source: West Bengal Forest Department

Checklist for Birds

Checklist for Birds	
1. Swamp Francolin - Francolinus gularis	183. Slender-billed Vulture - Gyps tenuirostris
2. Common Quail - Coturnix coturnix	184. Short-toed Eagle - Circaetus gallicus
3. Rain Quail - Coturnix coromandelica	185. Crested Serpent Eagle - Spilornis cheela
4. Blue-breasted Quail - Coturnix chinensis	186. Eurasian Marsh Harrier - Circus aeruginosus
5. Red Junglefowl - Gallus gallus	187. Pied Harrier - Circus melanoleucos
6. Lesser Whistling-duck - Dendrocygna javanica	188. Hen Harrier - Circus cyaneus
7. White-headed Duck - Oxyura leucocephala	189. Pallid Harrier - Circus macrourus
8. Greylag Goose - Anser anser	190. Crested Goshawk - Accipiter trivirgatus
9. Bar-headed Goose - Anser indicus	191. Shikra - Accipiter badius
10. Ruddy Shelduck - Tadorna ferruginea	192. Oriental Honey-Buzzard - Pernis ptilorhyncus
11. Common Shelduck - Tadorna tadorna	193. Greater Spotted Eagle - Aquila clanga
12. Comb Duck - Sarkidiornis melanotos	194. Indian Spotted Eagle - Pomarina hastata
13. Cotton Pygmy-goose - Nettapus coromandelianus	195. Bonelli's Eagle - Hieraaetus fasciatus
14. Gadwall - Anas strepera	196. Booted Eagle - Hieraaetus pennatus
15. Falcated Duck - Anas falcata	197. Changeable Hawk Eagle - Spizaetus cirrhatus
16. Eurasian Wigeon - Anas penelope	198. Common Kestrel - Falco tinnunculus
17. Mallard - Anas platyrhynchos	199. Red-necked Falcon - Falco chicquera
18. Spot-billed Duck - Anas poecilorhyncha	200. Amur Falcon - Falco amurensis
19. Common Teal - Anas crecca	201. Eurasian Hobby - Falco subbuteo
20. Garganey - Anas querquedula	202. Oriental Hobby - Falco severus
21. Northern Pintail - Anas acuta	203. Peregrine Falcon - Falco peregrinus
22. Northern Shoveler - Anas clypeata	204. Little Grebe - Tachybaptus ruficollis
23. Red-crested Pochard - Rhodonessa rufina	205. Darter - Anhinga melanogaster
24. Common Pochard - Aythya ferina	206. Little Cormorant - Phalacrocorax niger
25. Ferruginous Pochard - Aythya nyroca	207. Indian Cormorant - Phalacrocorax fuscicollis
26. Baer's Pochard - Aythya baeri	208. Great Cormorant - Phalacrocorax carbo
27. Tufted Duck - Aythya fuligula	209. Little Egret - Egretta garzetta
28. Greater Scaup - Aythya marila	210. Great Egret - Casmerodius albus
29. Red-breasted Merganser - Mergus serrator	211. Intermediate Egret - Mesophoyx intermedia
30. Eurasian Wryneck - Jynx torquilla	212. Cattle Egret - Bubulcus ibis
31. Speckled Piculet - Picumnus innominatus	213. Indian Pond Heron - Ardeola grayii
32. Rufous Woodpecker - Celeus brachyurus	214. Grey Heron - Ardea cinerea
33. Brown-capped Pygmy Woodpecker - Dendrocopos nanus	215. Goliath Heron - Ardea goliath
34. Fulvous-breasted Woodpecker - Dendrocopos macei	216. Purple Heron - Ardea purpurea
35. Yellow-crowned Woodpecker - Dendrocopos mahrattensis	217. Little Heron - Butorides striatus
36. Lesser Yellownape - Picus chlorolophus	218. Black-crowned Night Heron - Nycticorax nycticorax
37. Streak-throated Woodpecker - Picus xanthopygaeus	219. Yellow Bittern - Ixobrychus sinensis
38. Grey-headed Woodpecker - Picus canus	220. Cinnamon Bittern - Ixobrychus cinnamomeus
39. Common Flameback - Dinopium javanense	221. Black Bittern - Dupetor flavicollis
40. Black-rumped Flameback - Dinopium benghalense	222. Glossy Ibis - Plegadis falcinellus
41. Greater Flameback - Chrysocolaptes lucidus	223. Black-headed Ibis - Threskiornis melanocephalus
42. White-naped Woodpecker - Chrysocolaptes festivus	224. Eurasian Spoonbill - Platalea leucorodia
43. Brown-headed Barbet - Megalaima zeylanica	225. Great White Pelican - Pelecanus onocrotalus
44. Lineated Barbet - Megalaima lineata	226. Spot-billed Pelican - Pelecanus philippensis
45. Blue-throated Barbet - Megalaima asiatica	227. Painted Stork - Mycteria leucocephala
46. Coppersmith Barbet - Megalaima haemacephala	228. Asian Openbill - Anastomus oscitans
47. Common Hoopoe - Upupa epops	229. Black-necked Stork - Ephippiorhynchus asiaticus
48. Indian Roller - Coracias benghalensis	230. Lesser Adjutant - Leptoptilos javanicus
49. Dollarbird - Eurstomus orientalis	231. Greater Adjutant - Leptoptilos dubius
50. Common Kingfisher - Alcedo atthis	232. Christmas Island Frigatebird - Fregata andrewsi
51. Blue-eared Kingfisher - Alcedo meninting	233. Wilson's Storm-petrel - Oceanites oceanicus
52. Brown-winged Kingfisher - Halcyon amauroptera	234. Indian Pitta - Pitta brachyura
53. Stork-billed Kingfisher - Halcyon capensis	235. Mangrove Pitta - Pitta megarhyncha
	236. Golden-fronted Leafbird - Chloropsis aurifrons
	237. Brown Shrike - Lanius cristatus

Checklist for Birds

54. Ruddy Kingfisher - Halcyon coromanda
55. White-throated Kingfisher - Halcyon smyrnensis
56. Black-capped Kingfisher - Halcyon pileata
57. Collared Kingfisher - Todiramphus chloris
58. Pied Kingfisher - Ceryle rudis
59. Green Bee-eater -Merops orientalis
60. Blue-tailed Bee-eater - Merops philippinus
61. Chestnut-headed Bee-eater - Merops leschenaulti
62. Pied Cuckoo - Clamator jacobinus
63. Chestnut-winged Cuckoo - Clamator coromandus
64. Common Hawk Cuckoo - Hierococcyx varius
65. Indian Cuckoo - Cuculus micropterus
66. Eurasian Cuckoo - Cuculus canorus
67. Oriental Cuckoo - Cuculus saturatus
68. Lesser Cuckoo - Cuculus poliocephalus
69. Grey-bellied Cuckoo - Cacomantis passerinus
70. Plaintive Cuckoo - Cacomantis merulinus
71. Asian Koel - Eudynamys scolopacea
72. Green-billed Malkoha - Phaenicophaeus tristis
73. Greater Coucal - Centropus sinensis
74. Lesser Coucal - Centropus bengalensis
75. Rose-ringed Parakeet - Psittacula krameri
76. Asian Palm Swift - Cypsiurus balasiensis
77. House Swift - Apus affinis
78. Fork-tailed Swift - Apus pacificus
79. Barn Owl - Tyto alba
80. Oriental Scops Owl - Otus sunia
81. Indian Scops Owl - Otus bakkamoena
82. Brown Fish Owl - Ketupa zeylonensis
83. Buffy Fish Owl - Ketupa ketupu
84. Spotted Owlet - Athene brama
85. Short-eared Owl - Asio flammeus
86. Large-tailed Nightjar - Caprimulgus macrurus
87. Indian Nightjar - Caprimulgus asiaticus
88. Savanna Nightjar - Caprimulgus affinis
89. Rock Pigeon - Columba livia
90. Laughing Dove - Streptopelia senegalensis
91. Spotted Dove - Streptopelia chinensis
92. Red Collared Dove - Streptopelia tranquebarica
93. Eurasian Collared Dove - Streptopelia decaocto
94. Emerald Dove - Chalcophaps indica
95. Orange-breasted Green Pigeon - Treron bicincta
96. Yellow-footed Green Pigeon - Treron phoenicoptera
97. Masked Finfoot - Heliopais personata
98. Slaty-legged Crake - Rallina eurizonoides
99. Slaty-breasted Rail - Gallirallus striatus
100. Water Rail - Rallus aquaticus
101. White-breasted Waterhen - Amaurornis phoenicurus
102. Baillon's Crake - Porzana pusilla
103. Ruddy-breasted Crake - Porzana fusca
104. Watercock - Gallicrex cinerea
105. Purple Swamphen - Porphyrio porphyrio
106. Common Moorhen - Gallinula chloropus
107. Common Coot - Fulica atra
108. Eurasian Woodcock - Scolopax rusticola
109. Wood Snipe - Gallinago nemoricola
110. Pintail Snipe - Gallinago stenura
238. Bay-backed Shrike - Lanius vittatus
239. Long-tailed Shrike - Lanius schach tricolor
240. Grey-backed Shrike - Lanius tephronotus
241. Southern Grey Shrike - Lanius meridionalis
242. Mangrove Whistler - Pachycephala grisola
243. Rufous Treepie - Dendrocitta vagabunda
244. House Crow - Corvus splendens
245. Large-billed Crow - Corvus macrorhynchos
246. Ashy Woodswallow - Artamus fuscus
247. Eurasian Golden Oriole - Oriolus oriolus
248. Black-naped Oriole - Oriolus chinensis
249. Black-hooded Oriole - Oriolus xanthornus
250. Large Cuckooshrike - Coracina macei
251. Black-winged Cuckooshrike - Coracina melaschistos
252. Black-headed Cuckooshrike - Coracina melanoptera
253. Rosy Minivet - Pericrocotus roseus
254. Small Minivet - Pericrocotus cinnamomeus
255. Scarlet Minivet - Pericrocotus flammeus
256. Bar-winged Flycatcher-shrike - Hemipus picatus
257. White-throated Fantail - Rhipidura albicollis
258. Black Drongo - Dicrurus macrocercus
259. Ashy Drongo - Dicrurus leucocephalus
260. White-bellied Drongo - Dicrurus caerulescens
261. Bronzed Drongo - Dicrurus aeneus
262. Spangled Drongo - Dicrurus hottentottus
263. Greater Racket-tailed Drongo - Dicrurus paradiseus
264. Black-naped Monarch - Hypothymis azurea
265. Asian Paradise-flycatcher - Terpsiphone paradisi
266. Common Iora - Aegithina tiphia
267. Blue Rock Thrush - Monticola solitarius
268. Orange-headed Thrush - Zoothera citrina
269. Scaly Thrush - Zoothera dauma
270. Tickell's Thrush - Turdus unicolor
271. Red-throated Flycatcher - Ficedula parva
272. Little Pied Flycatcher - Ficedula westermanni
273. Verditer Flycatcher - Eumyias thalassina
274. Pale-chinned Flycatcher - Cyornis unicolor
275. Blue-throated Flycatcher - Cyornis rubeculoides
276. Tickell's Blue Flycatcher - Cyornis tickelliae
277. Grey-headed Canary Flycatcher - Culicicapa ceylonensis
278. Siberian Rubythroat - Luscinia calliope
279. Bluethroat - Luscinia svecica
280. Oriental Magpie Robin - Copsychus saularis
281. Indian Robin - Saxicoloides fulicata
282. Black Redstart - Phoenicurus ochruros
283. Siberian Stonechat - Saxicola torquata
284. White-tailed Stonechat - Saxicola leucura
285. Pied Bushchat - Saxicola caprata
286. Chestnut-tailed Starling - Sturnus malabaricus
287. Brahminy Starling - Sturnus pagodarum
288. Common Starling - Sturnus vulgaris
289. Asian Pied Starling - Sturnus contra
290. Common Myna - Acridotheres tristis
291. Bank Myna - Acridotheres ginginianus
292. Jungle Myna - Acridotheres fuscus
293. Chestnut-bellied Nuthatch - Sitta castanea

Checklist for Birds

111. Swinhoe's Snipe - Gallinago megala
112. Common Snipe - Gallinago gallinago
113. Jack Snipe - Lymnocryptes minimus
114. Black-tailed Godwit - Limosa limosa
115. Bar-tailed Godwit - Limosa lapponica
116. Whimbrel - Numenius phaeopus
117. Eurasian Curlew - Numenius arquata
118. Spotted Redshank - Tringa erythropus
119. Common Redshank - Tringa tetanus
120. Marsh Sandpiper - Tringa stagnatilis
121. Common Greenshank - Tringa nebularia
122. Green Sandpiper - Tringa ochropus
123. Wood Sandpiper - Tringa glareola
124. Terek Sandpiper - Xenus cinereus
125. Common Sandpiper - Actitis hypoleucos
126. Ruddy Turnstone - Arenaria interpres
127. Asian Dowitcher - Limnodromus semipalmatus
128. Great Knot - Calidris tenuirostris
129. Sanderling - Calidris alba
130. Little Stint - Calidris minuta
131. Red-necked Stint - Calidris ruficollis
132. Temminck's Stint - Calidris temminckii
133. Long-toed Stint - Calidris subminuta
134. Dunlin - Calidris alpine
135. Curlew Sandpiper - Calidris ferruginea
136. Spoon-billed Sandpiper - Calidris pygmeus
137. Broad-billed Sandpiper - Calidris falcinellus
138. Ruff - Philomachus pugnax
139. Red Phalarope - Phalaropus fulicaria
140. Greater Painted Snipe - Rostratula benghalensis
141. Pheasant-tailed Jacana - Hydrophasianus chirurgus
142. Bronze-winged Jacana - Metopidius indicus
143. Eurasian Thick-knee - Burhinus oedicnemus
144. Great Thick-knee - Esacus recurvirostris
145. Eurasian Oystercatcher - Haematopus ostralegus
146. Black-winged Stilt - Himantopus himantopus
147. Pied Avocet - Recurvirostra avosetta
148. Pacific Golden Plover - Pluvialis fulva
149. Grey Plover - Pluvialis squatarola
150. Common Ringed Plover - Charadrius hiaticula
151. Little Ringed Plover - Charadrius dubius
152. Kentish Plover - Charadrius alexandrinus
153. Lesser Sand Plover - Charadrius mongolus
154. Greater Sand Plover - Charadrius leschenaultii
155. River Lapwing - Vanellus duvaucelii
156. Grey-headed Lapwing - Vanellus cinereus
157. Red-wattled Lapwing - Vanellus indicus
158. White-tailed Lapwing - Vanellus leucurus
159. Oriental Pratincole - Glareola maldivarum
160. Small Pratincole - Glareola lactea
161. Heuglin's Gull - Larus heuglini
162. Pallas's Gull - Larus ichthyaetus
163. Brown-headed Gull - Larus brunnicephalus
164. Black-headed Gull - Larus ridibundus
165. Gull-billed Tern - Gelochelidon nilotica
166. Caspian Tern - Sterna caspia
167. River Tern - Sterna aurantia
294. Velvet-fronted Nuthatch - Sitta frontalis
295. Great Tit - Parus major
296. Sand Martin - Riparia riparia
297. Barn Swallow - Hirundo rustica
298. Red-rumped Swallow - Hirundo daurica
299. Streak-throated Swallow - Hirundo fluvicola
300. Red-whiskered Bulbul - Pycnonotus jocosus
301. Red-vented Bulbul - Pycnonotus cafer
302. Zitting Cisticola - Cisticola juncidis
303. Grey-breasted Prinia - Prinia hodgsonii
304. Yellow-bellied Prinia - Prinia flaviventris
305. Ashy Prinia - Prinia socialis
306. Plain Prinia - Prinia inornata
307. Oriental White-eye - Zosterops palpebrosus
308. Rusty-rumped Warbler - Locustella certhiola
309. Blyth's Reed Warbler - Acrocephalus dumetorum
310. Large-billed Reed Warbler - Acrocephalus orinus
311. Clamorous Reed Warbler - Acrocephalus stentoreus
312. Thick-billed Warbler - Acrocephalus aedon
313. Common Tailorbird - Orthotomus sutorius
314. Common Chiffchaff - Phylloscopus collybita
315. Dusky Warbler - Phylloscopus fuscatus
316. Tickell's Leaf Warbler - Phylloscopus affinis
317. Lemon-rumped Warbler - Phylloscopus chloronotus
318. Yellow-browed Warbler - Phylloscopus inornatus
319. Hume's Warbler - Phylloscopus humei
320. Greenish Warbler - Phylloscopus trochiloides
321. Large-billed Leaf Warbler - Phylloscopus magnirostris
322. Blyth's Leaf Warbler - Phylloscopus reguloides
323. Golden-spectacled Warbler - Seicercus burkii
324. Striated Grassbird - Megalurus palustris
325. Puff-throated Babbler - Pellorneum ruficeps
326. White-browed Scimitar Babbler - Pomatorhinus schisticeps
327. Striped Tit-Babbler - Macronous gularis
328. Chestnut-capped Babbler - Timalia pileata
329. Yellow-eyed Babbler - Chrysomma sinense
330. Striated Babbler - Turdoides earlei
331. Jungle Babbler - Turdoides striatus
332. Bengal Bushlark - Mirafra assamica
333. Ashy-crowned Sparrow Lark - Eremopterix nigriceps
334. Oriental Skylark - Alauda gulgula
335. Thick-billed Flowerpecker - Dicaeum agile
336. Orange-bellied Flowerpecker - Dicaeum trigonostigma
337. Pale-billed Flowerpecker - Dicaeum erythrorynchos
338. Scarlet-backed Flowerpecker - Dicaeum cruentatum
339. Purple-rumped Sunbird - Nectarinia zeylonica
340. Purple Sunbird - Nectarinia asiatica
341. Loten's Sunbird - Nectarinia lotenia
342. Crimson Sunbird - Aethopyga siparaja
343. Little Spiderhunter - Arachnothera longirostra
344. House Sparrow - Passer domesticus
345. Forest Wagtail - Dendronanthus indicus
346. White Wagtail - Motacilla alba
347. Citrine Wagtail - Motacilla citreola
348. Yellow Wagtail - Motacilla flava
349. Grey Wagtail - Motacilla cinerea

Checklist for Birds	
168. Lesser Crested Tern - Sterna bengalensis	350. Richard's Pipit - Anthus richardi
169. Great Crested Tern - Sterna bergii	351. Paddyfield Pipit - Anthus rufulus
170. Common Tern - Sterna hirundo	352. Tawny Pipit - Anthus campestris
171. Little Tern - Sterna albifrons	353. Tree Pipit - Anthus trivialis
172. Whiskered Tern - Chlidonias hybridus	354. Olive-backed Pipit - Anthus hodgsoni
173. White-winged Tern - Chlidonias leucopterus	355. Black-breasted Weaver - Ploceus benghalensis
174. Black Noddy - Anous minutus	356. Streaked Weaver - Ploceus manyar
175. Osprey - Pandion haliaetus	357. Baya Weaver - Ploceus philippinus
176. Black-shouldered Kite - Elanus caeruleus	358. Finn's Weaver - Ploceus megarhynchus
177. Black Kite - Milvus migrans	359. Red Avadavat - Amandava amandava
178. Brahminy Kite - Haliastur indus	360. Indian Silverbill - Lonchura malabarica
179. White-bellied Sea Eagle - Haliaeetus leucogaster	361. Scaly-breasted Munia - Lonchura punctulata
180. Pallas's Fish Eagle - Haliaeetus leucoryphus	362. Black-headed Munia - Lonchura malacca
181. Grey-headed Fish Eagle - Haliaeetus ichthyaetus	363. Common Rosefinch - Carpodacus erythrinus
182. White-rumped Vulture - Gyps bengalensis	364. Chestnut-eared Bunting - Emberiza fucata

Source: West Bengal Forest Department

Checklist for Fishes

Sl. No.	Name	Scientific Name	IUCN Status
1	Indian Dog Shark	*Scoliodon laticaudus*	Near Threatened
2	White cheeked shark	*Carcharhinus dussumieri*	Near Threatened
3	Blacktip shark	*Carcharhinus limbatus*	Near Threatened
4	Arrow headed hammer headed shark	*Sphryna blochii*	Endangered
5	Hammer headed shark	*Sphyrna zygaena*	vulnerable
6	River shark	*Glyphis gangeticus*	Critically Endangered
7	Sharpteeth shark	*Glyphis glyphis*	Endangered
8	Irrawady river shark	*Glyphis siamensis*	Critically Endangered
9	Tiger shark	*Galeocerdo cuvier*	Near Threatened
10	Bull shark	*Carcharhinus leucus*	Near Threatened
11	Bengal's snake eel	*Pisodonophis boro*	Least Concern
12	White sardine	*Escualosa thoracata*	-
13	Long finned eel, locally called Baan mach	*Anguilla bengalensis*	Near Threatened
14	Toli shad, locally called Kajli ilish	*Tenualosa toli*	-
15	Hilsa, locally called Ilish	*Tenualosa ilisha*	Least Concern
16	Elongate ilisha	*Ilisha elongata*	-
17	Indian ilish	*Ilisha melastoma*	-
18	Gold-spotted grenadier anchovy	*Coilia dussumeri*	-
19	Tapertail anchovy	*Coilia ramcarati*	-
20	Gangetic anchovy, locally called Phasa	*Setipinna phasa*	Least Concern
21	Hairfin anchovy	*Setipinna taty*	-
22	Spined anchovy	*Stolephorus baganensis*	-
23	Anchovy	*Stolephorus commersonii*	-
24	Dussumier's thryssa	*Thryssa dussumieri*	-
25	Hamilton's thryssa	*Thryssa hamiltonii*	-
26	Small-eye catfish	*Arius jella*	-
27	Hamilton's catfish	*Arius arius*	Least Concern
28	Bombay duck	*Harpadon nehereus*	-
29	Bhetki or Giant sea perch	*Lates calcarifer*	-
30	Silver sillago	*Sillago sihama*	Least Concern
31		*Sillago soringa*	-
32	Gangetic whiting	*Sillaginopsis panijus*	-
33	Spotted butterfish, locally called Pyra mach	*Scatophagus argus*	Least Concern
34	John's snapper	*Lutjanus johni*	Least Concern
35	Blotched grunt	*Pomadasys argenteus*	Least Concern
36	Asiatic milk fish	*Chanos chanos*	Least Concern

Sl. No.	Name	Scientific Name	IUCN Status
37		*Mystus gulio*	Least Concern
38	Half beck	*Zenarchopterus ectuntio*	-
39	Bloch's ponyfish	*Leiognathus blochii*	-
40	Common ponyfish	*Leiognathus equulus*	Least Concern
41	Parse	*Liza parsia*	-
42	Bhangone	*Liza tade*	Data Deficient
43	Corsula mullet, corsula	*Rhinomugil corsula*	Least Concern
44	Flathead grey mullet	*Mugil cephalus*	Least Concern
45	Paradise threadfin, locally called Topse	*Polynemus paradiseus*	-
46	Small-headed ribbonfish	*Lepturacanthus savala*	-
47	Gangetic ribbon fish	*Lepturacanthus pantuli*	-
48	Large head ribbon fish	*Trichiurus lepturus*	Least Concern

Source: West Bengal Forest Department

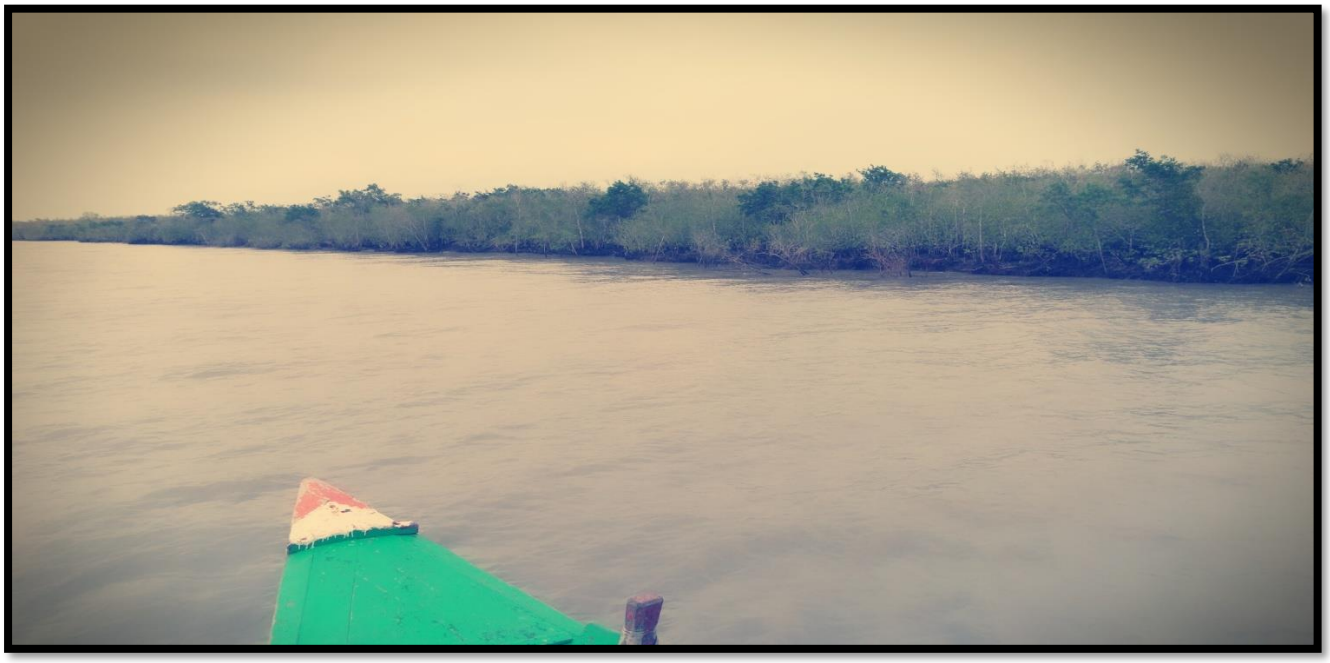
Annexure 4: PHOTOGRAPHS

Boat Mobilisation for Haribhanga

Unprotected Right Bank at Chainage 3.7

CHAINAGE 4.6

Unprotected Left Bank at CHAINAGE 5.2



Unprotected Right Bank at CHAINAGE 5.4

Unprotected Right Bank at CHAINAGE 5.6

Unprotected Bank at CHAINAGE 6.2

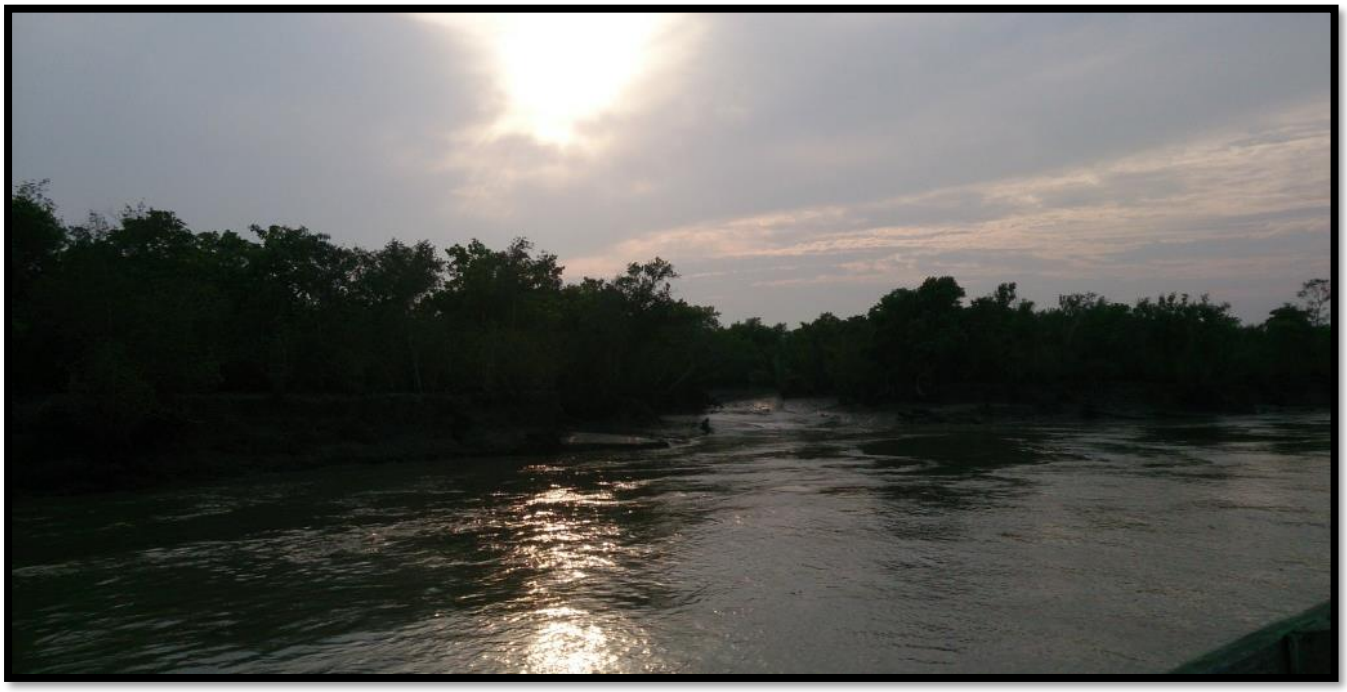
Unprotected Bank at CHAINAGE 6.3

Unprotected Right Bank at CHAINAGE 7.5

Unprotected Left Bank at CHAINAGE 8

Unprotected Right Bank at CHAINAGE 8.3

Unprotected Left Bank at CHAINAGE 8.4



Unprotected Left Bank at CHAINAGE 8.9

Unprotected Left Bank at CHAINAGE 9.3

Unprotected Left Bank at CHAINAGE 10.2

CHAINAGE 10.7

Unprotected Right Bank at CHAINAGE 10.8

Unprotected Right Bank at CHAINAGE 11.5

Unprotected Left Bank at CHAINAGE 11.8

Unprotected Left Bank at CHAINAGE 12.8

Unprotected Right Bank at CHAINAGE 13

Unprotected Left Bank at CHAINAGE 13.5

Unprotected Right Bank at CHAINAGE 13.5

CHAINAGE 14.9

CHAINAGE 14.9 (2)

Unprotected Left Bank at CHAINAGE 15

Unprotected Left Bank at CHAINAGE 15.827

Unprotected Right Bank at CHAINAGE 15.827

VOLUME – II

DRAWINGS