FINAL FEASIBILITY REPORT

Consultancy Services for Preparation of Two-stage

Detailed Project Report (DPR) of Cluster 4 of Proposed 53 National Waterways

Mahanadi and Luna (NW 64)

FEEDBACK INFRA (P) LIMITED

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Abbreviations

BM	Bench Mark
CAD	Computer Aided Design
CD	Chart Datum
CH	Chainage
CRZ	Coastal Regulation Zone
CWC	Central Water Commission
DF	Dual Frequency
DGLL	Directorate General of Lighthouses and Lightships
DGPS	Differential Global Positioning System
DPR	Detailed Project Report
DXF	Drawing Interchange Format
GPS	Global Positioning System
HFL	High Flood Level
HTL	High Tension Line
HC	Horizontal Clearance
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport
km	kilometre
LAT.	Latitude
LONG.	Longitude
m	meter
m/s	meter per second
MSL	Mean Sea level
MTPA	Million Tonnes per Annum
MoEF	Ministry of Environment and Forest
NH	National Highways
NW	National waterways
PWD	Public Works Department
SBES	Single Beam Echo Sounder
SH	State Highways
UTM	Universal Transverse Mercator
VC	Vertical Clearance
WGS	World Geodetic System
PSU	Public Sector Undertaking
USA	United States of America

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CHAPTER 1
EXECUTIVE SUMMARY

1 Executive Summary

A total of 425 km of Mahanadi River system from Sambalpur to Paradip sea mouth and 75km of Luna river was studied. The study mainly consists of carrying out single line bathymetry/topography and collection of all secondary details. The survey was carried out in February and April 2016. Major inventories like cross structures, dams, barrages and details of these structures in terms of vertical and horizontal clearances were also collected. The Mahanadi river has two barrages namely Mundali and Mahanadi, both without locks. The Mahanadi river and Luna river were found to have 17 and 8 cross structures respectively.

As part of the present study, preliminary market analysis were also carried out to ascertain the traffic potential along the study stretch. Sambalpur, Jharsuguda and Cuttack are the three major industrial clusters along the study stretch that can generate the traffic. Sponge iron industries, steel industries and thermal plants dominate the industrial landscape. Cement and Aluminum industries are other industries present in the cluster. The total traffic potential from Sambalpur and Jharsuguda cluster combined is estimated at 13.72 MTPA and 24.10 MTPA in 2015 and 2025 respectively. Mahanadi ends at Paradip sea mouth and can be used for cargo movement to Paradip port. If Birupa/Brahmani stretch is developed, traffic from Mahanadi can be routed to Dhamra port via NW5 through that river system. The summary of the study along with the major findings are as mentioned below:

Salient Features at a Glance – Mahanadi and Luna River

S. No.	Particulars	Details
1.	Name of the Consultant	Feedback Infra Pvt. Ltd.
2.	Cluster number & States	Cluster 4 : Odisha
3.	Waterway stretch, NW# From ….. to ; total length	National Waterway: 64 Stretch : Mahanadi river from Paradip Sea mouth to Sambalpur Total Length : 425km Luna river : An alternate route to Mahanadi from Balidia village to Tentola village (Total length – 75km)
4.	Navigability Status	Presently no navigation exists.
a)	Tidal and non-tidal portions (from ----- to ….. length, average tidal variation)	i) Tidal: From Paradip sea mouth to 35km length in Mahanadi stretch and 25km length in Luna stretch from the point where Luna re-joins Mahanadi. ii) Average Tidal variation : 2.1m

i) Survey period: February and April 2016
ii) LAD Status

b)
i) Survey period (---- to -----)
ii) LAD status (w.r.t. CD)- Mahanadi & Luna River

Depth	Length of river (km) - Mahanadi							Total
	0 - 50	**50-100**	**100-155**	**155-205**	**205-252**	**252-347**	**347-425**	
<1.0m	21.6	50	4.4	6.7	7.3	95	78.5	**263.5**
1.0-1.5	6.1	0	11.4	16	10.4	0	0	**43.9**
1.5-2.0	6.7	0	12.3	15	13	0	0	**47**
>2.0m	15.5	0	26.9	12.3	15.9	0	0	**70.6**

Depth (m)	Length of river (km) - Luna								Total
	0-10	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	
<1.0m	0.5	0.5	3.2	3.8	1.6	6.2	6.2	4.6	26.7
1.0-1.5	1.4	1.6	2.7	3	2.2	2.4	1.9	2.2	17.3
1.5-2.0	2.2	2.2	2.2	2.2	3.5	1.1	1.2	1.9	16.4
>2.0m	6	5.7	1.9	1.1	2.7	0.3	0.7	1.4	19.6

c) Cross Structures
i) Dams, weirs, barrages etc. (total number; with navigational locks or not)
ii) Bridges, power cables etc. (total number ; range of horizontal and vertical clearance w.r.t. H.F.L)

Mahanadi river :
i) 2 Barrages (Both without Navigational locks)
ii) Bridges: 15; HTL: 9
iii) Range of Horizontal Clearance : 21m - 40m
iv) Range of Vertical clearance (w.r.t. HFL) : 3m - 7m

Luna river:
i) No Barrages
ii) Bridges: 08; HTL: 11; Electric line: 01; cable: 01
Range of Horizontal Clearance : 13-43m
Range of Vertical clearance (w.r.t. HFL) : 3-7m

d) Avg discharge & no. of days

Avg Discharge: 128 m^3/s to 29000 m^3/s

Discharge in m^3/s	No. of days
<200	13 days
200-500	179 days
500-700	43 days
700-900	17 days
>900	112 days

e)	Slope (1 in -----)	1 in 3500
5.	Traffic potential	Divertible traffic – 24.10MTPA for the year 2025(year of inception)
a)	Present IWT operations, ferry services, tourism, cargo, if any	No operations. Local ferry service exists at Tikarpada.
b)	Important industries within 50km	Ultratech Cement Ltd, Vedanta Aluminium Ltd., Tata Refractories Ltd., R.B. Sponge Iron Ltd., Rathi Steel & Power Projects Ltd., IB Thermal Power Station, SMC Power Generation Corporation, Aditya Aluminium Limited.
c)	Distance of rail and road from Industry	7km from main line
6.	Consultant's recommendation for going ahead with Stage-II (	345km of Mahanadi and 75km of Luna river can be considered for Stage –II (DPR preparation)

	DPR preparation)	
7.	Any other information/comments	Entire stretch from Sonepur to Sambalpur in Mahanadi stretch is found to be rocky and navigation in this area is not possible.

CHAPTER 2
INTRODUCTION

2 Introduction

2.1 Inland Waterways Authority of India

Inland Waterways Authority of India (IWAI) was set up on 27th October 1986 in order to develop and regulate the inland waterways for shipping and navigation in India. The Authority primarily undertakes projects for development and maintenance of IWT infrastructure on National Waterways (NW).

2.2 Inland Waterways in India

Given India's long coastline and many waterways, coastal shipping and Inland Water Transport (IWT) segments have huge potential. India has about 14,500 km of navigable waterways which comprise rivers, canals, backwaters, creeks, etc. However, its operations are currently restricted to a few stretches in the Ganga-Bhagirathi-Hooghly Rivers, the Brahmaputra, the Barak River, the rivers in Goa, the backwaters in Kerala, inland waters in Mumbai and the delta in regions of the Godavari-Krishna Rivers. There is a need to promote these environment-friendly and cost-effective modes of transport as these remain largely underutilized accounting for less than 0.5% of total traffic within India.

Realizing the potential of the IWT sector, Government of India has announced several initiatives to promote IWT in the country for developing a strong water transport network.

National Waterways Act 2016 – This act is one such initiative designating 106 new rivers and canals as National waterways which are to be developed for year round commercial navigability.

2.3 Project overview

Inland Waterways Authority of India (IWAI) is the nodal agency responsible for development and operation of IWT infrastructure in India. As a step towards achieving the objectives laid down by the Government, IWAI intends to develop key inland waterway routes which would boost the overall contribution of waterways in India's modal share and reduce logistics costs in key areas.

IWAI initiated the project for preparation of Detailed Project Report of 53 inland waterways (out of 106 designated waterways) in India. The project has been divided into eight clusters and FEEDBACK INFRA has been engaged for the preparation of Detailed Project Report for cluster 4 which includes the following four river stretches of Odisha:

S.No.	River Name	Total Length (km)	Length under project (km)
1	Baitarani River	360	49
2	Birupa/Badi Genguti/ Brahmani River	799	152
3	Budha Balanga	198.75	56
4	Mahanadi	851 (494 km in Odisha)	425
5	Luna	75	75

Table 1: List of the river stretches under study

2.4 Objective of the study

Objective of present study is to explore the potential of rivers in cluster four for year round commercial navigation. To achieve this, the consultant needs to conduct a two stage study, Stage-1 consisting of a feasibility study and recommendations thereafter for a possibility of composite and integrated development of proposed waterways to achieve navigation and to develop water transport facilities in the study area. If feasibility study establishes the scope for navigation and potential to develop waterway transport facility, a Detailed Project Report needs to be prepared for identified feasible waterways and that would include detailed hydrographic surveys, investigation, traffic survey, proposed location for terminals and cost assessment etc.

During the conduction of primary survey, the consultant observed that the discharge water from Mahanadi barrage at Jobra, Cuttack passes through river Luna. Hence the actual river Mahanadi gets no water at all and is dried up. In view of the above, the consultant requested IWAI for conducting Reconnaissance survey for tributary river Luna (75KM), which may help in finding an alternative route with all-time water availability, minimum dredging and development cost.
In response to the request, FEEDBACK INFRA has been engaged for conducting the primary survey, as part of the stage 1 study, along 75 km alternate route to the Mahanadi stretch (river in cluster 4 study) i.e. Luna River.

The present Final feasibility Report covers the review of data, reconnaissance survey, present state of affairs, traffic analysis, available navigable stretches for Mahanadi and Luna rivers.

2.5 Scope

Scope of Work - Stage 1

Stage-I study consists of conducting feasibility study of the waterway for navigation. Broad scopes of Stage-1 activities are as mentioned below,

a) Reconnaissance Survey
b) Collection and review of available data
c) Feasibility Report

Scope of Work - Stage 2

Stage -2 study consists of preparation of detailed project report for feasible stretch of the river. Broad scope of stage-2 activities are mentioned below.

a) Detailed Hydrographic Survey & hydro-morphological survey
b) Traffic Survey & Techno economic feasibility
c) Preparation of Detailed Project Report

The present study is limited to establish the feasibility of waterways for inland navigation i.e. upto Stage -1 only.

CHAPTER 3
APPROACH & METHODOLOGY

3 Approach & Methodology

3.1 Stage - 1

To successfully deliver the project requirements, the Consultant prepared a stepwise delivery model. The approach and methodology used for Stage -1 studies are as mentioned in Figure 1below:

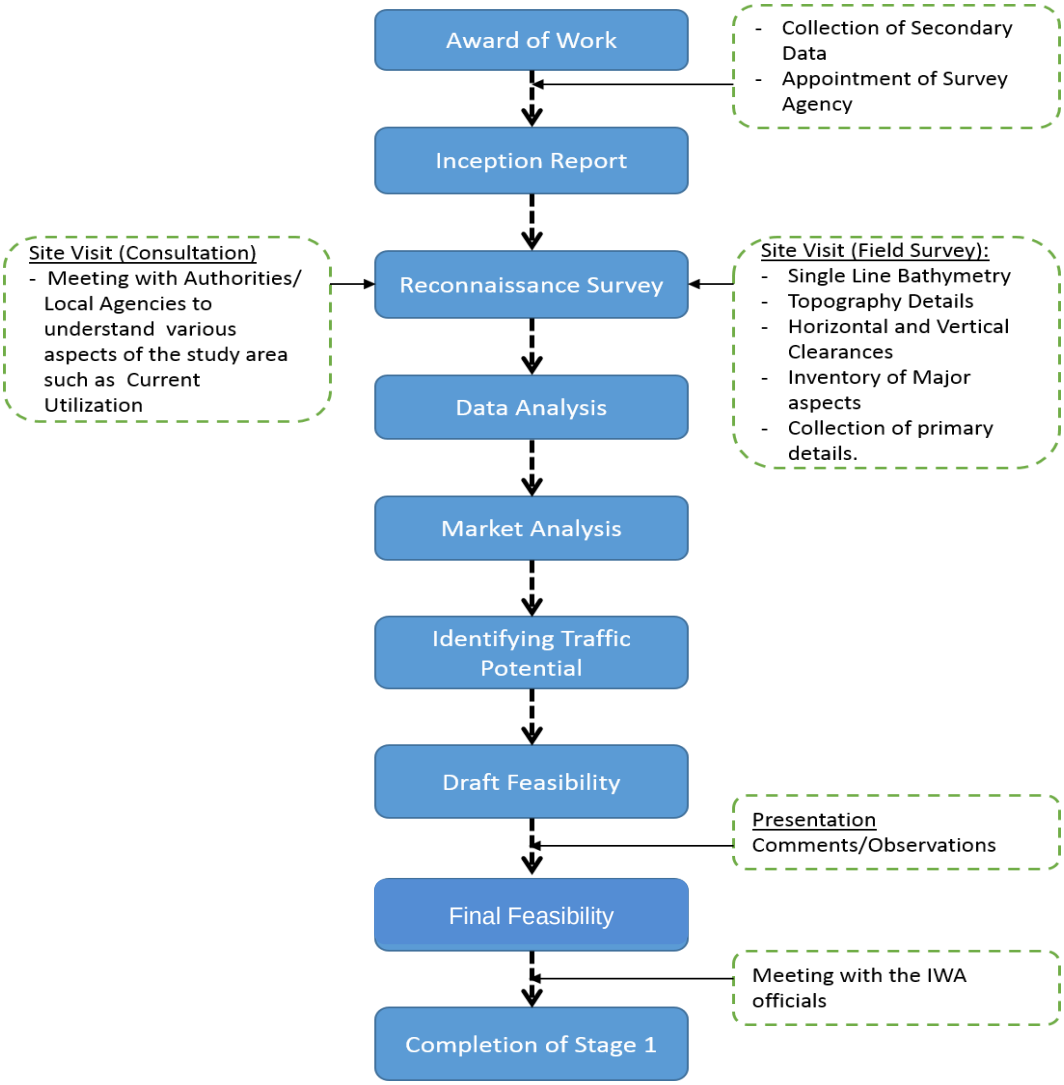


Figure 1: Stage-1 methodology flowchart

Subsequent to award of the assignment, the consultant engaged a survey agencies for the collection of the required primary and secondary data. Parallel to the submission of the Inception report, the consultant visited the site for reconnaissance survey, site supervision and stakeholder consultation. Present condition of the rivers was visually assessed. Survey progress was checked and secondary data pertaining to the present river was obtained. The data thus collected was analysed to determine the navigational feasibility of the earmarked river stretches along with the market analysis and the analysis of the traffic potential on the navigable stretches.

CHAPTER 4
STUDY AREA PROFILE

4 Study area profile

Odisha is a state on the eastern seaboard of India, located between 17^0 49' and 22^0 36' N latitudes and between 81^0 36' and $87^0$18' E longitudes. It spreads over an area of 1,55,707 sq. km. It is bounded by West Bengal in north-east, Bihar in the north, Madhya Pradesh in the west, Andhra Pradesh in the south and the Bay of Bengal in the east.

4.1 Physiography

On the basis of homogeneity, continuity and physiographical characteristics, Odisha has been divided into five major morphological regions: the Odisha Coastal Plain in the east, the Middle Mountainous and Highlands Region, the Central plateaus, the western rolling uplands and the major flood plains.

The Odisha Coastal Plains are the depositional landforms of recent origin and geologically belong to the Post-Tertiary Period. This region stretches from the West Bengal border.
This region is the combination of several deltas of varied sizes and shapes formed by the major rivers of Odisha, such as the Subarnarekha, the Budhabalanga, the Baitarani, the Brahmani, the Mahanadi, and the Rushikulya. Therefore, the coastal plain of Odisha is called the "Hexadeltaic region".

Middle Mountainous and Highlands Region covers about three-fourth of the entire State. Geologically it is a part of the Indian Peninsula which as a part of the ancient landmass of the Gondwanaland. The major rivers of Odisha with their tributaries have cut deep and narrow valleys. This region mostly comprises the hills and mountains of the Eastern Ghats which rise abruptly and steeply in the east and slope gently to a dissected plateau in the west running from north-east (Mayurbhanj) to north-west (Malkangirig). This region is well marked by a number of interfluves or watersheds.

The Central plateaus are mostly eroded plateaus forming the western slopes of the Eastern Ghats with elevation varying from 305-610 metres. The Panposh - Keonjhar -Pallahara plateau comprises the Upper Baitarani catchment basin.

The western rolling Uplands are lower in elevation than the plateaus having heights varying from 153 metres to 305 metres.

4.2 Rivers

4.2.1 River System of Odisha

There are four groups of rivers which flow through Odisha into the Bay of Bengal forming the flood plains.

- Rivers with source outside the state (the Subarnarekha, the Brahmani and the Mahanadi)
- Rivers with source inside the state (the Budhabalanga, the Baitarani, the Salandi, and the Rusikulya)
- Rivers with source inside the Odisha flow through other states (the Bahudu the Vansadhara, and the Nagavali)

- Rivers with source inside Odisha, but tributary to rivers which flow through other states (the Machkund, the sileru, the Kolab and the Indravati)

The state accommodates the river basins of 12 rivers flowing through the state.

4.2.2 Rivers under Study

The study area includes sections of four main river stretches namely Mahanadi and its anabranch Luna, Baitarani, Budha Balanga, Brahmani, Badi Genguti and Birupa that form part of an elaborate network of rivers flowing through the State of Odisha. Given below is the map of four main stretches earmarked for the study.

1 Mahanadi(Luna)	2 Birupa/Badi Genguti/Brahmani			3 Baitarani	4 Budha Balanga
425 km (Sambalpur – Paradip)	77km (Birupa Barage – Bhrahmani Dhamra confluence)	25km	54 km	49 km (Dattapur – Confluence with Bay of Bengal)	56 km (Patliputra – Confluence with Bay of Bengal)

Figure 2: Rivers stretches under study

The present Final feasibility Report covers the review of data, reconnaissance survey, present state of affairs, traffic analysis, available navigable stretches for Mahanadi and Luna rivers.

I. Mahanadi

It originates from the Amarkantak hills of the Bastar Plateau near Pharasiya village in Raipur district of Chhatisgarh. The river traverses a total distance of 851 km (in Odisha - 494 km) and falls into the Bay of Bengal. The important tributaries of Mahandi inside Odisha are Ib, Ong, Tel, Jira, Bagh, Salki, Kuanria, Hariharjore, Sagada, Ret, Hati, Indra, Suktel, Utei, Remal, Udanti, Lanth, Sapua etc. The Major branches and sub-branches of Mahanadi are Kathajodi, **Birupa**, Kuakhai, Daya, Bhargavi, Kushabhadra, Biluakhai, Devi, Kandala, Chitrotpala, Luna, Karandia, Paika and **Badi Genguti**. All the major branches and sub branches including Mahanadi falls into Bay of Bengal. It enters the north west of modern Odisha in the Sambalpur district near padigan, a little above Hirakudand covers the distance of 494 km in the state before it falls into the Bay of Bengal.

425 km length of the river Mahanadi, from Sambalpur Barrage at Latitude 21°27'34.33"N, Longitude 83°57'49.80"E to Paradip at Latitude 20°19'38.12"N, Longitude 86°40'16.96"E, of the total of 494 km in Odisha has been earmarked for the present study. The study stretch is shown in the Figure 3 below.

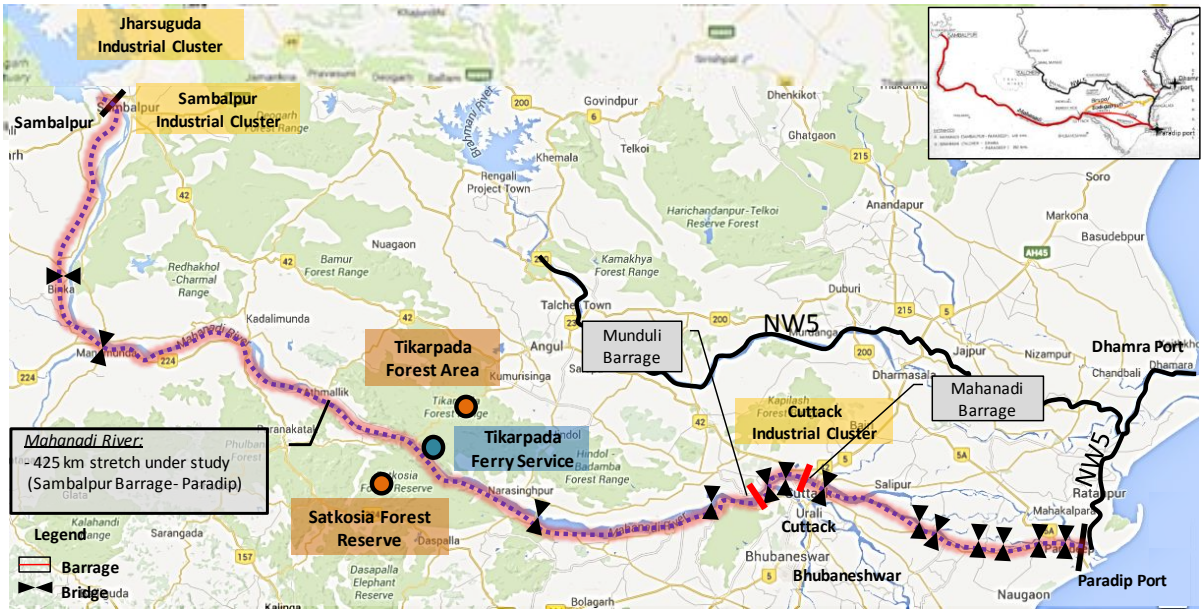


Figure 3: Mahanadi River stretch under study

II. Luna River

The river Luna is a branch of the river Mahanadi and originates from the village Tentola (20°27'5.40"N, 86° 2'7.39"E) and joins with river Mahanadi at village Balidia (20°20'15.61"N, 86°37'10.51"E). This has been surveyed as an alternate route to Mahanadi stretch within same co-ordinates due to availability of water. The length of the alternate path is nearly equal to the Mahanadi stretch i.e. 75 km. The study stretch is shown in Figure 4 below.

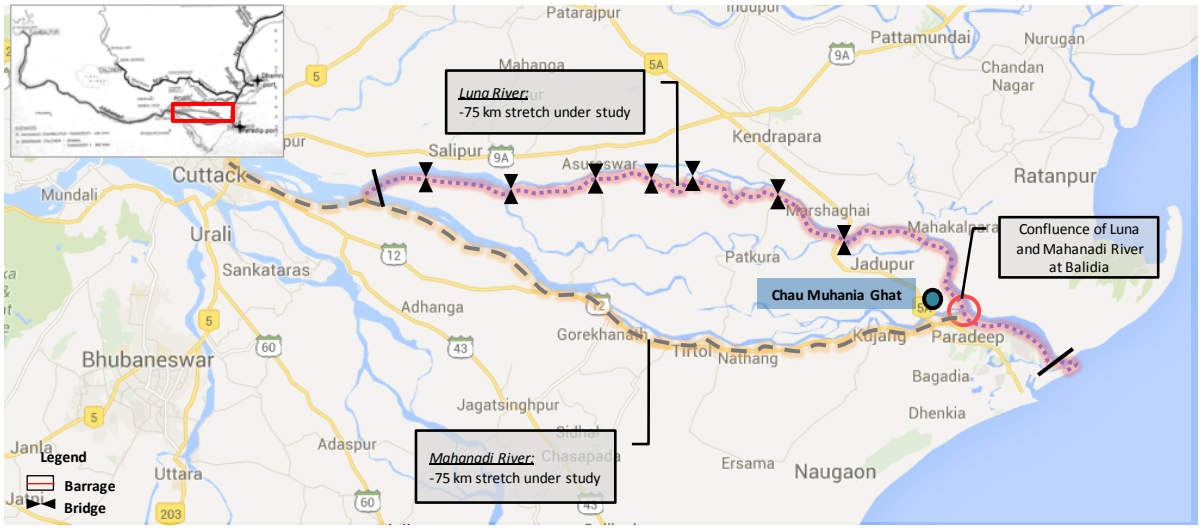


Figure 4: Luna River stretch under study

4.3 Basin information of rivers under study

4.3.1 Mahanadi Basin

The Mahanadi is the 8th largest basin having total catchment area of 139681.51 Sq.km which is nearly 4.28% of the total geographical area of the country. The geographical extent of the basin lies between 80°28' and 86°43' east longitudes and 19°8' and 23°32' north latitudes. It is physically bounded in the north by Central India hills, in the south and east by the Eastern Ghats and in the West by Maikala hill range. The map of Mahanadi basin is shown in Figure 5.

River	Total Basin Area	Basin Area in Odisha	Districts covered
Mahanadi	1,39,682	65,847	Jharsuguda, Baragarh, Sambalpur, Sonepur, Boudh, Bolangir, Nuapada, Kalahandi, Kandhama, Cuttack, Khordha, Puri and Angul

Table 2: Mahanadi Basin details

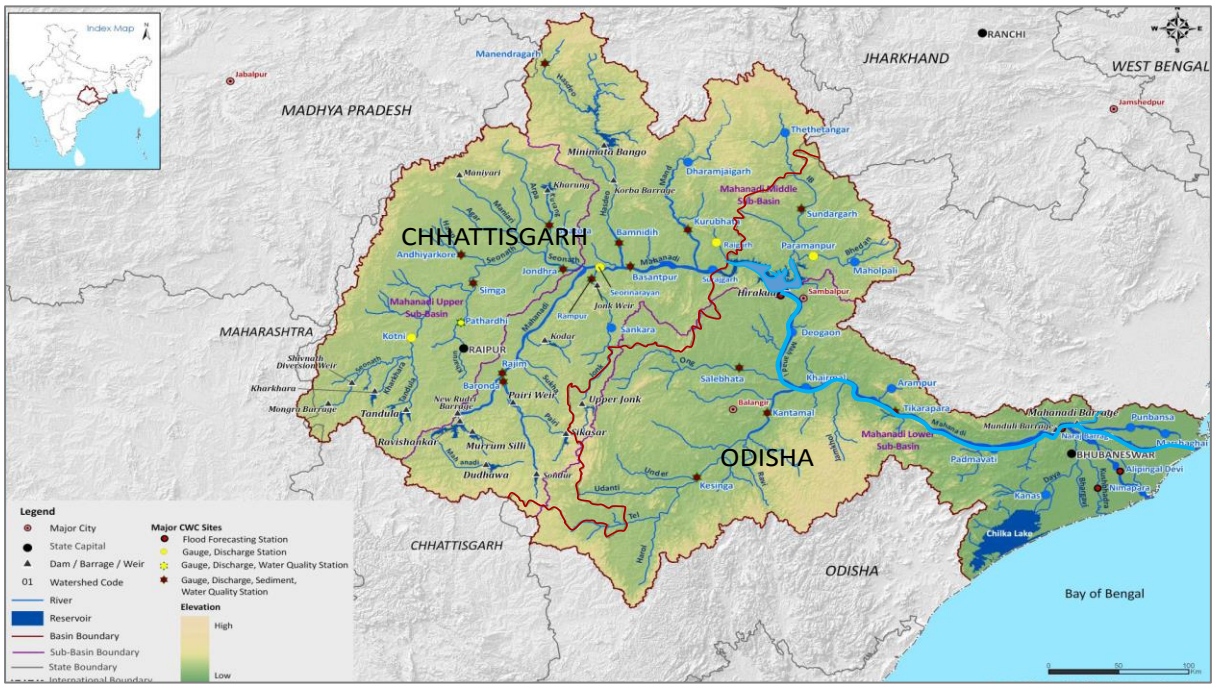


Figure 5: Map of Mahanadi Basin

I. Topography

The Mahanadi basin has varying topography with the lowest elevation in coastal reaches and highest elevation found in northern hills. The Mahanadi basin is divided into three sub-basins namely the Upper Mahanadi, Middle Mahanadi and Lower Mahanadi. The Mahanadi upper sub basin has predominant hilly terrain in its northern upper part. The middle Mahanadi sub basin has high hilly terrain in its north-eastern stretch. Odisha lies in Lower Sub Basin of Mahanadi that includes coastal plain stretching over the districts of Cuttack and Puri covers the large delta by Mahanadi and elevation decreases towards this deltaic stretch reaching upto 10-50 m.

II. Land use along the Mahanadi

Forty Six percent of the land along the river stretches under study is being used for agricultural purpose followed by 27 percent under forest. Fallow land constitutes 12 percent of the total land available. The chart below shows the land-use pattern along the river.

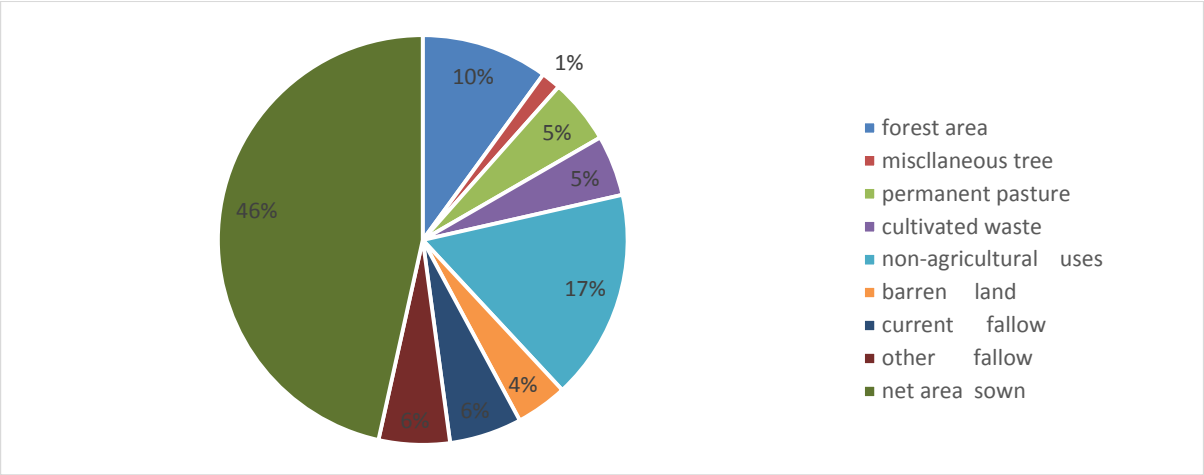


Figure 6: Chart showing landuse along Mahandi study stretch

4.4 Climate

The state has tropical climate, characterized by high temperature, high humidity, medium to high rainfall and short and mild winters. The south-west monsoon normally sets in the first week of June in the coastal plain, and by first week of July, the whole of the state is under the full sway of the south-west monsoons. By mid-October, the south-west monsoon withdraws completely from Orissa.

4.4.1 Rainfall

The normal rainfall of the state is 1451.2 mm. About 75% to 80% of rainfall is received from June to September. Floods, droughts and cyclones occur almost every year varying intensity. The graph below shows the rainfall trend from 1961 to 2013.

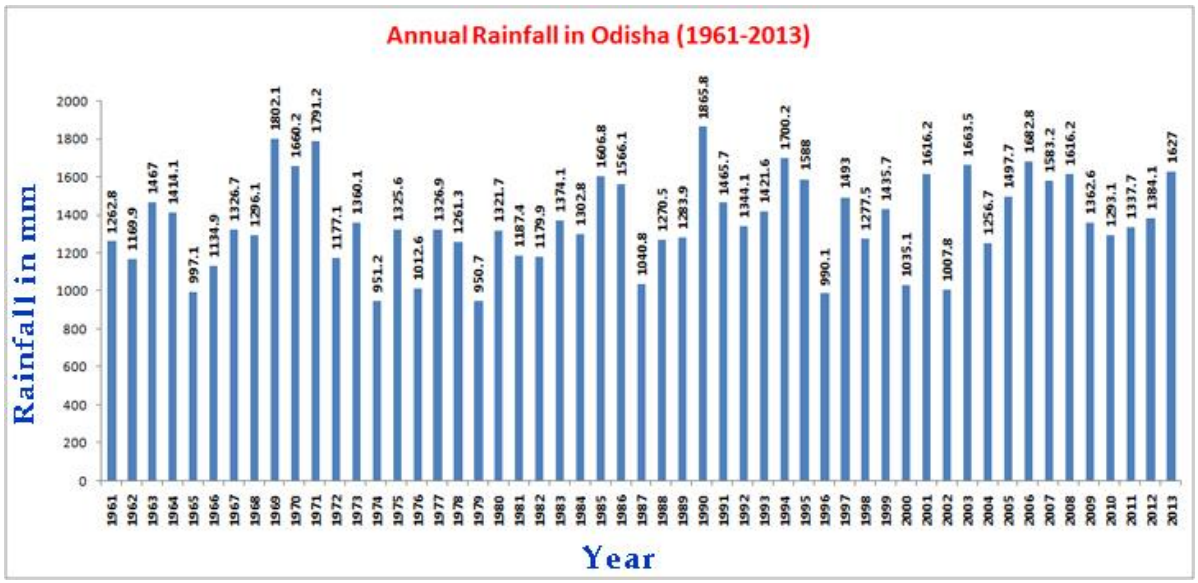


Figure 7: Rainfall trend from 1961-2013

CHAPTER 5
DATA COLLECTION & SURVEY METHODOLOGY

5 Data Collection and Survey Methodology

5.1 Details of primary and secondary surveys for stage-1

In addition to the methodology flowchart presented in Chapter 2.1, a detailed descriptive methodology of surveys and analysis for stage-1 has also been prepared which further details out the aspects which shall be covered and sample templates of the analysis which shall be carried out.

5.2 Secondary data collection

Consultant carried out secondary data collection from various stakeholders related to the waterway which included various Govt. agencies, PSUs, Central Water Commission etc. Detailed list of stakeholders consulted are as mentioned in Table below:

Central Water Commission	**Pollution Control Boards**
River Boards	**Committees**
Survey of India	**Census of India**
Industry Boards	**Statistical Department**
MoEF	**MoS/ IWAI**

Table 3: List of Stakeholders consulted

5.3 Primary data collection (Reconnaissance survey)

As part of the reconnaissance survey, the Consultant carried out the field surveys covering the inventory of major aspects including terrain, cross structures, land use, existing facilities etc. across the proposed Inland Waterways. The detailed flowchart of the reconnaissance survey is shown in below.

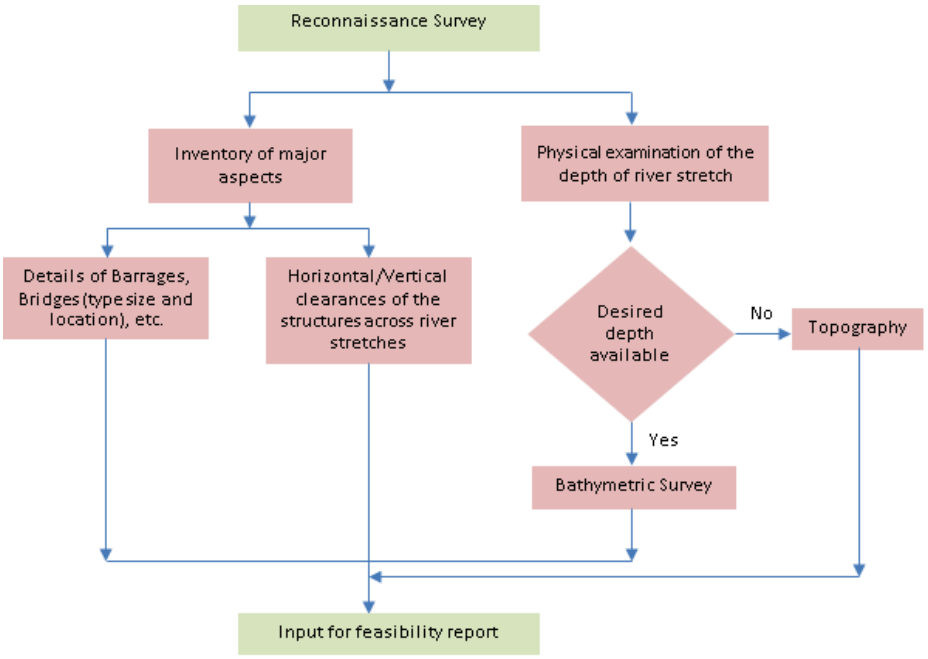


Figure 8: Flowchart showing Reconnaissance survey methodology

As part of the reconnaissance survey, the Consultant carried out single line bathymetric/ topographic survey. In addition to the single line bathymetry/topographic survey, details of bridges, cross structures such as barrages, weirs, terrain details, vertical and horizontal clearance etc. were collected during this reconnaissance survey.

Two survey agencies were appointed to carry out the above mentioned reconnaissance task. Given below are the details of the agencies:

S.No.	Survey Agency	River	Total length
1	GMI	Mahanadi River from CH:0km – CH:85km	85 km
		Luna River from CH: 0km - CH:75km	75km
2	Infratech Surveys	Mahanadi River from CH:85km to CH:425km	340 km

Table 4: List of the survey agencies appointed for Survey

5.4 Survey equipment details for reconnaissance survey

I. Bathymetric survey

The bathymetry survey will be carried out using Bathy 500 portable shallow water Echosounder supported by DGPS Beacon Receiver and HYPACK data collection and processing software. The survey will be carried out using a fiber boat with safety equipment. The Bathy- 500MF echosounder is an electronic hydrographic survey instrument used for measuring depths with precision chart recordings and digital data output. The Bathy-500 echo sounding systems are based on the principle that when a sound signal is sent into the water it will be reflected back when it strikes an object. HYPACK survey software is used for bathymetry data collection and processing. The Echosounder and DGPS receiver were interfaced through HYPACK software with onboard PC. The position and depth will be recorded along the pre-planned transect at determined interval continuously.

Survey vessel

Locally hired survey vessel was used for carrying out the survey.

Figure 9: Survey vessel

Position fixing

The position fixing was done by using differential global positioning system not less than 12 Channel receivers for sub-metre accuracy. Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that provides improved location accuracy.

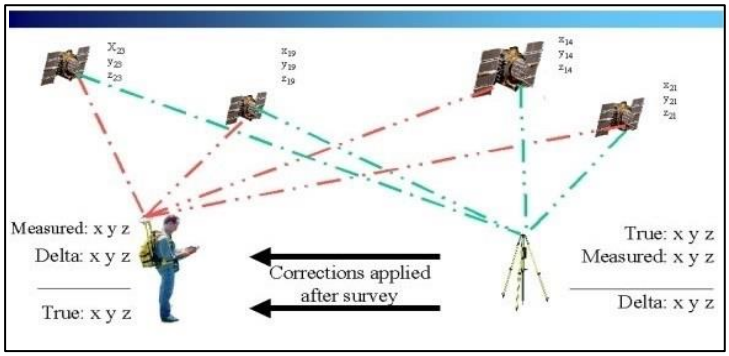


Figure 10: Position fixing using differential GPS

Other instruments

Hemisphere R110 DGPS system

For present study one Hemisphere R110 DGPS system (Receiver) was used.

Navigation & data logging system

- To provide on-line route guidance, log navigation data, provide QC of navigation data, etc. The system comprises of the following equipment:
- One HP Laptop
- One HYPACK Version 2012 Navigation & Data Logging Software
- One Positioning & sensor interfaces
- Sufficient Paper Rolls

The survey was conducted in WGS-84 spheroid with no datum transformation.

Local Datum Geodetic Parameters	
Spheroid	WGS-84
Datum Transformation	None
Semi-major axis (a)	6378137.0000 m
Semi-minor axis (b)	6356752.3142 m
Eccentricity	0.0818 191909 28906
Inverse flattening (1/f)	298.257223563
Projection Parameters	
Grid Projection	Universal Transverse Mercator
Central Meridian (CM)	87 ° East (Zone 45)
Origin Latitude (False Lat)	0.0°
Hemisphere	North
False Easting (FE)	500000.0 m
False Northing (FN)	0.0 m
Scale Factor on CM	0.999600
Units	International Meters

Table 5: Local Datum Geodetic Parameters

Single Beam Echo Sounder System

Single beam echo sounders are by far the most numerous sonar systems in use today. They are used on a wide range of vehicles from small pleasure boats, to huge cruise ships and tankers. They span a wide range of applications including:

- Water depth indicators, both for bottom avoidance and for navigation
- Fish finding, both sport and commercial
- Bottom classification, (rock, silt, eelgrass, etc.)
- Military, target localization
- Upward looking, for submarine ice avoidance
- Surveying, both for navigational charts and for resources exploration

Single beam sonars measure the time it takes for an acoustic pulse to travel from the sonar transducer to the bottom and back up to the sonar transducer.

The depth is given by the following equation.
Z=t*c/2

Where Z is the depth, t is the time, c is the average sound speed and the division by two accounts for the pulse having to travel the distance in both directions. Following are some of the instruments used for present study.

Bathy 500 dual frequency Echo Sounder

One Dual frequency transducer 33kHz & 200 kHz + mounting bracket & base plate.

Survey software (HYPACK)

Survey software was used for data collection and processing. It is integrated, first generation hydro graphic survey software developed by Coastal Oceanographical INC., USA. It works in MS Windows operating environment. The HYPACK's design program allows importing background map in CAD's DFX or Microsoft's DGN format. It enables to quickly create planned survey lines, plotting sheets and bottom coverage grids in a graphical environment. The survey tracks were planned using this software for accurate manoeuvring of the vessel and to keep the accuracy of the track. The post processing of the survey data and preparation of map were carried out using this software.

II. Topographic survey

Following are the instruments used for topographical survey

- Two Trimble SPS 855 RTK System with one Base and two Rover
- One Nikon Auto level with levelling stave
- Three Auto Level with levelling staves and tripod

Figure 11: Topographic Survey Instrument (Two Trimble SPS 855 RTK System)

CHAPTER 6
TECHNICAL ANALYSIS

6 Technical Analysis

In this section, various parameters like analysis of present state of affairs, details of single line bathymetry/topography survey, water depth details, details of bridges/cross structures and other salient features along the river, river bed profile, available navigable stretch, classification of waterways etc. are covered.

6.1 Analysis of present state of affairs – Mahanadi

River Mahanadi, one of the major rivers of Odisha is the sixth largest river in India having various tributaries. Mahanadi originates from the Maipal range in Chhatisgarh popularly known as the Amarkantak plateau. The biggest tributary is Kathajodi river and it originates from north of Cuttack city at Naraj. Then it enters the north west of modern Odisha in the Sambalpur district near padigan, above Hirakud. Hirakud dam, the longest major earthen dam in Asia, has been built across the river.

6.2 Zoning

Mahanadi Stretch has been divided into four zones and each zone has been explained in separate sections. Zone - 0 is from Paradip sea mouth to Cuttack (CH:0 – CH:100km), Zone - I is from Cuttack to Tikarpada(CH:100 – CH:251.6), Zone – II is from Tikarpada to Sonepur(CH:261.6 - CH:346.6) and Zone – III is from Sonepur to Sambalpur(CH:346.6 to CH:425) Given below is the zoning map of the Mahanadi river stretch.

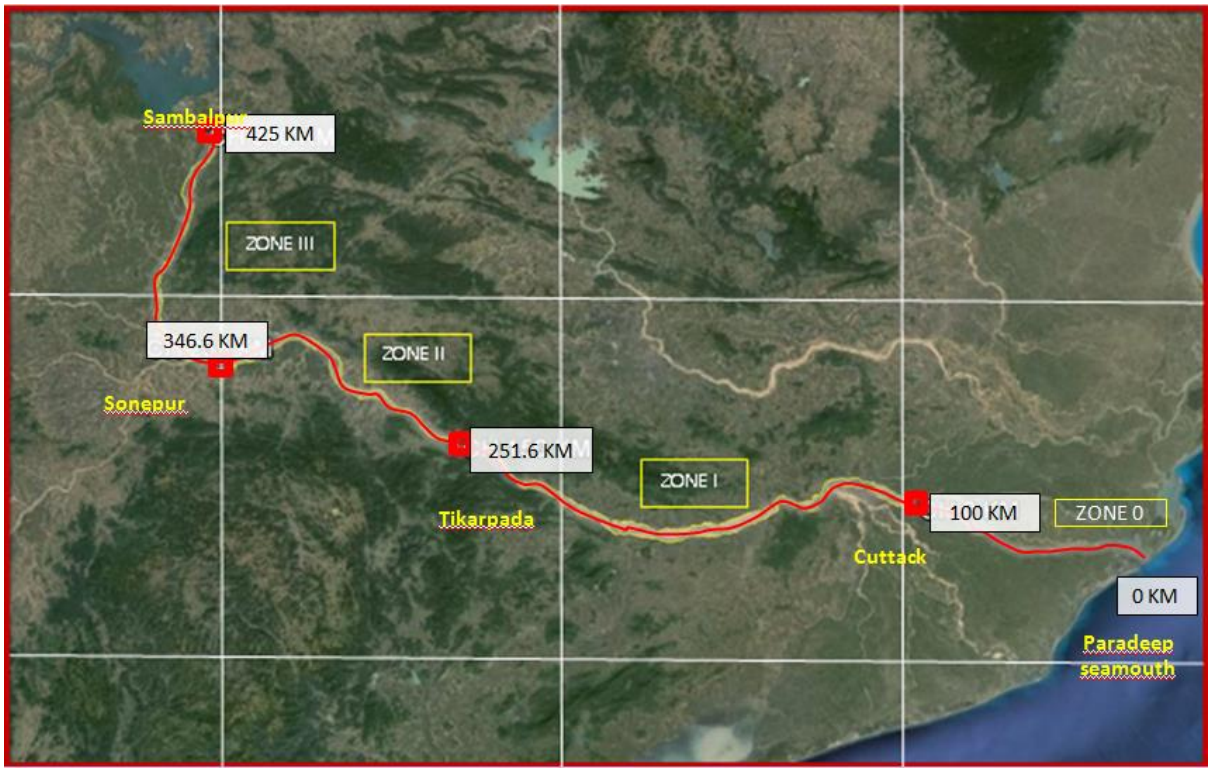


Figure 12: Zoning of Mahanadi under study

6.2.1 Mahanadi Zone- 0 (CH: 0km – 100km)

The Zone 0 extends for a distance of about 100km from Paradip sea mouth to Jobra barrage at Cuttack. The survey for this area was conducted in February, 2016.

During the survey, navigable water has been found in initial 38km from Paradip sea mouth to upstream. Balance portion was found to be dry. Bathymetric survey has been carried out for 35km and topographic survey was conducted for the remaining portion. The tidal influence zone in the region is about 35km upstream from the sea mouth. The H.F.L at Naraj gauge station i.e. 27.610m above M.S.L has been adopted in this zone. Site observation revealed that most of the discharge of water from Jobra barrage flows through the river Luna which is the tributary of Mahanadi. The Mahanadi river Zone-0 stretch under study is shown in Figure below.

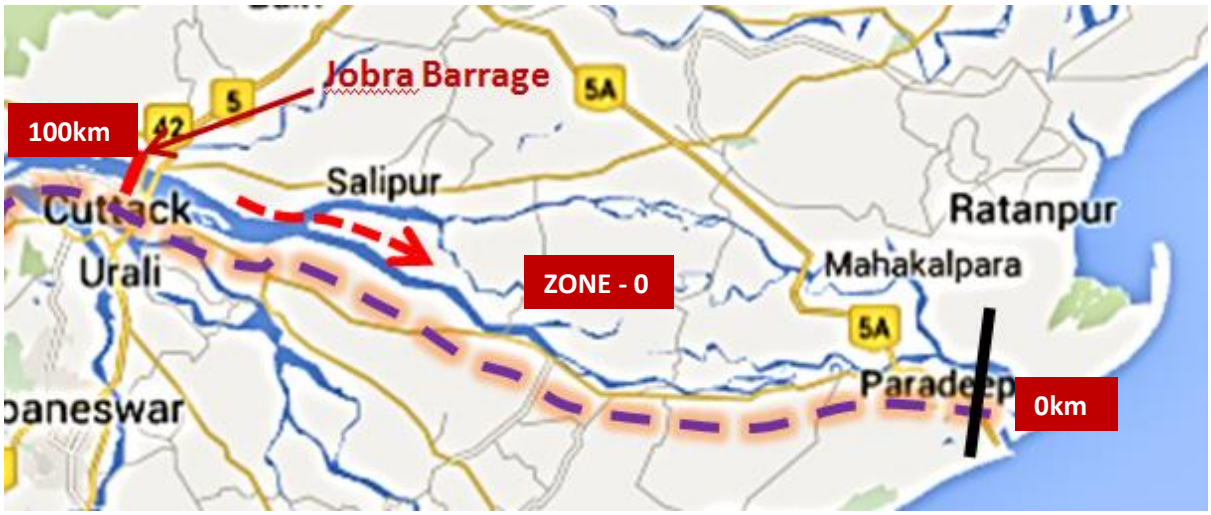


Figure 13: Mahanadi Map from Ch. 0km to Ch. 100km (Zone-0)

I. Water Depth Details

River in this zone is found to have water depth ranging from 0.0m to 10.0m. During the survey, lot of dry areas were observed in this section of the river and this was due to water diversion to another River Luna (discuxxed later).

S.No.	Chain-age (km)	Draft Variation		Length of River (km)				Zone
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1 m	1-1.5 m	1.5-2.0 m	>2.0 m	
1	0 - 5	10	0.6	0.5	0.7	0.8	3	Zone - 0
2	5 - 15	8.3	0.1	3.1	1.2	1.5	4.2	
3	15 - 25	8.1	0	1.5	2	2.4	4.1	
4	25 - 35	4.6	0.5	3.1	1.6	1.5	3.8	
5	35 - 37.84	8.2	0.5	1.4	0.6	0.5	0.4	
6	37.84 - 100	0	0	62	DRY AREA			
		Total (km)		71.6	6.1	6.7	15.5	

Table 6: Water depth details of Mahandi from Ch. 0 to Ch. 100 (Zone-0)

As the river bed in this stretch mainly consist of sand and silt, the stretch can be made navigable through technical intervention such as dredging.

II. Bridge Details

Given below is the detailed account of the bridges along the study stretch of Mahanadi (Zone–0).

S.No.	Name	Chain-age (km)	Easting	Northing	Vertical Clearance w.r.t. H.F.L (m)	Horizontal Clearance (m)	Place
1	Kessan-Nagar Bridge	79.2	405253.74	2259622.3	3	21	Kessan-Nagar
2	Rahama Bridge	37.8	437957.45	2246075.8	6	40	Rahama
3	Tarapur Bridge	59.6	419396.67	2251416.3	6	36	Tarapur
4	Tartol Bridge	41.5	434723.55	2246575.8	6	40	Tartol
5	Bhutamundai Bridge	17.4	455431.96	2248371.6	6	38	Bhutamundai
6	Bhutamundai Bridge	17.6	455461.66	2248384.4	7	38	Bhutamundai
7	Bhutamundai Rly Bridge	16.5	456111.26	2248835.5	7	38	Bhutamundai

Table 7: Bridge details of Mahanadi (Zone-0) River

III. Cross Structure Details

Given below is the detailed account of the High Tension lines across the Mahanadi (Zone–0).

S.No.	Name	Easting	Northing	Vertical Clearance w.r.t. H.F.L (m)	Place
1	High tension line	455818.97	2248605.73	12	Bhutamundai
2	High tension line	457336.06	2248888.16	12	Bhutamundai

Table 8: High Tension Line details across Mahanadi (Zone-0)

IV. Images of structures across Mahanadi River

Given below are the images of structures across Mahanadi River (Zone 0):

Figure 14: Bhutamundei Bridge (CH:17.4km) across Mahanadi River

Figure 15: Bhutamundei NH Bridge (CH:17.6km) across Mahanadi River

Figure 16: Bhutamundei Rail Bridge (CH:16.5km) across Mahanadi River

Figure 17: Kessann Nagar Bridge(CH: 79.2km) across Mahanadi River

Figure 18: Rahama Bridge (CH: 37.8km) across Mahanadi River

6.2.2 Mahanadi Zone – 1 (CH: 100km – 251.6km)

Zone 1 extends from 100 km at Cuttack to 251.6 km near Satkosia Forest at Tikarpada. The survey for this area was conducted from 18th April to 26th April, 2016. The maximum depth at Zone I area was about 12.6m w.r.t MSL near western side of Railway Bridge at Naraj. The average depth from Cuttack to Tikarpada was around 2.0 m. Many sandbars and few island was seen on the Mahanadi river in this stretch. Water depth was relatively more near Cuttack barrage and Naraj Barage. The

H.F.L at Naraj gauge station and Tikarpada gauge station (i.e. 27.610m and 74.980m above M.S.L respectively) has been adopted in this zone.

There were no major river drain/mixes with Mahanadi in the Zone I area. Chandaka forest and elephant reserves are present on the southern bank of the river near Chandaka. Anushupa lake present on the northern bank of the river which attracts tourism.

The width of the river varies 2000 m at CH:100 km to 600 m at CH: 235 km. The maximum width of the river is about 3500 m at Kantilo and Banki.

Five groins each 15 m length are located on the northern bank of the river at an interval of around 100 m on the eastern side of Cuttack.

Presence of Satkosia reserved forest on the both side of the river near Tikarpada. Forest area at upstream of Zone I runs parallel to the river from Tikarpada to Ranikhol of around 25 km. The Forest dept. didn't allow the survey agency to carry out survey during initial survey period from CH:229.6km to CH: 251.6km due to security reasons. The survey for this stretch has been carried out on 25th to 29th July, 2016. The Mahanadi river Zone-1 stretch under study is shown in Figure below.

Figure 19: River stretch under study Mahanadi (Zone – 1)

I. Water Depth Details

Around 150km long river stretch in this zone is found to have varying water depth with average minimum and maximum depth recorded at 0.5m and 5.8m respectively (all the depths have been adjusted with respect to CD).

S.No.	Chainage (km)	Draft Variation		Length of River (km)				Zone
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m	
1	100 - 105	4.6	1	0	1.1	1.1	2.8	
2	105 - 115	4.1	0.7	1.1	2.2	2.8	3.9	
3	115 - 125	12.6	0.5	0.6	1.6	1.4	6.4	**Zone – 1**
4	125 - 135	6.9	0.5	0.6	0.6	1	7.8	
5	135 - 145	6.9	0.5	1	2.8	3	3.2	

S.No.	Chainage (km)	Draft Variation		Length of River (km)				Zone
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m	
6	145 - 155	8.4	0.5	1.1	3.1	3	2.8	
7	155 - 165	3.1	0.5	1.1	3.6	3.6	1.7	
8	165 - 175	4.9	0.5	1.1	2.2	2.2	4.5	
9	175 - 185	3.8	0.5	1.7	3.6	3.6	1.1	
10	185 - 195	7.8	0.5	1.7	3.3	2.8	2.2	
11	195 - 205	3.7	0.5	1.1	3.3	2.8	2.8	
12	205 - 215	3.7	0.5	1.1	3.3	3.4	2.2	
13	215 - 225	3.1	0	2.2	3.3	3.4	1.1	
14	225 - 229.6	2	0.5	2.3	1.2	1.1	0	
15	229.6 to 240	7.8	0.5	0.8	0.8	2.4	6.4	
16	240 to 251.6	9	0.5	0.9	1.8	2.7	6.2	
Total				18.4	37.8	40.3	55.1	

Table 9: River depth details Mahanadi from Ch.100km to Ch. 251.6km (Zone – 1)

More than 62 percent of the stretch has greater than 1.5m water depth making it navigable. Rest of the stretch can be made navigable through technical interventions as river bed in this stretch has sandy soil texture.

II. Bridge Details

Given below is the detailed account of the bridges along the study stretch of Mahanadi River (Zone-1).

S.No.	Name	Chainage (km)	Easting	Northing	Vertical Clearance w.r.t. H.F.L (m)	Horizontal Clearance (m)	Place
1	Nh5 Bridge	100	386667	2265245	5.0	20.0	Cuttack
2	Railway Bridge	100.5	386381	2265452	5.0	20.0	Cuttack
3	Jobra Barrage (No Navigation Lock)	101	385823	2265749	5.0	20.0	Cuttack
4	Railway Bridge	120	370703	2264265	4.5	46.0	Naraj
5	Mundali Barrage (No Navigation Lock)	123.5	368633	2261725	5.5	20.5	Mundali
6	Ghasiput Bridge	141	353946	2258707	5.5	41.7	Ghasiput
7	Sidhamula Bridge	200	303589	2257138	5.5	45.0	Sidhamula

Table 10: Bridge details of Mahanadi (Zone-1) River

III. Cross Structure Details

Given below is the detailed account of the High Tension lines/Cable lines across the Mahanadi river (Zone–1).

S.No.	Name	Easting	Northing	Vertical Clearance w.r.t H.F.L (m)	Place
1	HTL Crossing	378810	2267344	7.0	Near Cuttack
2	Cable Crossing	370936	2264517	8.0	Naraj
3	HTL Crossing	370187	2263991	6.0	Naraj
4	HTL Crossing	370219	2263833	7.0	Naraj
5	HTL Crossing	369755	2263156	7.0	Naraj
6	HTL Crossing	303231	2257423	6.5	Sidhamula
7	HTL Crossing	301222	2257906	6.0	Sidhamula
8	HTL Crossing	295403	2260769	6.0	Rasanga

Table 11: High Tension Line and Cable Line details of Mahanadi (Zone-1) River

IV. Images of structures across Mahanadi River

Given below are the images of structures across Mahanadi River (Zone-1):

Figure 20: Mundali Barrage (CH: 123.5km) across Mahanadi River

Figure 21: Jobra Barrage (CH: 100km) across Mahanadi River

6.2.3 Mahanadi Zone – 2(CH: 251.6km – 346.5km)

Zone 2 extends from 251.6km at Tikarpada to 346.5km at Sonepur. The survey for this area was conducted in April 2016. The H.F.L at Tikarpada gauge station i.e. 74.980m above M.S.L has been adopted in this zone.

During Bathymetry survey, water was observed intermittently varying from 0.3m to 1.7m. Due to lack of water, Topography has been carried out in this stretch. However, no rocky strata or any show stoppers were observed in this area. The Mahanadi river Zone -2 stretch under study is shown in Figure below.

Figure 22: River stretch under study Mahanadi (Zone – 2)

I. Water Depth Details

This 95km of the river stretch constituting zone 2 of Mahanadi study stretch is found to have water depth of less than 1.0m for nearly entire stretch with majority of it being dry. However, the soil texture in this zone is found to be sandy and therefore, can be dredged to make it navigable.

S.No.	Chainage (km)	Draft Variation		Length of River (km)				Zone
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m	
1	251.6 km - 346.5km	1.7	0.3	95	During Bathymetry survey, water observed intermittently varying from 0.3m to 1.7m. Due to lack of water, Topography has been carried out in this stretch. However, no rocky strata or any show stoppers were observed in this area.			**Zone - 2**

Table 12: River depth details Mahanadi from Ch.251.6 km to Ch. 346.5km (Zone – 2)

II. Bridge Details

Given below is the detailed account of the bridges along the study stretch of Mahanadi River (Zone-2).

S.No.	Name	Chainage (m)	Easting	Northing	Vertical Clearance w.r.t. H.F.L (m)	Horizantal Clearance (m)	Place
1	SH 62 Bridge	310	220174.8	2308989	5.8	25.45	Hatuapada

Table 13: Bridge details of Mahanadi (Zone 2)

6.2.4 Details of Rivers joining Mahanadi

Given below is the detailed account of the rivers joining to Mahanadi River (Zone-2).

S.No.	Name	Easting (m)	Northing (m)
1	Surubali river	206772	2312930
2	Harihara river	199709	2308370
3	Manjore river	225225	2301509

Table 14: Rivers joining to Mahanadi River (Zone-2)

6.2.5 Mahanadi Zone – 3 (346.5km – 425km)

Zone 3 extends from 346.5 KM at Sonepur to 425KM at Sambalpur. The survey for this area was conducted from May, 2016. The H.F.L at Deogaon gauge station i.e. 130.160m above M.S.L has been adopted in this zone.

Most of the area in Zone-3 was occupied by rocky patches for the entire stretch except at (CH: 374km to CH: 380km). Many outcrop rocks were seen in the entire stretch. There was no water flow on the river because of the presence of rocky patches. The Mahanadi river Zone-3 stretch under study is shown in figure below.

Figure 23: River stretch under study - Mahanadi (Zone – 3)

I. Water Depth Details

The entire river stretch of 78 km in this zone is found to be rocky and cannot be made navigable. Thus, this part is being rejected by the consultant.

S.No.	Chainage	Draft Variation		Length of River (km)				Zone
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m	
1	346.5km - 425km	0	0	78.5	Most of the area was occupied by rocky patches for the entire stretch except at (CH 374km to CH 380km). Many outcrop rocks were seen in the entire stretch. **Navigation in this area is not possible.**			**Zone - 3**

Table 15: River depth details Mahanadi from Ch.346.5 km to Ch. 425km (Zone – 3)

II. Images of structures across Mahanadi River (Zone 3)

Figure 24: Sonepur bridge at CH: 357km

Figure 25: Binka bridge at CH: 381km

Figure 26: Rocky strata at CH: 370km

Figure 27: Rocky strata at CH: 400km

6.3 Analysis of present state of affairs – Luna River

The river Luna is an anabranch of the Mahanadi and it originates from the village Tentola and joins with Mahanadi at the village Balidia. The total distance of this river is 75km. The survey was carried out in this stretch during February, 2016. During the course of survey it was observed that, ferry services are available at CH:3km at Chhau Muhania Ghat. It was observed during the course of

survey that the maximum water of Mahanadi passes through Luna river. There is a tidal effect in this river up to a distance of 25 km from Balidia village which is approx. 35 km from Paradip sea mouth. The H.F.L at Naraj gauge station i.e. 27.610m above M.S.L has been adopted in this zone. The main crop grown is paddy. The villages are dependent on cultivation and fishing. During the monsoon most of the agricultural land and villages gets inundated due to floods and being low lying areas. The Luna river stretch under study is shown in following Figure.

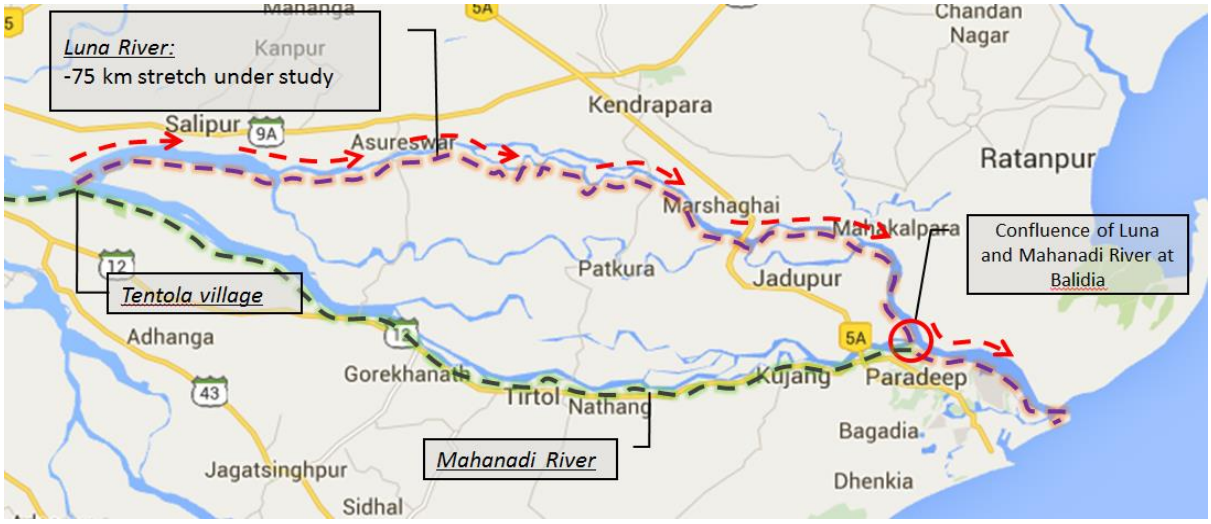


Figure 28: Luna River stretch under study

I. Water Depth Details

An alternate route to Mahanadi from Ch. 37.8km to 100km, 77 percent of the Luna River has water depth of more 1.0m. Around 36km of the total 80km investigated stretch has water depth of greater than 1.5m.

S.No.	Chainage (km)	Draft Variation		Length of River (Km)			
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m
1	0-10	10.8	1	0.54	1.35	2.16	5.95
2	10-20	13.6	0	0.54	1.62	2.16	5.68
3	20-30	6.6	0	3.24	2.7	2.16	1.9
4	30-40	3.7	0.1	3.78	2.97	2.17	1.08
5	40-50	10.7	0.1	1.62	2.16	3.52	2.7
6	50-60	2.2	0	6.21	2.44	1.08	0.27
7	60-70	2.5	0	6.21	1.9	1.21	0.68
8	70-80	3.7	0	4.59	2.16	1.9	1.35
		TOTAL		**26.73**	**17.3**	**16.36**	**19.61**

Table 16: River depth details Luna River, an alternate stretch to Mahanadi from Ch.37.8km to Ch. 100km

II. Bridge Details

Given below is the detailed account of the bridges along the study stretch of Luna river.

S. No.	Name	Chain-age (km)	Easting	Northing	Vertical Clearance w.r.t. H.F.L (m)	Horizontal Clearance (m)	Place
1	Sisua bridge	76.25	403433.50	2263245.33	5	13	Sisua
2	Barpada bridge	63	414026.84	2261705.42	5	25	Barapada
3	Ashureswar bridge	54.5	421704.29	2262839.08	7	30	Ashureswar
4	Danapur bridge	49	426501.90	2263869.95	Under Construction		Danapur
5	Basapur bridge	40	433093.96	2262673.60	3	36	Basapur
6	Kalapada bridge	30.3	440133.91	2261416.87	7	28	Kalapada
7	Marshaghai NH bridge	20.9	447051.30	2256853.80	7	43	Marshaghai
8	Marshaghai NH bridge	20.8	447077.35	2256841.58	7	43	Marshaghai

Table 17: Bridge details of Luna River

Given below are the details of HTL/cable lines along the study stretch of Luna River.

S.No.	Name	Easting	Northing	Vertical Clearance w.r.t. H.F.L (m)
1	HTL	413541.27	2261787.05	15
2	HTL	425732.82	2263573.55	6
3	HTL	425746.51	2263586.69	5
4	HTL	428923.73	2262474.35	4
5	Electric line	430340.91	2261812.87	5
6	HTL	431264.46	2262506.51	4
7	HTL	432657.45	2262204.92	4
8	HTL	438346.24	2261227.29	5.5
9	HTL	439014.71	2261384.86	5
10	HTL	447161.33	2256798.63	15
11	HTL	447234.36	2256746.87	15
12	HTL	450859.10	2257373.95	5
13	Cable line	451117.09	2257369.92	3

Table 18: Details of HTL/cable lines along the study stretch of Luna River

Given below are the details of stones along the study stretch of Luna River.

S.No.	Name	Easting	Northing
1	Stone wall	427773.59	2263009.39
2	Stone in the river	444190.74	2257467.76
3	Stone in the river	444251.99	2257440.58
4	Stone in the river	444300.91	2257396.02

Table 19: Details of stones along the study stretch of Luna River

Given below is the details of the river joining Luna

S.No.	Name	Easting	Northing
1	Kurandi river	427611.84	2263164.42

Table 20: Details of river joining Luna

III. Images of structures across Luna River.

Figure 29: Sisua bridge at CH: 76.25km

Figure 30: Barpada bridge at CH: 63km

Figure 31: Kalapada bridge at CH: 30.3km

Figure 32: Ashureswar bridge at CH: 54.5km

Figure 33: Basapur bridge at CH: 40km

Figure 34: Marshaghai NH bridge at CH: 20.8km

6.4 Reconnaissance Survey

Tidal Influence zone and Tidal Range:

It was observed that 35km from the Paradip sea mouth to Chandapur is tidal effected. The tidal range in Odisha coast varies from 2.8 m during springs to 0.7 m during neaps.

6.4.1 Description of the Benchmarks

I. Horizontal Control

The survey boat used for the survey operations throughout the project was positioned by the Differential Global Positioning System (DGPS). Differential corrections were received continuously from the nearest existing DGLL beacons at Paradip which are capable of transmitting corrections up to range of 250 kilometres.

The Hemisphere DGPS Receiver was used for positioning of the depths. The position correction details were received from the nearest DGLL Beacon at Paradip Port and position data were found to be in differential mode, and in order.

For topographic survey horizontal control was carried out from IWAI Bench mark MP7 for Mahanadi and Luna stretch.

II. Vertical Control

Chart Datum (CD) at the Tidal portion – Mahanadi and Luna stretch:

Datum values in tidal regions, i.e, till 35km for Mahanadi and 25km for Luna stretch, soundings observed were reduced to Chart datum using real time tidal observation and applying MSL~CD value of -1.228m for the already established IWAI Bench Mark MP7 of NW5 near Paradip river mouth. The coordinates of Chart Datum (CD) used is given below.

S. No.	Location	Easting	Northing	Z_0(m)
1	IWAI Bench Mark MP7 of NW5	464241.2	2247376	-1.228m (below MSL)

Table 21: Coordinates of Chart Datum

Chart Datum / Sounding Datum at Non- tidal region – Mahanadi and Luna stretch:

- As instructed by IWAI, datum value in non-tidal region was fixed as average lowest water level for a period of last six years data at Naraj obtained from IWAI.
- The datum value for in between bench marks are derived by interpolation method.

Yearly Minimum and Maximum water levels

Below table shows yearly maximum and minimum water levels at Naraj gauging site:

S.No.	YEAR	Max. Water Level(m)	Min. Water Level(m)
1	2006-2007	26.680	20.360
2	2007-2008	25.800	20.500
3	2008-2009	27.150	20.180

S.No.	YEAR	Max. Water Level(m)	Min. Water Level(m)
4	2009-2010	26.100	20.140
5	2010-2011	26.260	20.280
6	2011-2012	27.540	20.680
7	2012-2013	26.020	20.360
8	2013-2014	26.100	20.800
9	2014-2015	26.840	20.320
10	2015-2016	22.570	20.400

Table 22: Yearly minimum and maximum water levels

As per the discussion with IWAI, Sounding datum in rivers is taken as average of minimum yearly water level for last six years at Naraj gauging site. The gauge discharge data of Naraj site was collected from CWC. Accordingly, the C.D at G.D site has been arrived as below:

C.D at Naraj G.D site = (20.400+20.320+20.800+20.360+20.680+20.280)/6 = 20.473m w.r.t. MSL

A straight line was drawn joining the CD level at this gauge station with the CD level at the river estuary. Thereafter, the CD levels at every 10km stretch of the river were interpolated for computing the height of the river bed with respect to these interpolated CD levels.

The map below show the location of benchmarks.

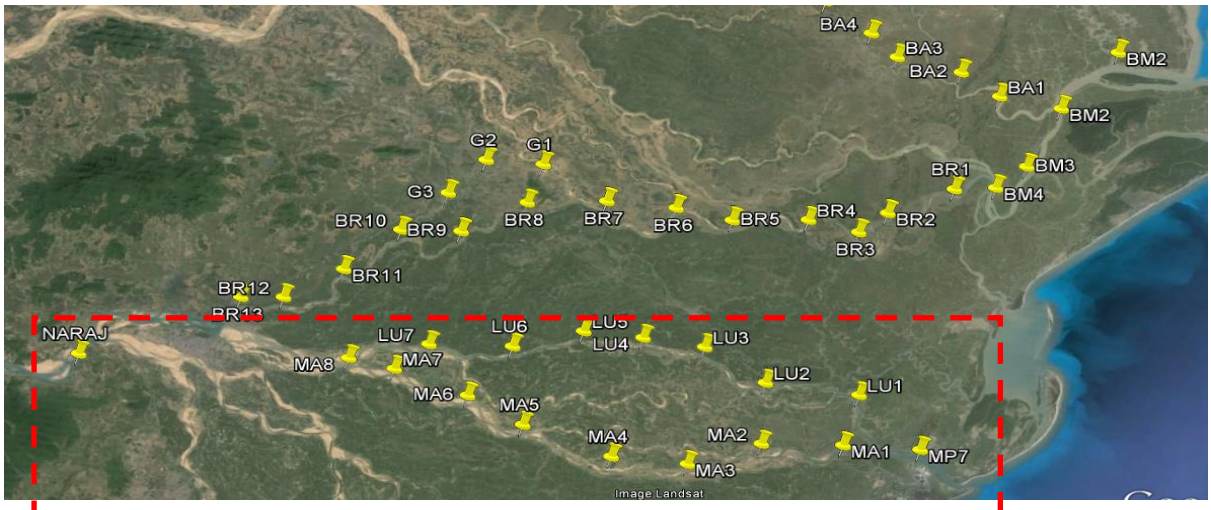


Figure 35: Bench Mark Details

Chart Datum/Sounding Datum at Non- tidal region from Naraj to Sambalpur– Mahanadi stretch:
Similarly the average of minimum yearly water level for last six years at Tikarpada and Deogaon gauging site has been found out for the remaining stretch from Naraj to Sambalpur. The gauge discharge data of Tikarpada and Deogaon site was collected from CWC. Accordingly, the C.D at G.D sites has been arrived as below:

C.D at Tikarpada G.D site = (54.230+54.420+54.500+54.060+54.090+54.200)/6 = 54.250m w.r.t. MSL
C.D at Deogaon G.D site = (120.000+120.150+120.260+119.990+119.820+120.010)/6 = 120.038m w.r.t. MSL.

6.4.2 Hydrographic Surveys

I. Bathymetric Survey

On conduct of Bathymetric survey from Paradip, it was found that the tidal area is up to 35 km north in Zone-0. Hence the Bathymetric Survey could be conducted in the water bound areas. The rest of the area till Naraj in Zone-0 was dry due to lean season. In Zone -1 from CH:100km to Ch:229.6km, Bathymetric survey was carried out. On field observation, it was found that the discharge of water from Jobra barrage flows through the river Luna which is a branch of Mahanadi.

In Luna River - the tidal area is upto 35km from Paradip sea mouth. For the entire stretch of Luna River, bathymetric survey has been carried out.

II. Topographic Survey

Topographic survey was conducted wherever there were no water. Following are the portions in which Topographic survey was carried out:

Zone-0 - Topographic survey was carried out from CH: 37.84 to CH: 100km

Zone-2 - Topographic survey was carried out from CH: 251.6km to 346.5km

Zone-3 - Topographic survey was carried out from CH: 346.5km to CH: 425km

6.5 River details - Mahanadi River

6.5.1 Bathymetry Data Collected - Mahanadi River (Zone 0):

Mahanadi River from (CH: 0km - 5km) – Tidal Zone

This section extends from Paradip Sea Mouth to Musadia. This is the estuary portion of the river where it meets Bay of Bengal, and hence influenced by tidal variations. The minimum depth recorded in this section is 0.5m w.r.t. CD and the maximum depth recorded is 10m w.r.t. CD. The width of the river varies from 710m to 1700m in this section.

Mahanadi River from (CH: 5km - 15km) - Tidal Zone

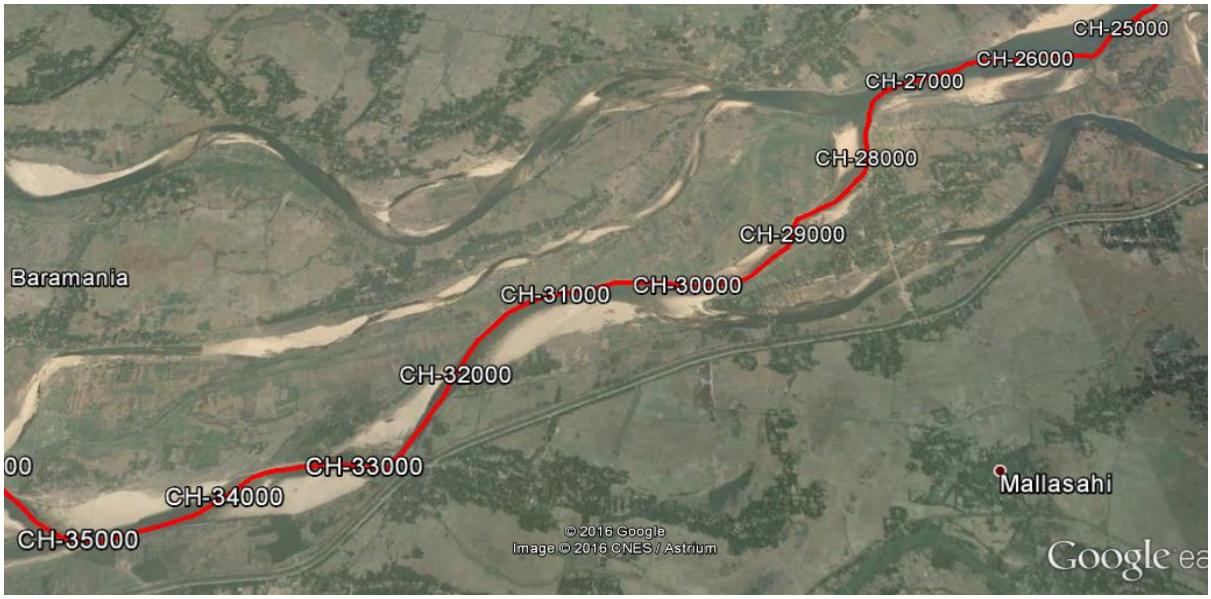
This section extends from Musadia to Singitalia. River Luna meets at this section (CH:13km). The minimum depth recorded in this section is 0.1m w.r.t. CD and the maximum depth recorded is 8.3m w.r.t. CD. The width of the river varies from 290m to 1440m in this section.

Mahanadi River from (CH: 15km - 25km) – Tidal Zone

This section extends from Singitalia to Bhandua. The minimum depth recorded in this section is 0.1m w.r.t. CD and the maximum depth recorded is 8.1m w.r.t. CD. The width of the river varies from 150m to 580m in this section. Bhutamundai NH bridge(CH:17.4km), Bhutamundai railway bridge(CH:16.5km) and 3 High tension lines passes across the river at this section. At the southern bank, small streams were found to be running parallel to the main river joining it at CH:21km.

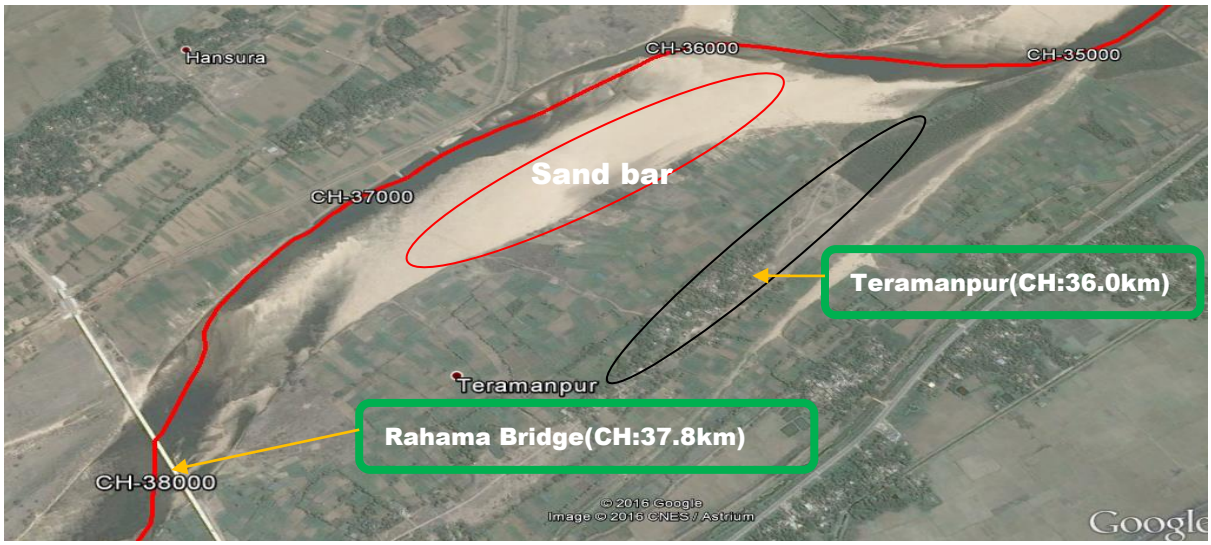
Mahanadi River from (CH: 25km - 35km) – Tidal Zone

This section extends from Bhandua to Teramanpur. The minimum depth recorded in this section is 0.5m w.r.t. CD and the maximum depth recorded is 4.6m w.r.t CD. The tidal influence zone ends at this section. The width of the river varies from 30m to 250m in this section. At the northern bank, small streams were found to be running parallel to the main river joining it at CH:27.3km and small islands and sand depositions were also found in this section.



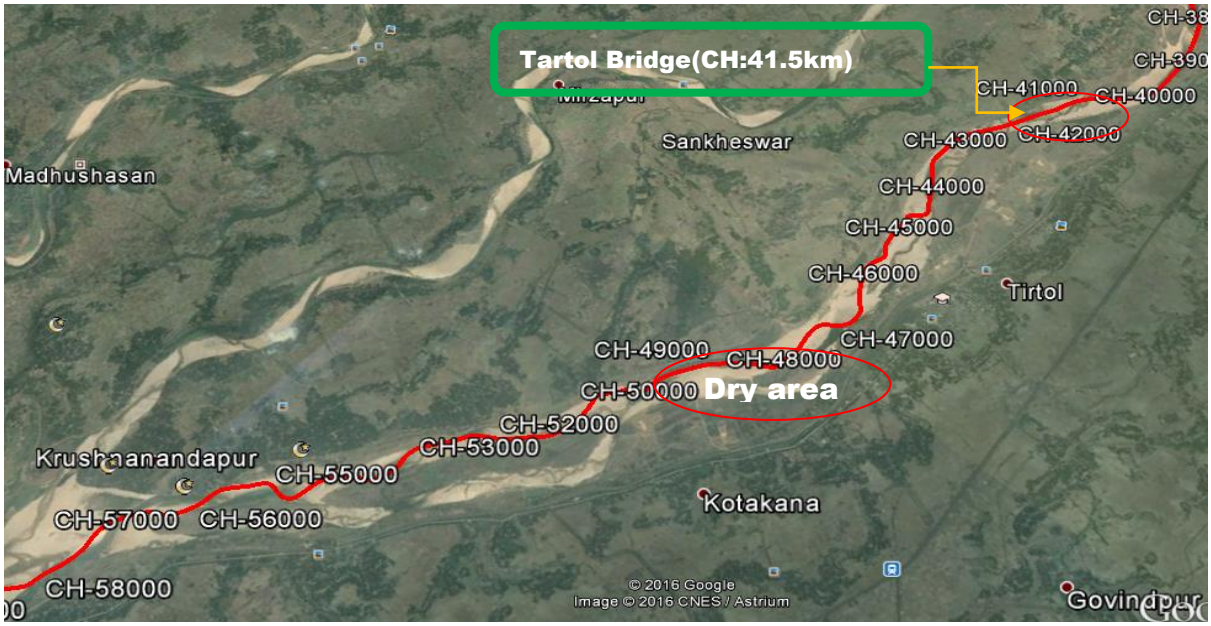
Mahanadi River from (CH: 35km – 37.84km)

This section extends from Teramanpur to Srichandanpur. The minimum depth recorded in this section is 0.5m w.r.t. CD and the maximum depth recorded is 8.2m w.r.t CD. The width of the river varies from 300m to 500m in this section. 1 Bridge(Rahama bridge at CH:37.8km) passes across the river at this section. Sand Chur is seen on this section.



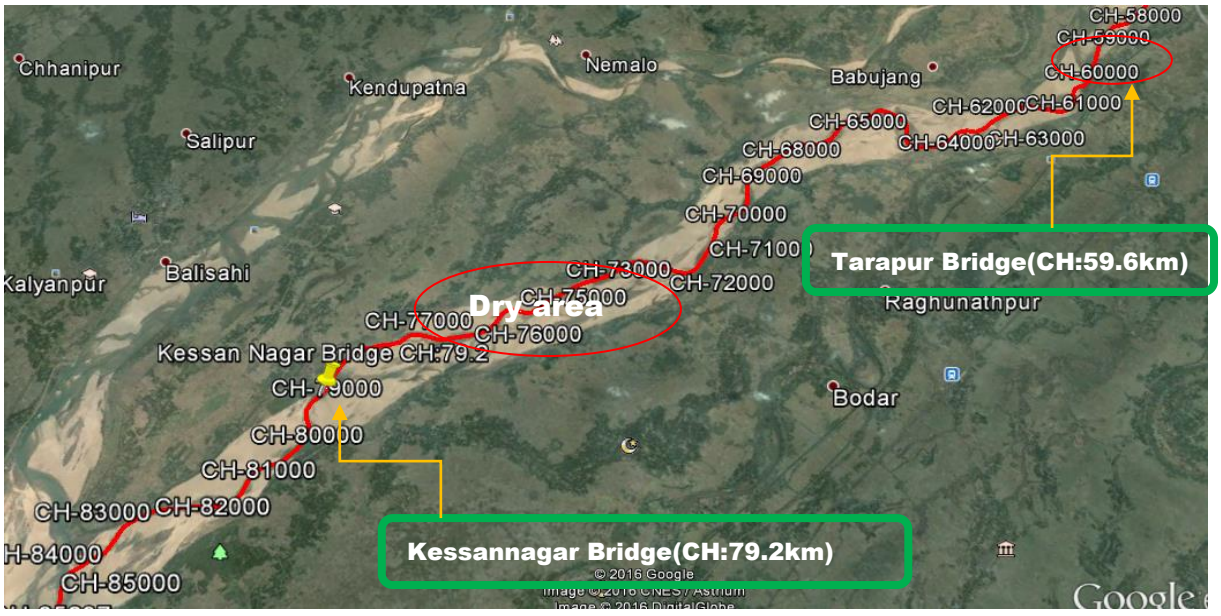
Mahanadi River from (CH: 37.84km - 58km)

This section extends from Srichandanpur to Krushnandapur. The area is found to be dry. Topography has been carried out in this stretch, hence no water level details were mentioned. One Bridge(Tartol Bridge) passes across the river at this section. At the northern bank, small stream was found to be running parallel to the main river which starts at CH:57km.



Mahanadi River from (CH: 58km - 85km)

This section extends from Krushnandapur to Barada. The area is found to be dry. Topography has been carried out in this stretch, hence no water level details were mentioned. 2 Bridges(Tarapur Bridge and Kessannagar Bridge) passes across the river at this section. At the northern bank, river Luna distributes from the main river at CH:84km. Sand deposition is seen on this section.



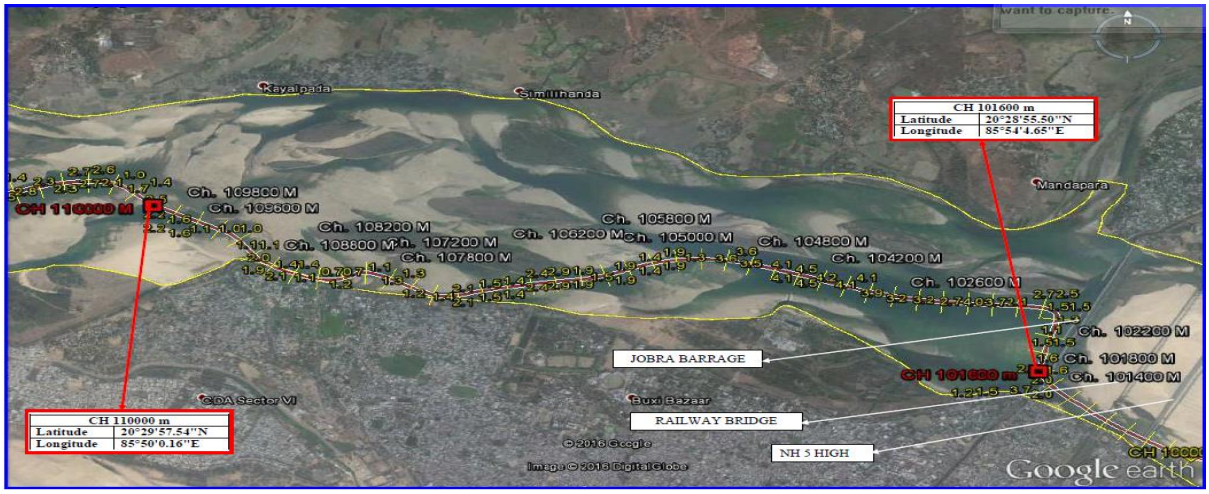
Mahanadi River from (CH: 85km - 100km)

This section extends from Barada to Mandapara. The area is found to be dry. Topography has been carried out in this stretch, hence no water level details were mentioned. Sand deposition is seen on this section.

6.5.2 Bathymetry Data Collected – Mahanadi River (Zone 1):

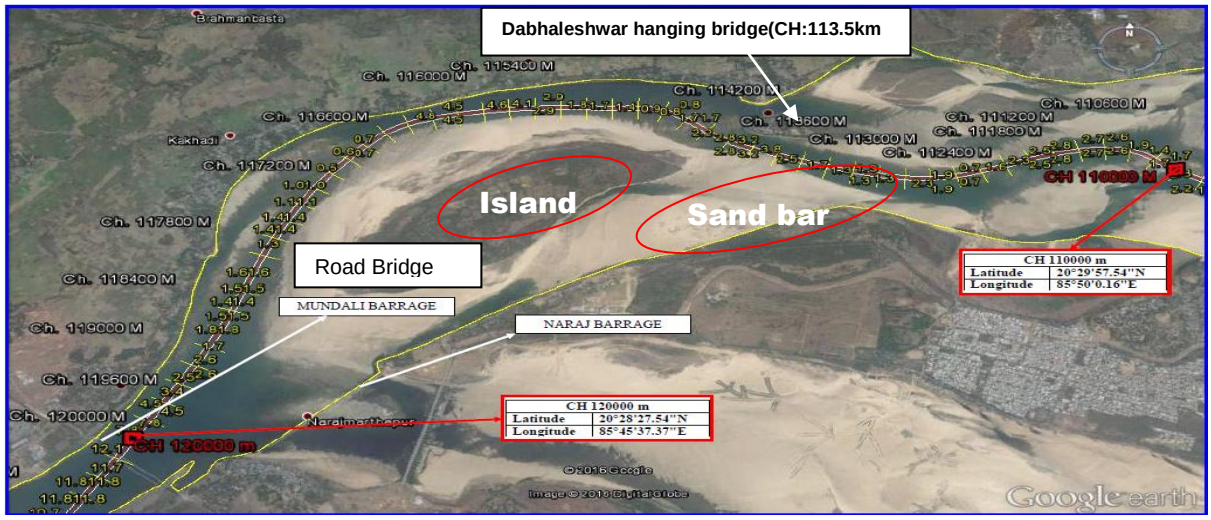
Mahanadi River from (CH: 100km - 110km)

This section extends from Mandapara to Kayalpada. The minimum depth recorded in this section w.r.t. CD is 0.7m and the maximum depth recorded w.r.t. CD is 4.8m. The width of the river varies from 600m to 2400m in this section. NH5 bridge(CH:100km), railway bridge(CH:100km) and Jobra barrage(CH:100km) passes across the river at this section. Jobra Barrage doesn't have navigation lock and irrigation canals are present at both sides of the barrage.



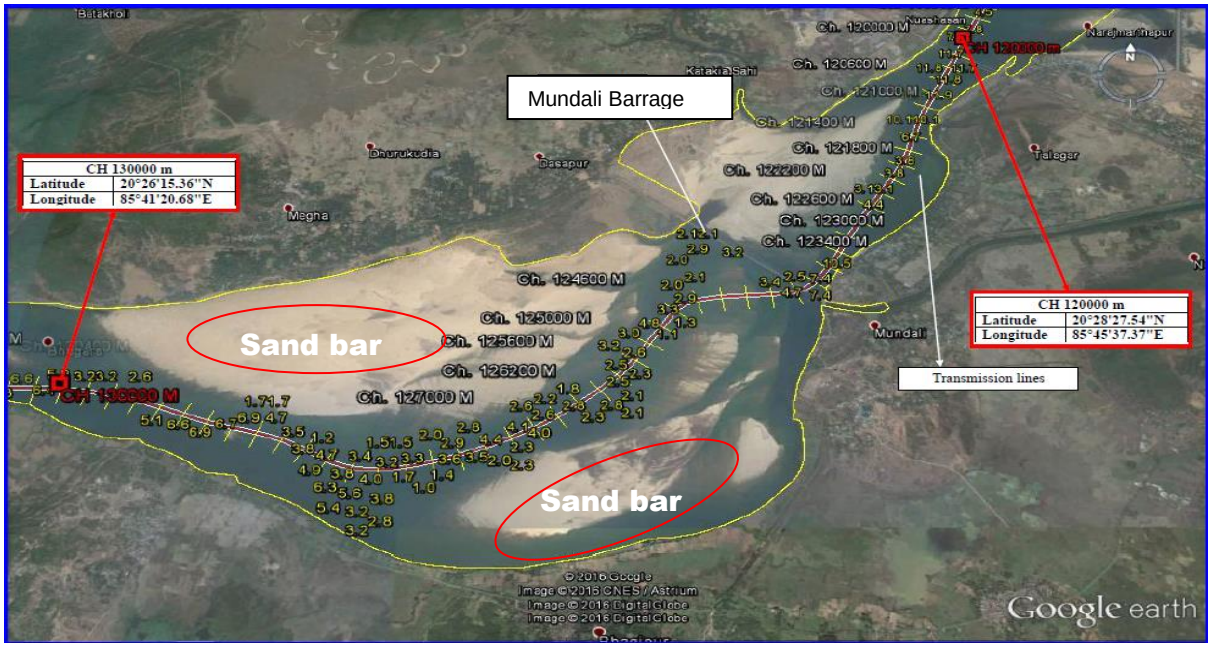
Mahanadi River from (CH: 110km – 120km)

This section extends from Kayalpada to Nuashasan. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 7.8m. The width of the river varies from 600m to 2400m in this section. Dabhaleshwar hanging bridge(CH:113.5km)and Road bridge(CH: 120km) passes across the river at this section. Naraj Barrage(CH:118km) also comes along the river in this section. Sand deposition and island formation is seen in this section.



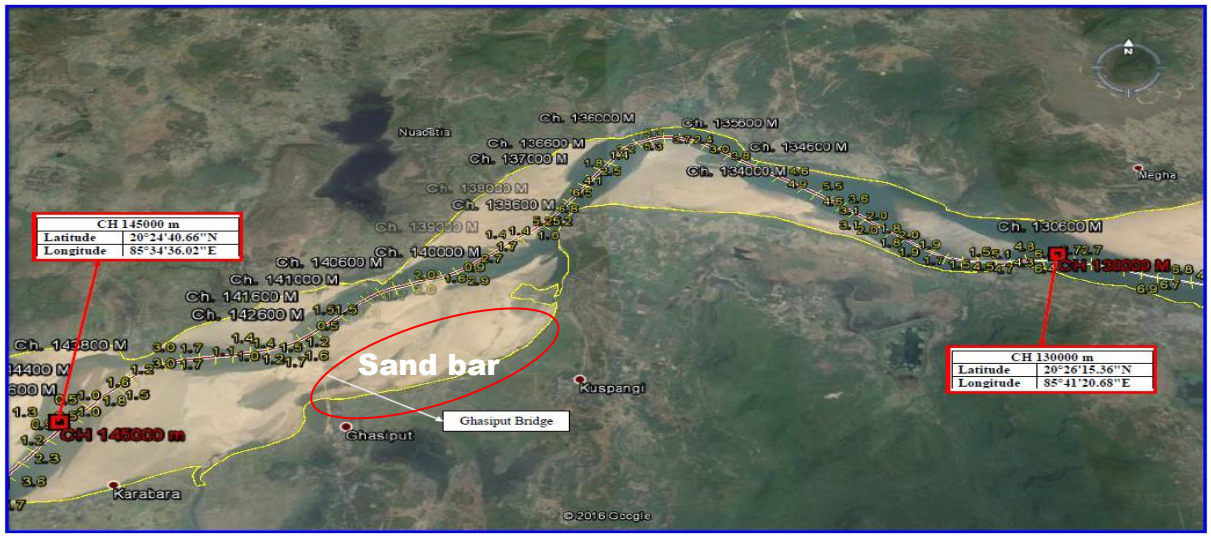
Mahanadi River from (CH: 120km - 130km)

This section extends from Nuashasan to Bhogara. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 12.5m. The width of the river varies from 1500m to 3600m in this section. Mundali Barrage (CH:123.5km) passes across the river at this section. Mundali barrage doesn't have a navigation lock and irrigation canal is seen on the southern bank. Sand chur is seen in this section.



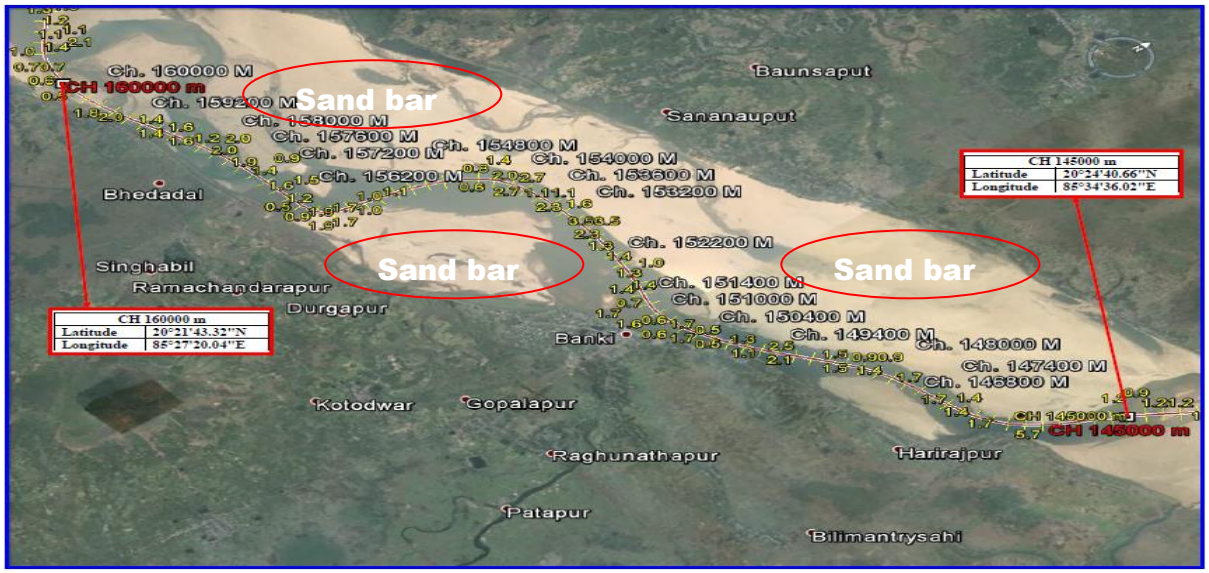
Mahanadi River from (CH: 130km - 145km)

This section extends from Bhogara to Karabara. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 6.9m. The width of the river varies from 1500m to 3600m in this section. Ghasiput bridge(CH:141km) passes across the river at this section. Huge quantity of sand deposition were observed in this stretch.



Mahanadi River from (CH: 145km - 160km)

This section extends from to Karabara to Bhedadal. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 5.7m. The width of the river varies from 1500m to 3600m in this section. Sand deposition were observed in this stretch.

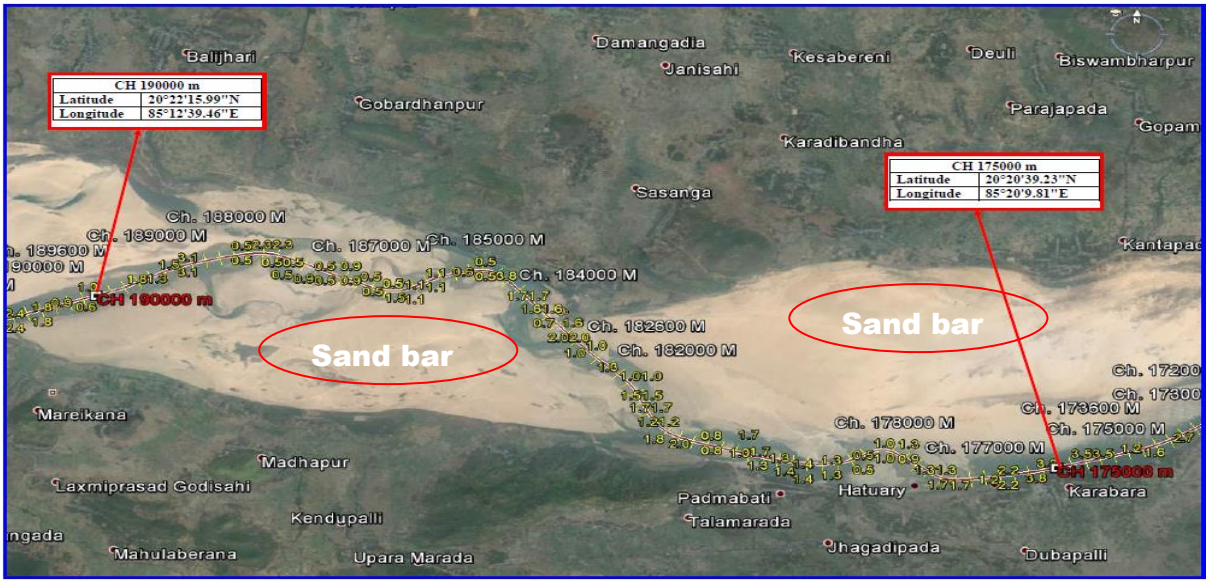


Mahanadi River from (CH: 160km - 175km)

This section extends from to Bhedadal to Kantapada. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 4.8m. The width of the river varies from 1500m to 3600m in this section. Sand deposition were observed in this stretch.

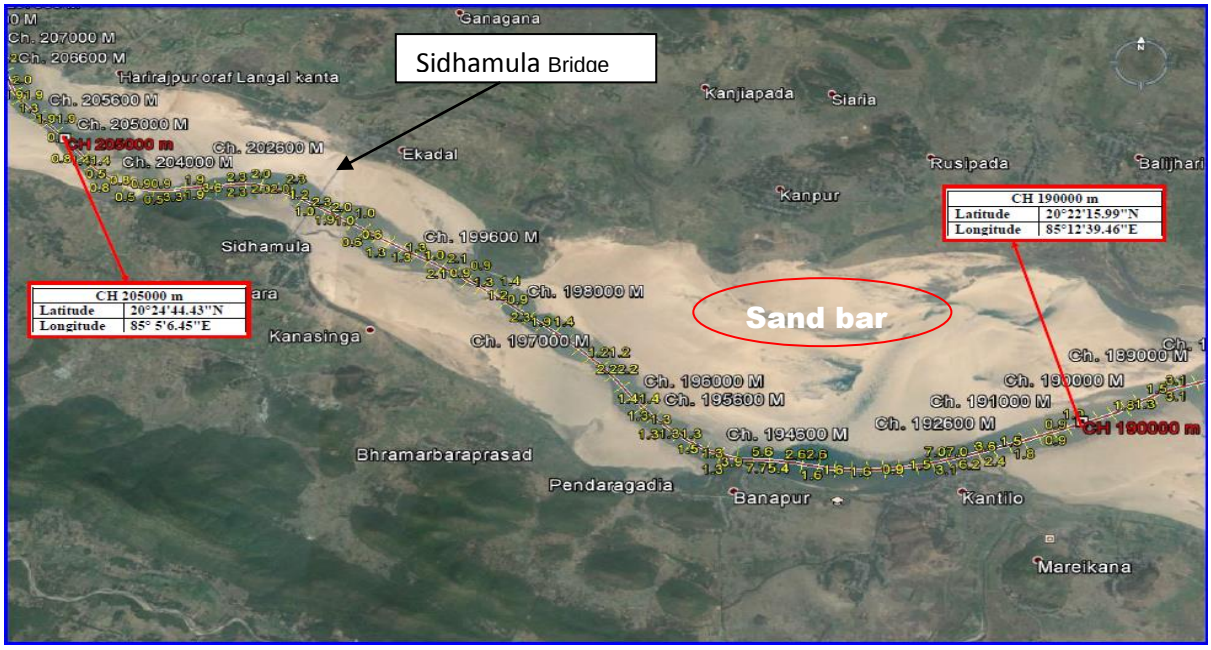
Mahanadi River from (CH: 175km – 190km)

This section extends from Kantapada to Mareikana. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 4.8m. The width of the river varies from 1400m to 2000m in this section. Sand deposition were observed in this stretch.



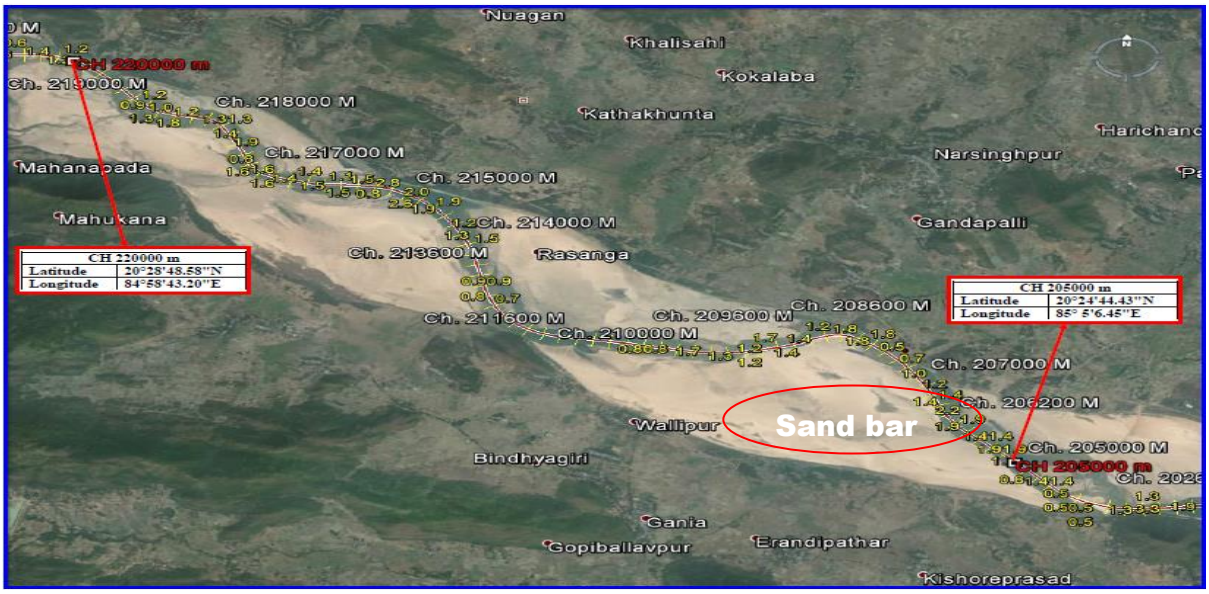
Mahanadi River from (CH: 190km – 205km)

This section extends from Mareikana to Harirajpur. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 7.7m. The width of the river varies from 1400m to 2000m in this section. Sidhamula bridge(CH:200km) passes across the river at this section. Sand deposition were observed in this stretch.



Mahanadi River from (CH: 205km – 220km)

This section extends from Harirajpur to Mahanapada. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 2.8m. The width of the river varies from 600m to 1500m in this section. Sand depositions were observed in this stretch.

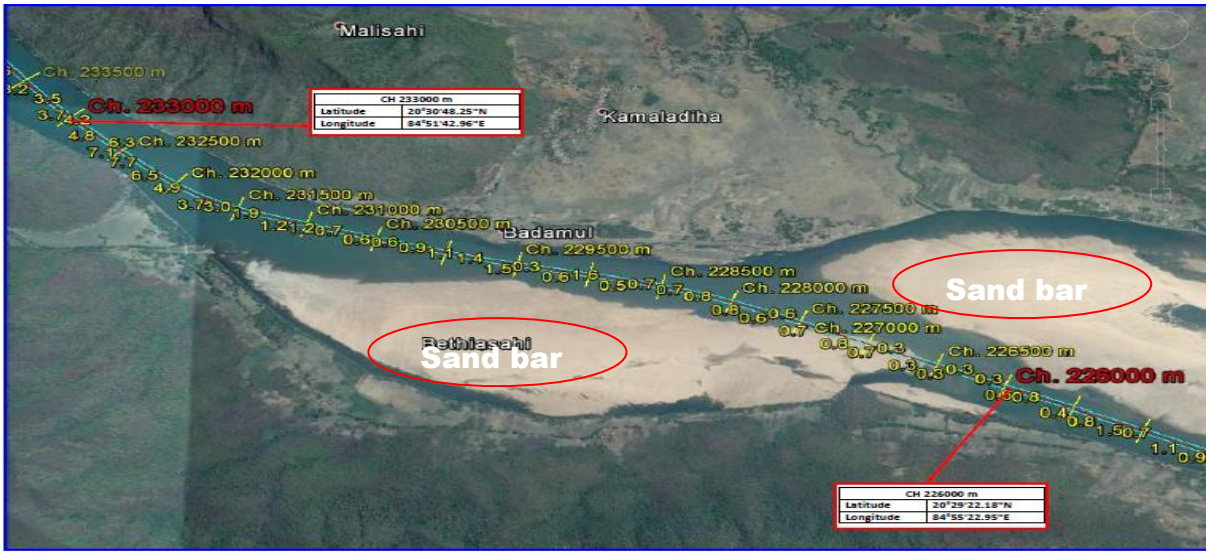


Mahanadi River from (CH: 220km – 226km)

This section extends from Mahanapada to Chamundia. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 2.8m. The width of the river varies from 600m to 1500m in this section. Sand depositions were observed in this stretch.

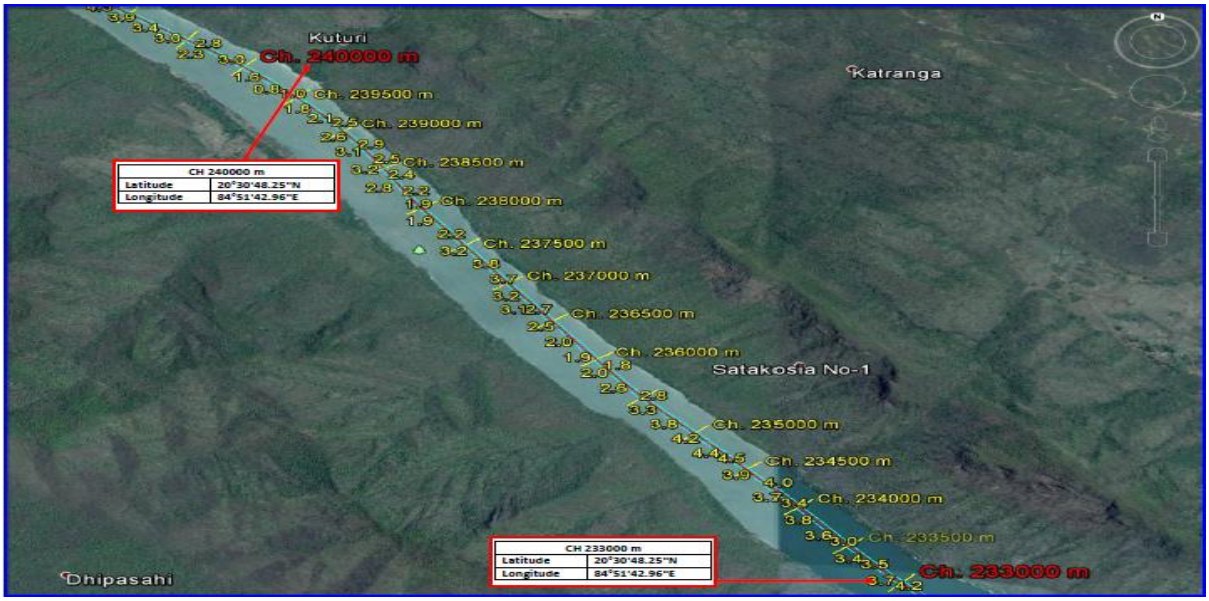
Mahanadi River from (CH: 226km – 233km)

This section extends from Satkosia No-1 to Malisani. This section passes through Satakosia reserved forest and the Forest dept. didn't allow the survey agency to carry out survey during initial survey period from CH:229.6km to CH: 251.6km due to security reasons. The survey for this stretch has been carried out on 25th to 29th July, 2016. The Satkosia forest area starts at CH 229.6km. The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 7.8m.



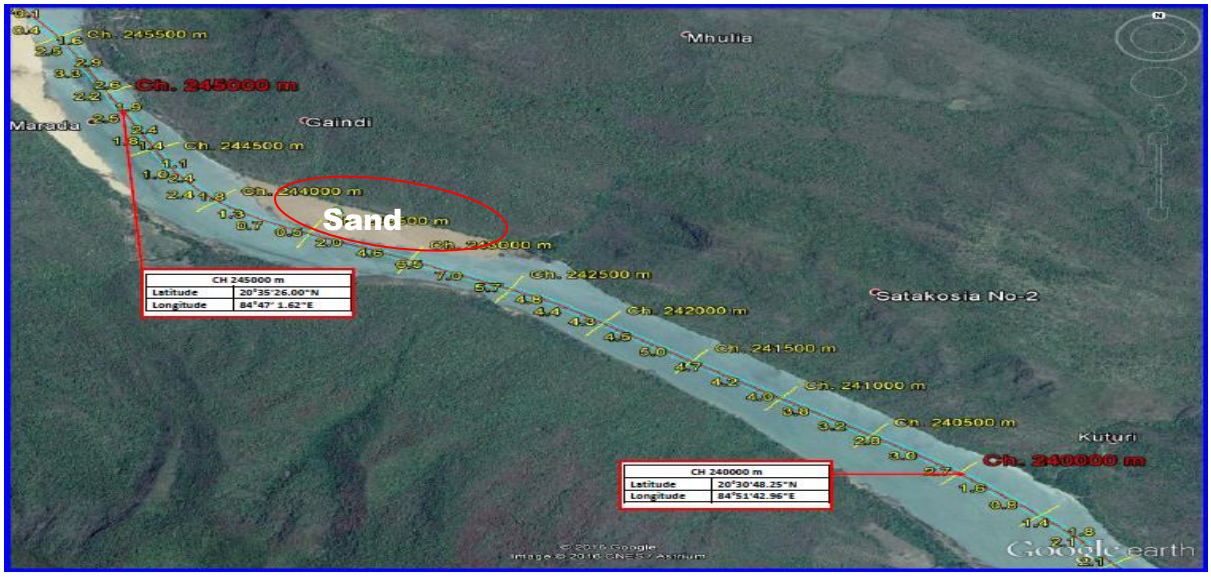
Mahanadi River from (CH: 233km – 240km)

This section extends from to Malisani to Kuturi. The minimum depth recorded in this section w.r.t. CD is 0.8m and the maximum depth recorded w.r.t. CD is 4.5m. The width of the river varies from 600m to 700m.



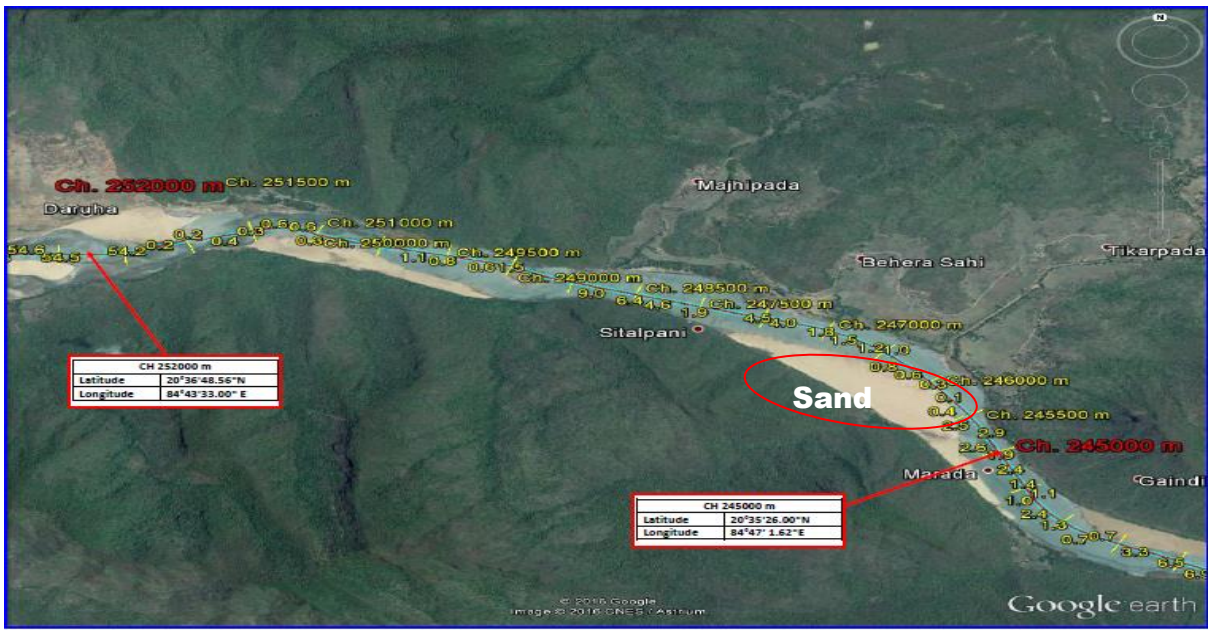
Mahanadi River from (CH: 240km – 245km)

This section extends from to Kuturi to Marada. The minimum depth recorded in this section w.r.t. CD is 0.7m and the maximum depth recorded w.r.t. CD is 7m. The width of the river varies from 600m to 700m.



Mahanadi River from (CH: 245km – 252km)

This section extends from to Marada to Daruha . The minimum depth recorded in this section w.r.t. CD is 0.5m and the maximum depth recorded w.r.t. CD is 9m. The width of the river varies from 600m to 700m.

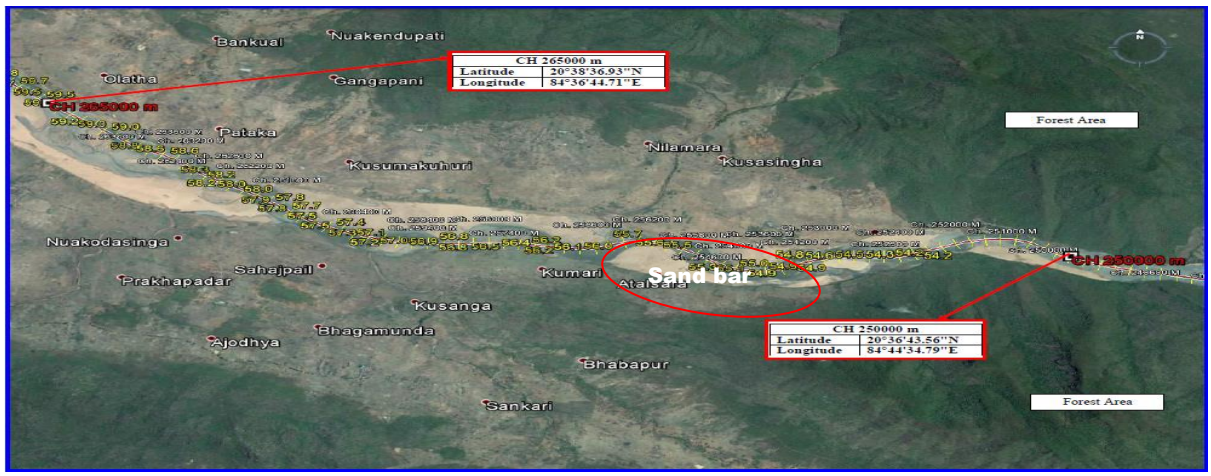


6.5.3 Topographic Data Collected – Mahanadi River (Zone 2):

During Bathymetry survey, water was observed intermittently varying from 0.3m to 1.7m. Due to lack of water, Topography has been carried out in Zone- 2. However, no rocky strata or any show stoppers were observed in this area. Since Topography has been carried out in this stretch, no water level details are mentioned in Zone-2.

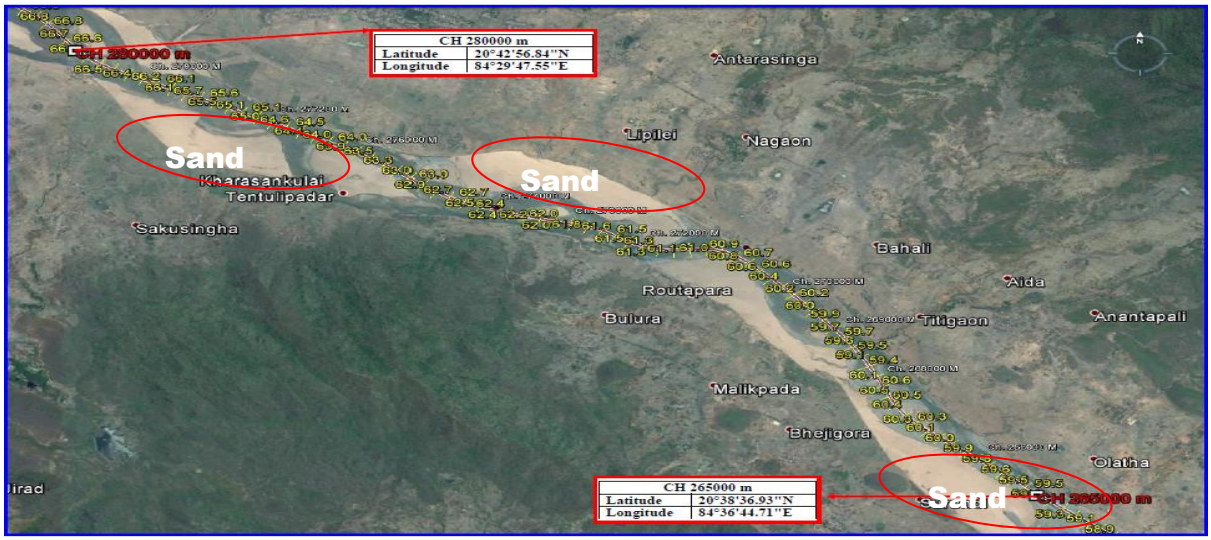
Mahanadi River from (CH: 250km – 265km)

This section extends from Sitalpani to Olatha. The maximum land elevation w.r.t. MSL is 59.4m and the minimum land elevation w.r.t. MSL is 54.2m. The width of the river varies from 950m to 1200m in this section.



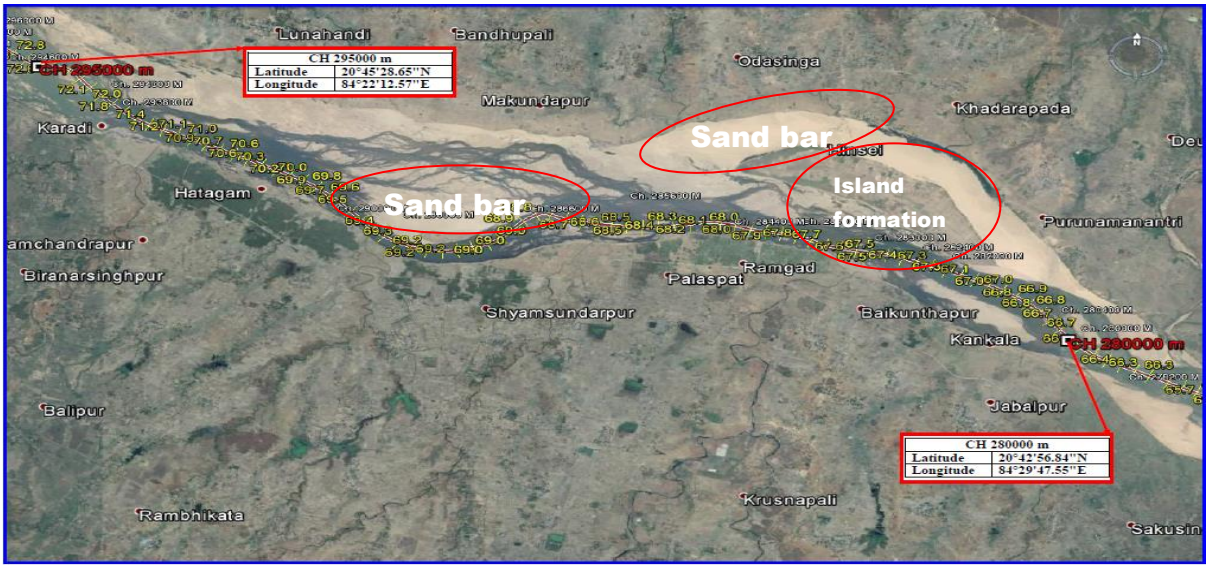
Mahanadi River from (CH: 265km – 280km)

This section extends from Olatha to Sakusingha . The maximum land elevation w.r.t. MSL is 66.6m and the minimum land elevation w.r.t. MSL is 59.5m. The width of the river varies from 950m to 1200m in this section. Sand deposition can be seen in this section.



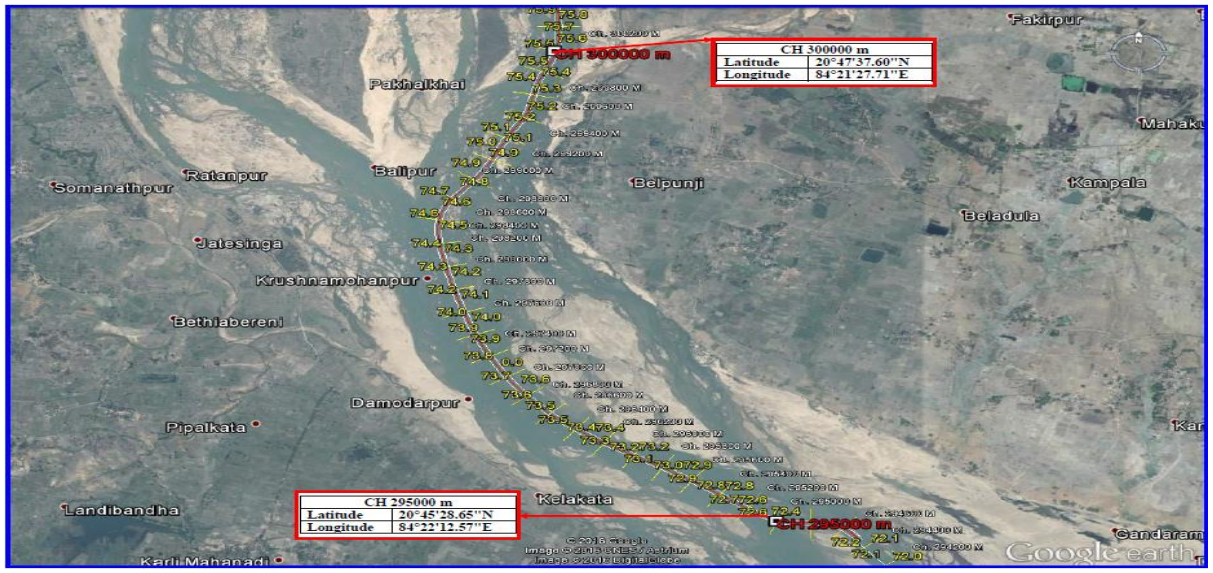
Mahanadi River from (CH: 280km – 295km)

This section extends from Sakusingha to Karadi . The maximum land elevation w.r.t. MSL is 72.5m and the minimum land elevation w.r.t. MSL is 66.6m. The width of the river varies from 850m to 1200m in this section. Island formation and sand deposition can be seen in this section.



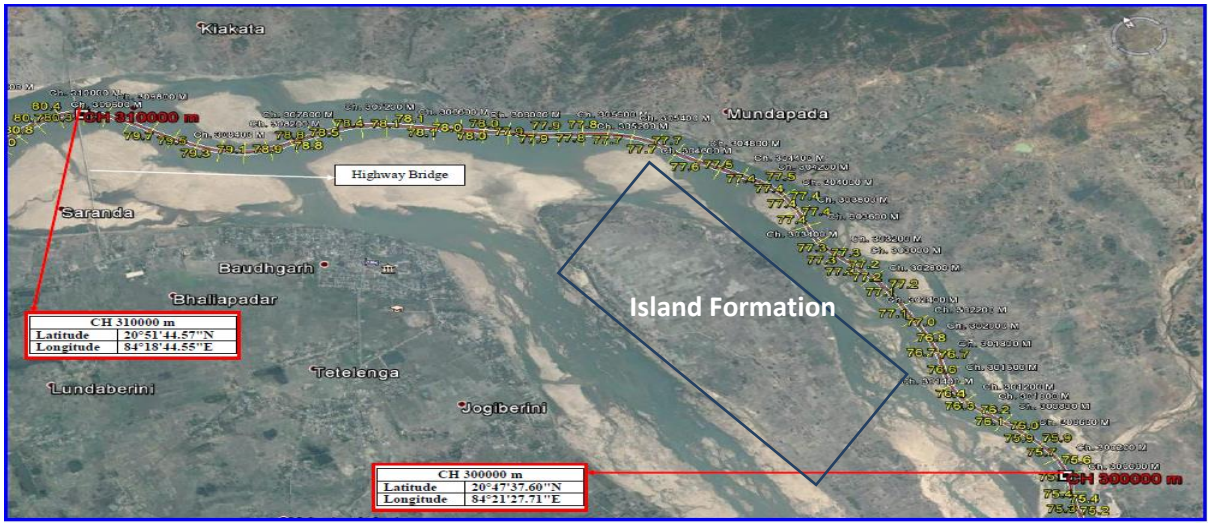
Mahanadi River from (CH: 295km – 300km)

This section extends from Karadi to Pakhalkhai . The maximum land elevation w.r.t. MSL is 75.5m and the minimum land elevation w.r.t. MSL is 72.5m. The width of the river varies from 1000m to 1200m in this section.



Mahanadi River from (CH: 300km – 310km)

This section extends from Pakhalkhai to Saranda. The maximum land elevation w.r.t. MSL is 80.2m and the minimum land elevation w.r.t. MSL is 75.5m. The width of the river varies from 1200m to 2350m in this section. Highway bridge SH 62 (CH:310km) passes across the river at this section. Island formation were also found in this stretch.



Mahanadi River from (CH: 310km – 330km)

This section extends from Saranda to Kampara. The maximum land elevation w.r.t. MSL is 87.2m and the minimum land elevation w.r.t. MSL is 80.3m. The width of the river varies from 2350m to 1800m in this section. Sand deposition was found in this section

Mahanadi River from (CH: 330km – 346.6km)

This section extends from Kampara to Chaunriapadar. The maximum land elevation w.r.t. MSL is 95.1m and the minimum land elevation w.r.t. MSL is 87.2m. The width of the river varies from 2000m to 1800m in this section. Sand chur was found in this section. Rocky strata starts from the end of this section(CH:346.6km)

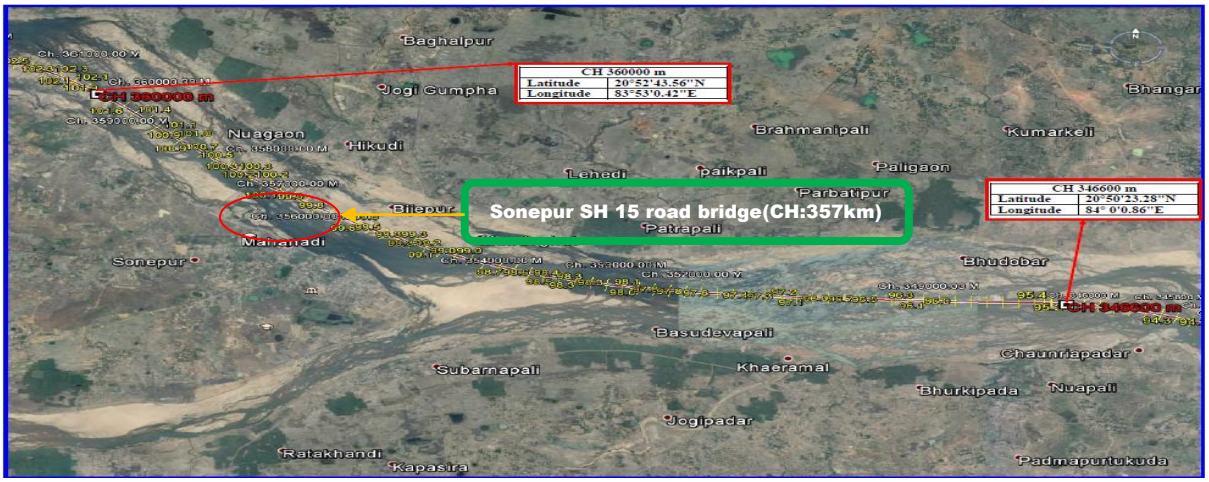
6.5.4 Topographic Data Collected - Mahanadi River (Zone 3)

Due to lack of water, Topography has been carried out in Zone- 3. Most of the area was occupied by rocky patches for the entire stretch except at (CH 374km to CH 380km). Many outcrop rocks were seen in the entire stretch. Navigation in Zone-3 area is not possible**.** Since Topography has been carried out in this stretch, no water level details are mentioned in Zone-3.

Mahanadi River from (CH: 346.6km - 360km)

This section extends from Chaunriapadar to Nuagaon. The maximum land elevation w.r.t. MSL is 101.9m and the minimum land elevation w.r.t. MSL is 95.2m. The width of the river varies from

900m to 1300m in this section. Sonepur SH 15 Road Bridge(CH:357km) passes across the river at this section. At the southern bank, small stream was found to be running parallel to the main river which joins it at CH:353km.

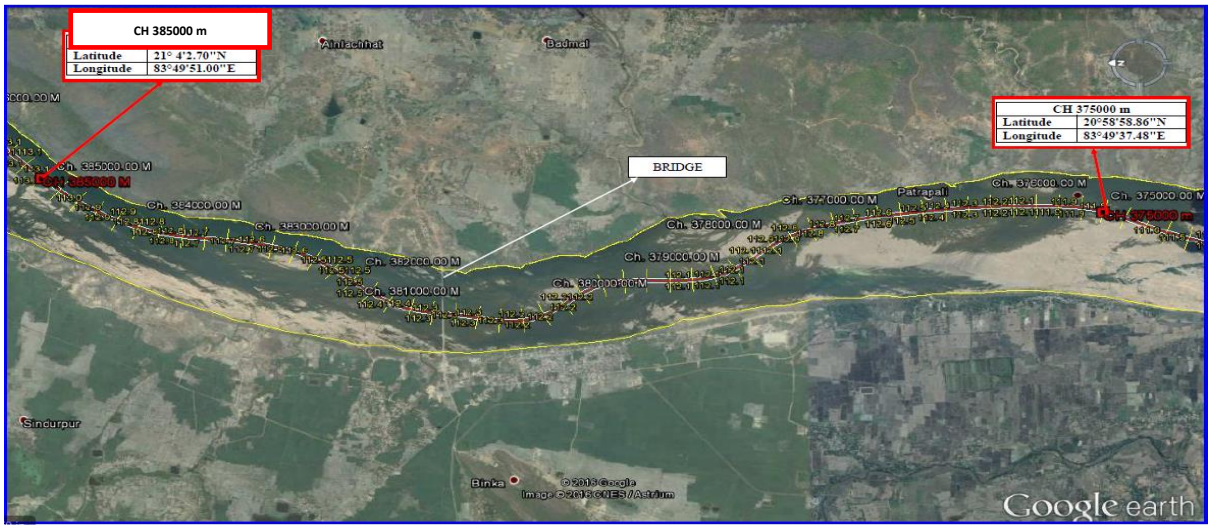


Mahanadi River from (CH: 360km - 375km)

This section extends from Nuagaon to Badmal. The maximum land elevation w.r.t. MSL is 111.8m and the minimum land elevation w.r.t. MSL is 101.9m. The width of the river varies from 900m to 1300m in this section. At the southern bank, small stream was found to be joining the main river at CH:365km.

Mahanadi River from (CH: 375km - 385km)

This section extends from Badmal to Sindurpur. The maximum land elevation w.r.t. MSL is 113m and the minimum land elevation w.r.t. MSL is 111.8m. The width of the river varies from 900m to 1300m in this section. Binka bridge(CH:381km) passes across the river at this section.



Mahanadi River from (CH: 385km - 400km)

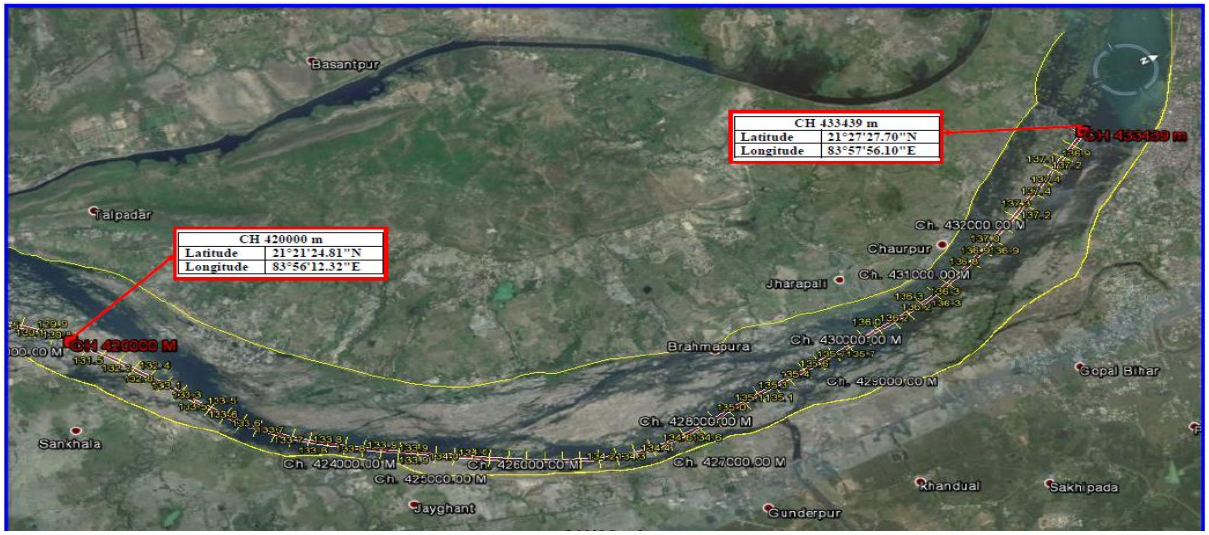
This section extends from Sindurpur to Kutapali. The maximum land elevation w.r.t. MSL is 114.9m and the minimum land elevation w.r.t. MSL is 113m. The width of the river varies from 900m to 1300m in this section.

Mahanadi River from (CH: 400km - 420km)

This section extends from to Kutapali to Chipilima. The maximum land elevation w.r.t. MSL is 130.7m and the minimum land elevation w.r.t. MSL is 114.9m. The width of the river varies from 600m to 900m in this section.

Mahanadi River from (CH: 420km - 433km)

This section extends from Chipilima to Chaurpur. The maximum land elevation w.r.t. MSL is 114.9m and the minimum land elevation w.r.t. MSL is 113m. The width of the river varies from 600m to 900m in this section.



6.6 River Details - Luna River

The Luna River is a distributary of Mahanadi. The main Mahanadi was found to be dry beyond Mahanadi barrage at Narrage and the water flows through its distributary Luna. It branches out at Tentola village and joins Mahanadi again at the Balidia village. This 80.0km of Luna River is surveyed as an alternate route to Mahanadi from Tentola village to Baldia village.The survey was conducted from 17th February 2016 to 20th February 2016 and the river stretch from CH: 0.0km to CH: 25.0km is found to be under tidal influence.

6.6.1 Bathymetry Data Collected - Luna River:

Luna River (CH: 0.0km – 5.0km) – Tidal Zone

This section extends from CH: 0.0km in Banabiharipur to CH: 5.0km in Madhusudanpur. The minimum depth recorded in this section is 0.7m and the maximum depth recorded is 12.3m. The width of the river varies from 230m to 600m in this section. No cross structures are present in this

section and river here is under tidal influence. Here the Luna river re-joins the Mahanadi river at CH: 1.5km.

Luna River (CH: 5.0km – 10.0km) – Tidal Zone

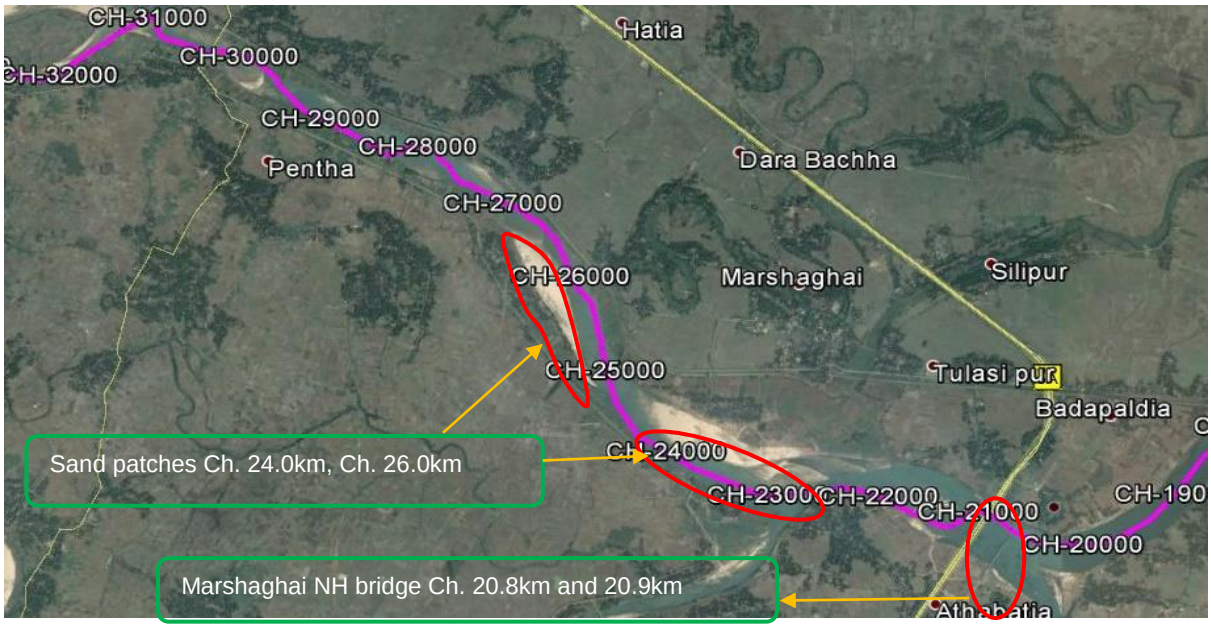
This section extends from CH: 5.0km in Madhusudanpur to CH: 10.0km in Gokhakhati. The minimum depth recorded in this section is 0.7m and the maximum depth recorded is 12.3m. The width of the river varies from 230 m to 700m in this section. There are no cross structures along this section and the river is under tidal influence. The land on both the sides is being used for agricultural purpose.

Luna River (CH: 10.0km – 20.0km) – Tidal Zone

This section extends from CH: 10.0km in Gokhakhati village to CH: 20.0km in Gopinathpur village. The minimum depth recorded in this section is 0.9m and the maximum 14.6m. The width of the river varies from 210 m to 835 m. No cross structures are present in this section. The river here is under tidal influence. At the southern bank, small stream was found to be running parallel to the main river which rejoins at Ch. 11km.

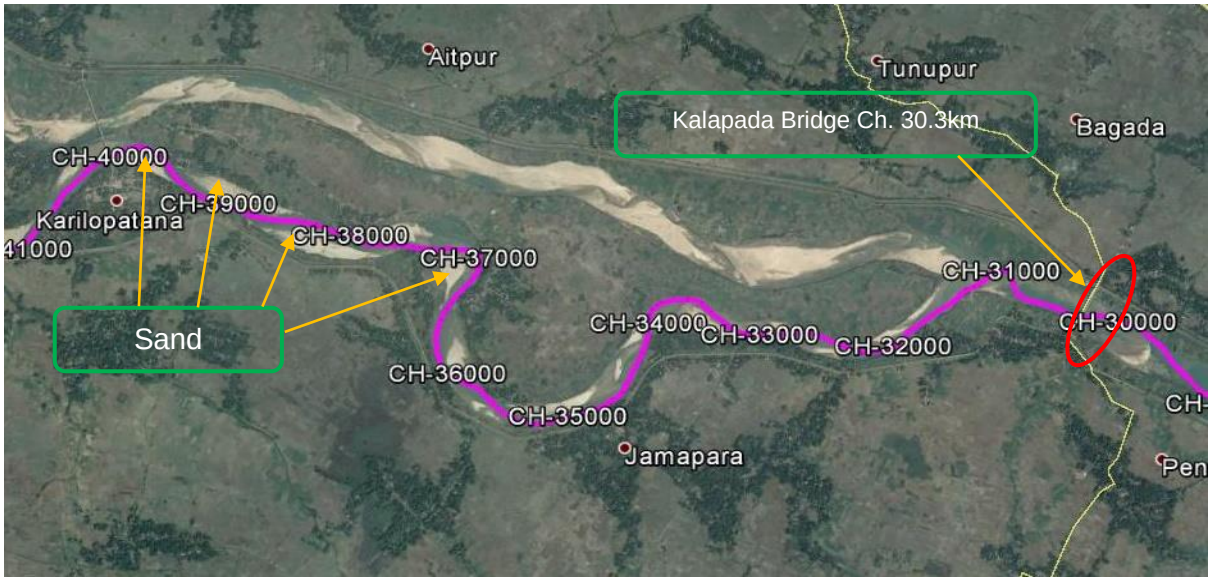
Luna River (Ch. 20.0km – 30.0km) – Tidal Zone

This section extends from Ch. 20.0km in Gopinathpur village to Ch. 30.0 km in Gothan village. The minimum depth recorded in this section is 0.7m and maximum 8.0m. The width of the river varies from 130m to 480m in this section. Marshaghai NH bridge runs across the river at Ch 20.8km and 20.9km. Two high tension lines pass across the river at this section. Sand patches are present at Ch. 24.0km and Ch. 26.0km. The river is under tidal influence from Ch. 20.0km to Ch. 25km.



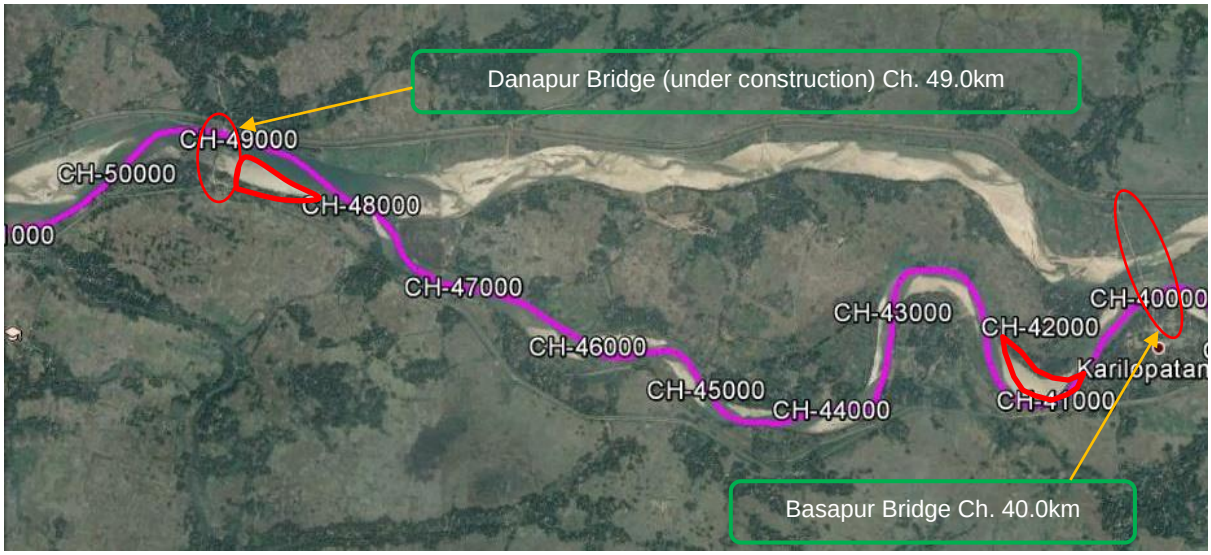
Luna River (Ch. 30.0km – 40.0km)

The river section extends from Ch.30.0km in Godhan to Ch. 40.0km in Talagan. The minimum depth recorded in this section is 0.7m and maximum 9.0m. The width of the river in this section varies from 20m to 300m. Kalapada Bridge runs across the river at Ch. 30.3km. Two high tension lines pass across the river in this section. Sand patches can be seen at regular intervals. Two sharp bends were observed at Ch. 34.0km and 37.0km. This can make navigation difficult.



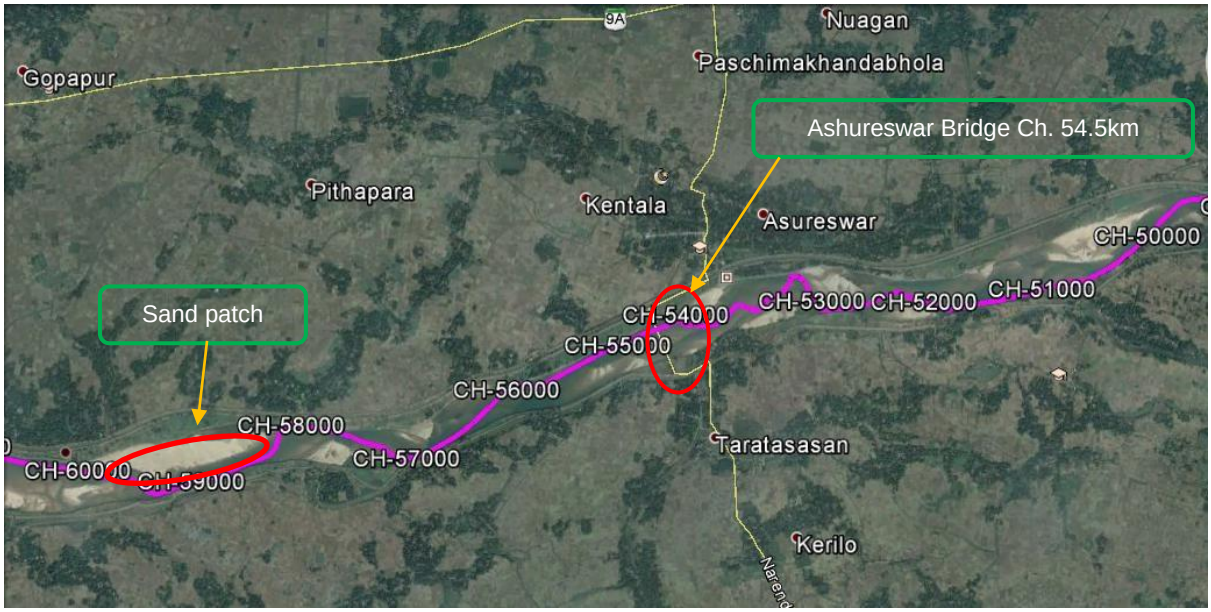
Luna River (CH: 40 km - 50km)

This section extends from Ch. 40.0km at Talagan village to Ch.50.0km at Artamula village. The minimum and maximum depth recorded in this section is 0.7m and 14.5m respectively. The width of the river varies from 20m to 120m in this section. Basapur Bridge and an under construction Danapur bridge run across the river at Ch. 40.0km and Ch. 49.0km respectively. Three high tension lines run across the river in this section. There are sand patches at Ch. 41.0km and Ch. 48.5km.



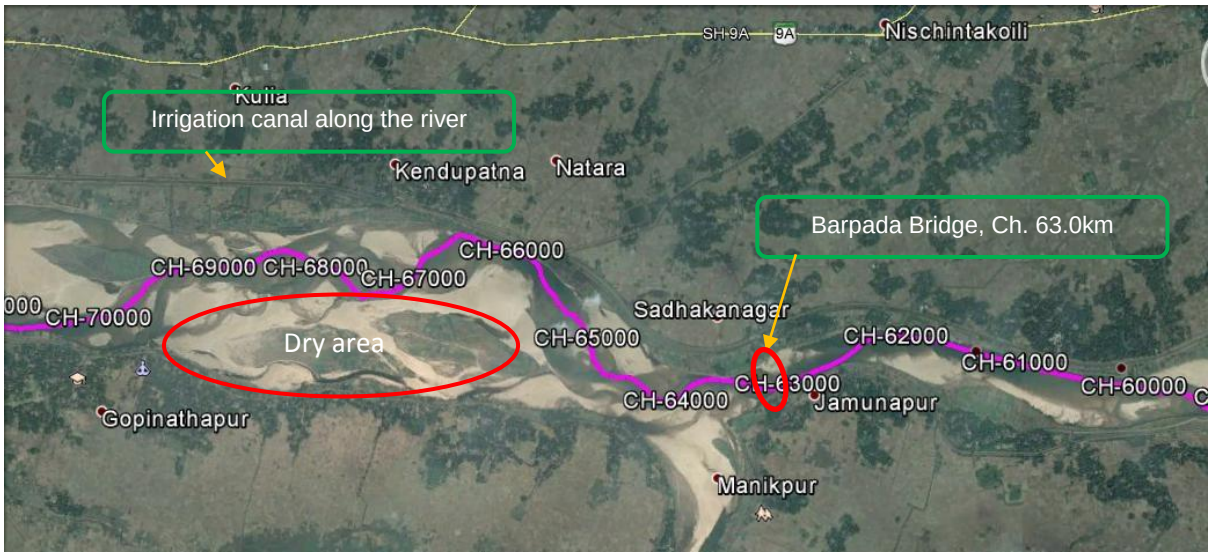
Luna River (Ch. 50km - 60km)

This section extends from Ch. 50.0km (Artamula) to Ch.60.0km (Fatepur). The minimum depth recorded in this section is 0.7m and maximum recorded is 11.6m. The width of the river varies from 35m to 250m in this section. Ashureswar Bridge runs across the river at Ch. 54.5km and either side of the river stretch is found to be agricultural land. Sand deposits are prominent along the section.



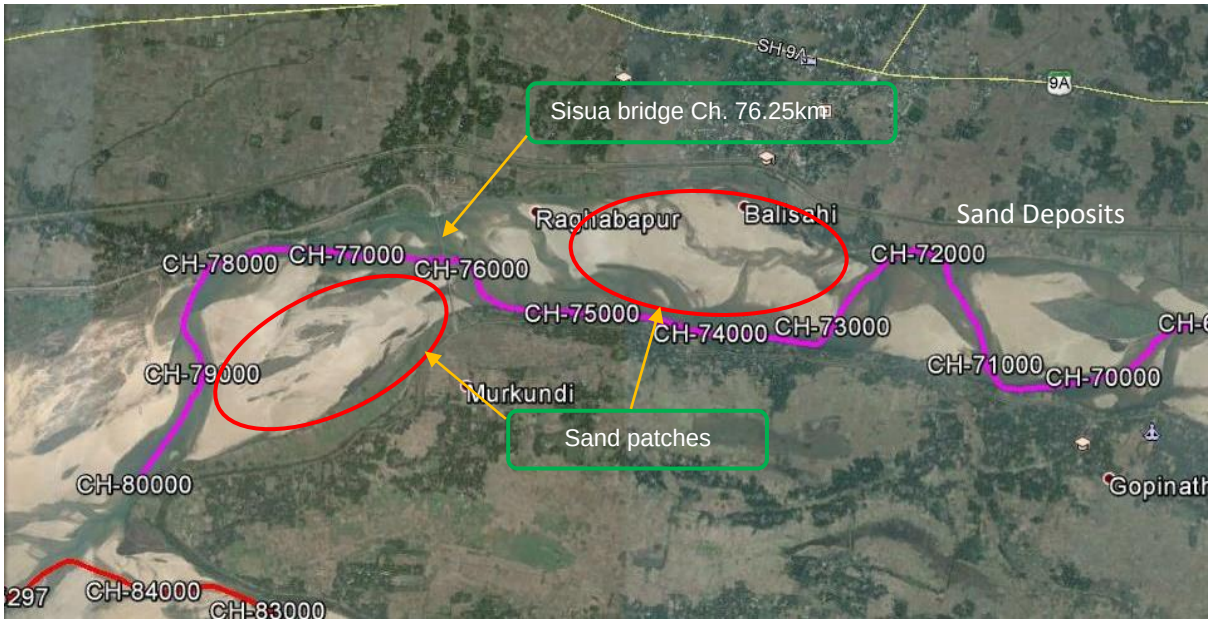
Luna River (Ch.60km - 70km)

The figure below shows the section of river from Ch.60.0km at Fatehpur to Ch.70.0km at Kulanpur. Water depth recorded in this section varies from 0.7m to 5.1m. The width of the river varies from 30 m to 160 m in this stretch. A bridge (Barpada bridge) runs across the river at Ch.63.0km. Sand patches are found all along this river section. Land on both sides of the river is being used for agricultural purpose and an irrigation canal runs along the Northern bank of the river.



Luna River (Ch. 70km - 80km)

The survey ends at the confluence of Mahanadi and Luna River at Tentola village. The figure below shows the stretch from Kulanpur village, Ch. 70.0km to Tentola village, Ch 80.0 km. The minimum depth recorded in this section is 0.7m and the maximum depth recorded is 5.1m. The width of the river varies from 25 m to 130 m in this section. Sand deposits are found at regular intervals. Sisua Bridge runs across the river at Ch. 76.25km.



6.7 Bed Profile of Proposed Waterway

6.7.1 Mahanadi river Zone 0

All soundings were reduced to chart datum in the area. Chainage Vs water depth and soil texture @100m interval is shown in Annexure-I. The observed bed profile of Mahanadi river (Zone-0) waterways are presented in below Figure 36.

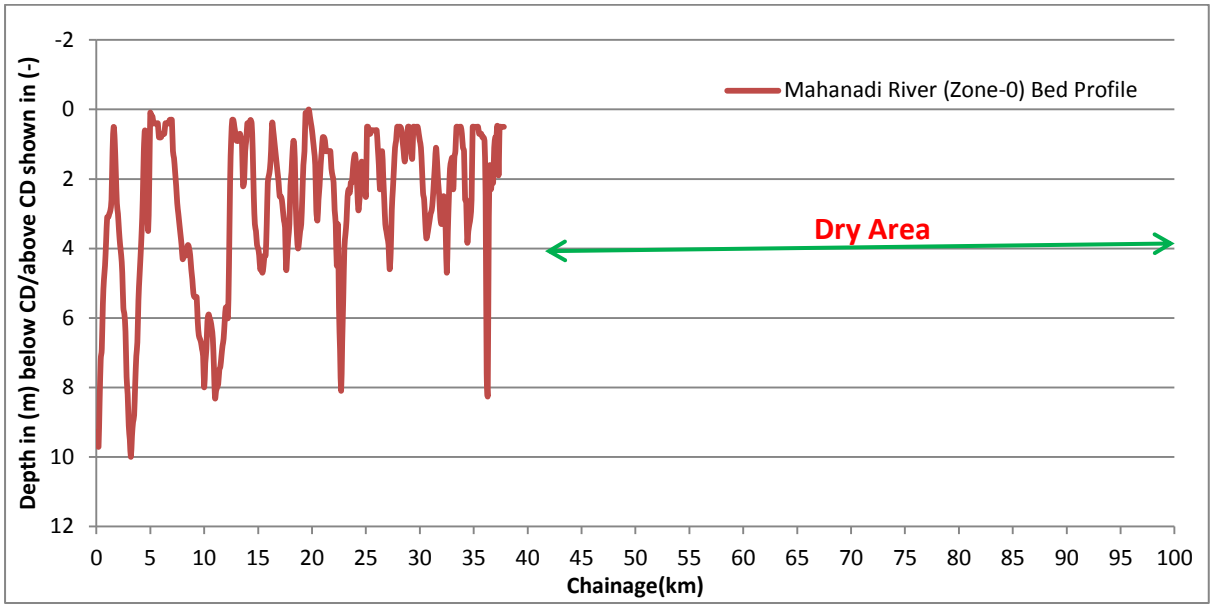


Figure 36: Mahanadi River (Zone - 0) bed profile w.r.t. CD

6.7.2 Mahanadi river Zone 1

The observed bed profile of Mahanadi (Zone-1) waterways are presented in Figure 37 below.

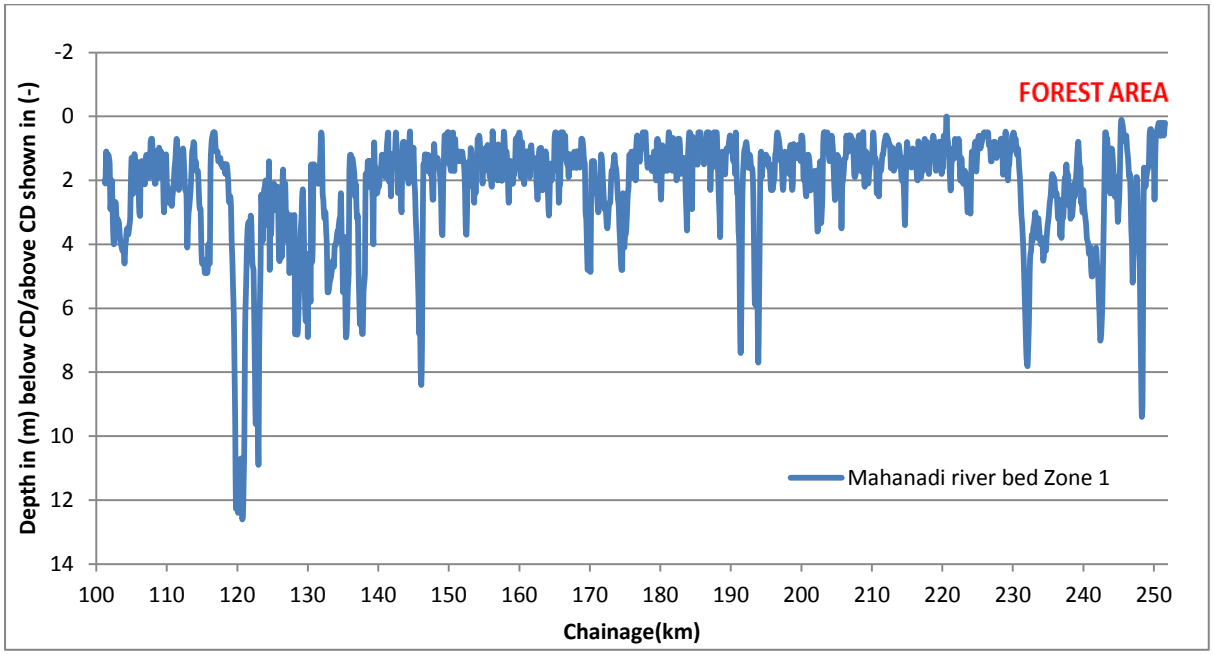


Figure 37: Mahanadi (Zone - 1) bed profile w.r.t. CD

6.7.3 Mahanadi river Zone 2

The observed bed profile of Mahanadi (Zone-2) waterways are presented in Figure 38 below.

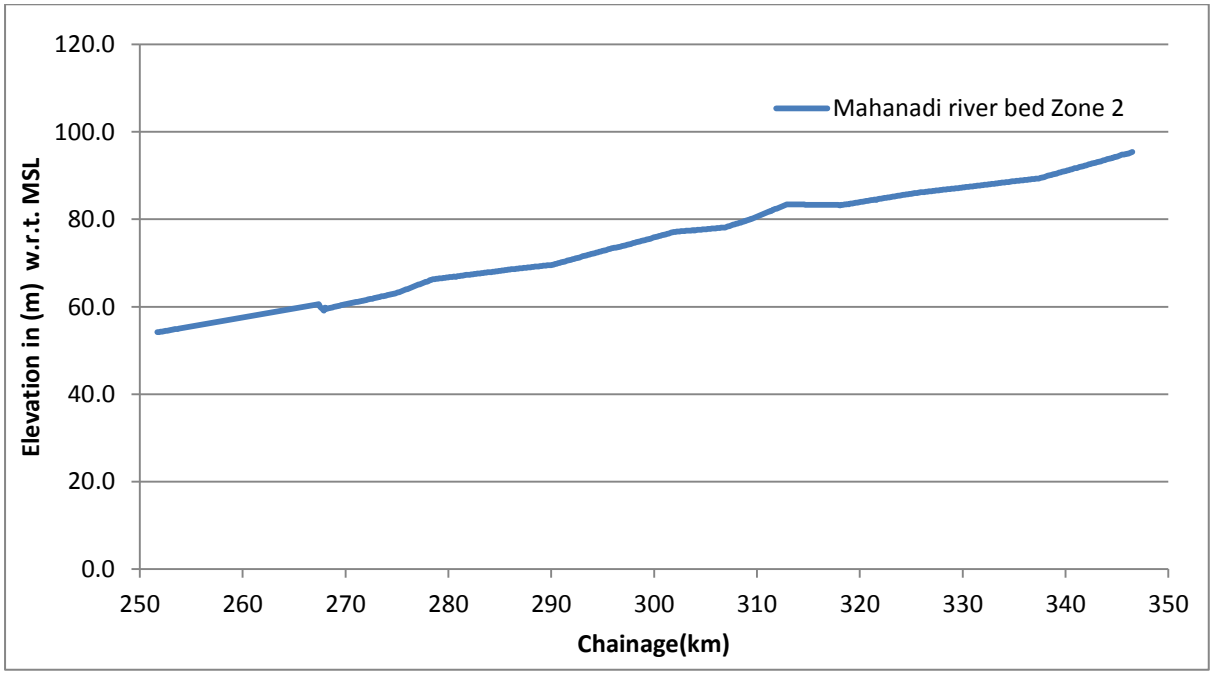


Figure 38: Mahanadi river (Zone - 2) bed profile w.r.t. MSL

6.7.4 Mahanadi river Zone 3

The observed bed profile of Mahanadi (Zone-3) waterways are presented in below Figure 39.

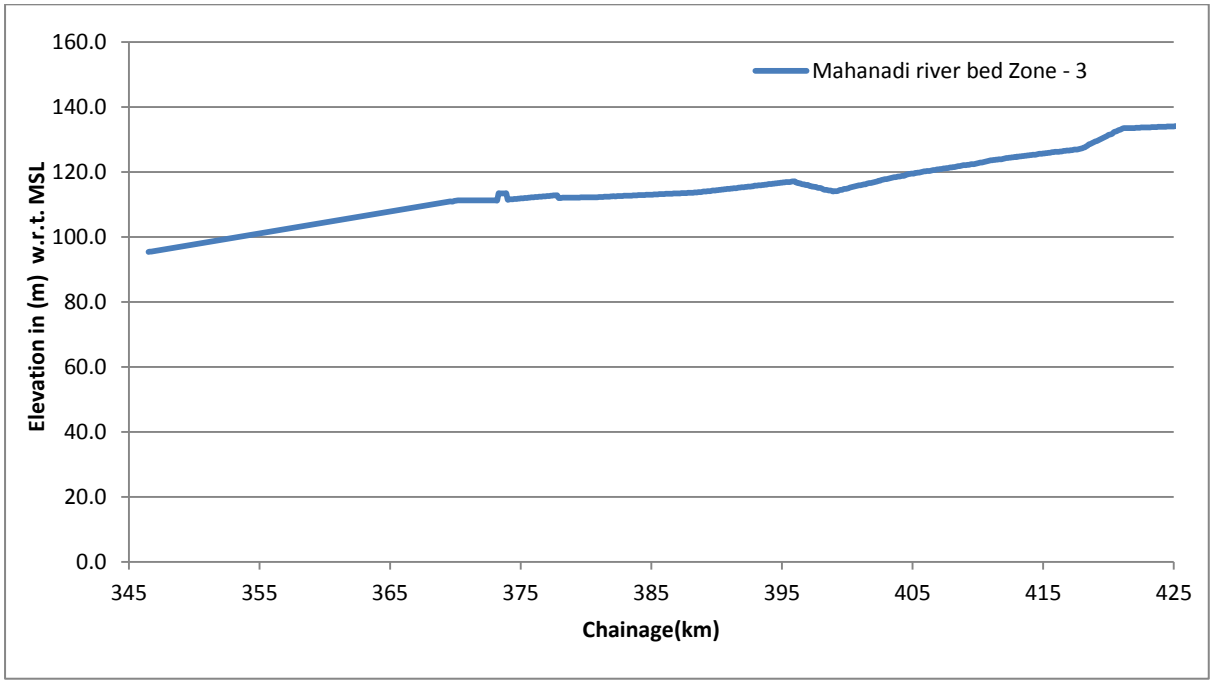


Figure 39: Mahanadi (Zone - 3) bed profile w.r.t. MSL

6.7.5 Luna River

The observed bed profile of Luna river waterways are presented in below Figure 40.

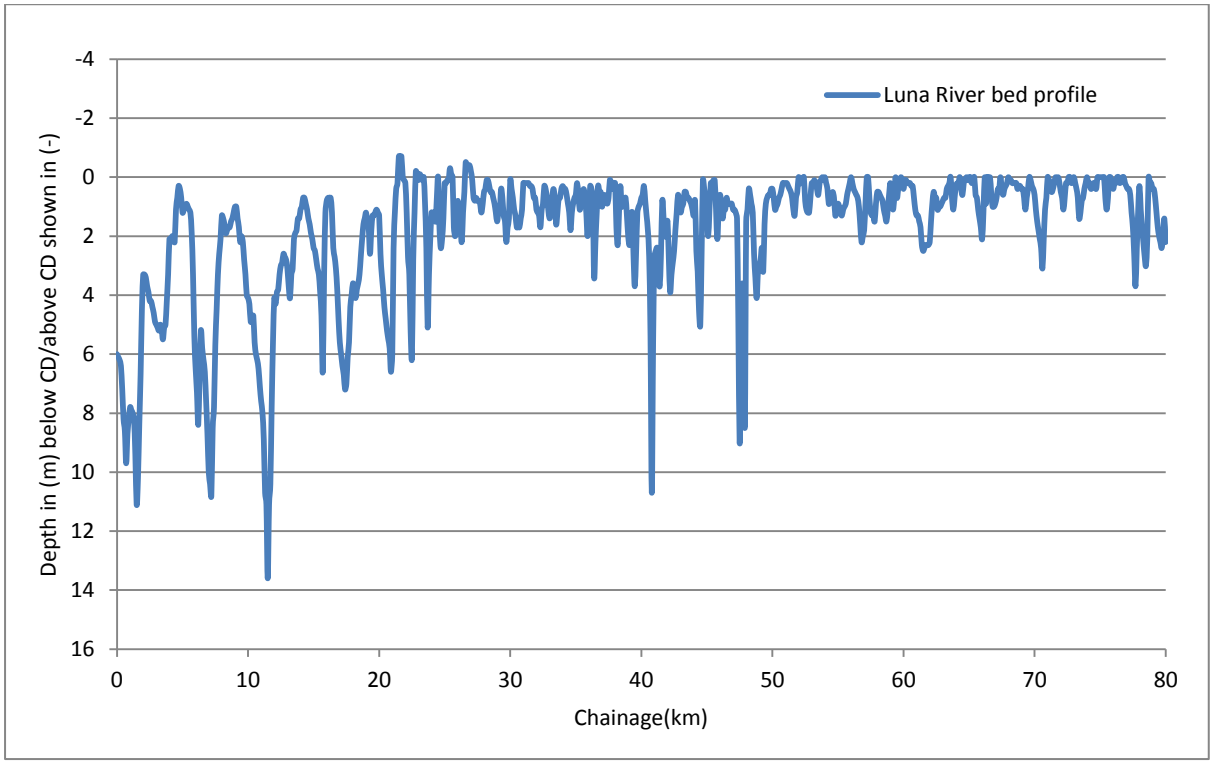


Figure 40: Luna river bed profile w.r.t. CD

6.8 Available Navigable Stretch – Mahanadi

The table below shows the representation of available navigable stretch for – 1.0m, 1.5m & 2.0m LAD @ chainage of 10km along with draft variation for Mahanadi under cluster IV.

S.No.	Chainage (km)	Draft Variation		Length of River (km)				Zone
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m	
1	0 - 5	10	0.6	0.5	0.7	0.8	3	Zone - 0
2	5 - 15	8.3	0.1	3.1	1.2	1.5	4.2	
3	15 - 25	8.1	0	1.5	2	2.4	4.1	
4	25 - 35	4.6	0.5	3.1	1.6	1.5	3.8	
5	35 - 37.84	8.2	0.5	1.4	0.6	0.5	0.4	
6	37.84 - 100	0	0	62	**DRY AREA**			
7	100 - 105	4.6	1	0	1.1	1.1	2.8	Zone – 1
8	105 - 115	4.1	0.7	1.1	2.2	2.8	3.9	
9	115 - 125	12.6	0.5	0.6	1.6	1.4	6.4	
10	125 - 135	6.9	0.5	0.6	0.6	1	7.8	
11	135 - 145	6.9	0.5	1	2.8	3	3.2	
12	145 - 155	8.4	0.5	1.1	3.1	3	2.8	
13	155 - 165	3.1	0.5	1.1	3.6	3.6	1.7	
14	165 - 175	4.9	0.5	1.1	2.2	2.2	4.5	
15	175 - 185	3.8	0.5	1.7	3.6	3.6	1.1	
16	185 - 195	7.8	0.5	1.7	3.3	2.8	2.2	
17	195 - 205	3.7	0.5	1.1	3.3	2.8	2.8	
18	205 - 215	3.7	0.5	1.1	3.3	3.4	2.2	Zone - 1
19	215 - 225	3.1	0	2.2	3.3	3.4	1.1	
20	225 - 229.6	2	0.5	2.3	1.2	1.1	0	
21	229.6 to 240	7.8	0.5	0.8	0.8	2.4	6.4	
22	240 to 251.6	9	0.5	0.9	1.8	2.7	6.2	
23	251.6 - 346.5	1.7	0.3	95	During Bathymetry survey, water observed intermittently varying from 0.3m to 1.7m. Due to lack of water, Topography has been carried out in this stretch. However, no rocky strata or any show stoppers were observed in this area.			Zone - 2
24	346.5km - 425km	0	0	78.5	Most of the area was occupied by rocky patches for the entire stretch except at (CH 374km to CH 380km). Many outcrop rocks were seen in the entire stretch. **Navigation in this area is not possible.**			Zone - 3
		TOTAL		**263.5**	**43.9**	**47**	**70.6**	

Table 23: Mahanadi river: Available Navigable Stretch

6.9 Available Navigable Stretch – Luna River

The table below shows the representation of available navigable stretch for – 1.0m, 1.5m & 2.0m LAD @ chainage 10km along with draft variation for Luna River under cluster IV

S.No.	Chainage (km)	Draft Variation		Length of River (Km)			
		Max. Available w.r.t. CD(m)	Min. Available w.r.t. CD(m)	<1m	1-1.5m	1.5-2.0m	>2.0m
1	0-10	10.8	1	0.54	1.35	2.16	5.95
2	10-20	13.6	0	0.54	1.62	2.16	5.68
3	20-30	6.6	0	3.24	2.7	2.16	1.9
4	30-40	3.7	0.1	3.78	2.97	2.17	1.08
5	40-50	10.7	0.1	1.62	2.16	3.52	2.7
6	50-60	2.2	0	6.21	2.44	1.08	0.27
7	60-70	2.5	0	6.21	1.9	1.21	0.68
8	70-80	3.7	0	4.59	2.16	1.9	1.35
	TOTAL			**26.73**	**17.3**	**16.36**	**19.61**

Table 24: Luna river: Available Navigable Stretch

6.10 Gauge Discharge Analysis

An average gauge discharge for 12 years (2000-2012) at Tikarpada has been analysed and following are the observations:

S.No.	Discharge(m^3/s)	Availability period in No. of days per year	% days in year
1	<200	13	3.6%
2	200-500	179	49.2%
3	500-700	43	11.8%
4	700-900	17	4.7%
5	>900	112	30.7%

Table 25: Water Availability in Mahanadi

The average discharge in the river varies from 128 m^3/s to 29000 m^3/s.

6.11 Classification of Waterways

The Inland waterways in India are classified into seven categories for rivers as well as canals as per the 'The Inland Waterways Authority of India Act, 1985' for safe plying of self-propelled vessels upto 2000 dead weight tonnage(DWT) and tug-barge formation in push-tow units of carrying capacity upto 8000tonnes. The classification of waterways is discussed below:

S.No.	Class of Waterways	Minimum Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance (m)
1	Class I	1.2	30	300	4	30
2	Class II	1.4	40	500	5	40
3	Class III	1.7	50	700	7	50
4	Class IV	2.0	50	800	10	50
5	Class V	2.0	80	800	10	80
6	Class VI	2.75	80	900	10	80
7	Class VII	2.75	100	900	10	100

Table 26: Classification of Inland Waterways for rivers

S.No.	Class of Waterways	Minimum Depth (m)	Bottom Width (m)	Bend Radius (m)	Vertical Clearance (m)	Horizontal Clearance (m)
1	Class I	1.5	20	300	4	20
2	Class II	1.8	30	500	5	30
3	Class III	2.2	40	700	7	40
4	Class IV	2.5	50	800	10	50
5	Class VI	3.50	60	900	10	60

Table 27: Classification of Inland Waterways for canals

Provided that this classification shall be effective only if:

a) Minimum depth of channel should normally be available for about 330 days of the year.
b) 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.
c) Reference level for vertical clearance in different types of channel shall be :
    i. For rivers, 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.
    ii. For tidal canals, over the highest high water level.
    iii. For other canals, over designed full supply level.

Type of vessels that can be used in different classes of waterways as per 'The Inland Waterways Authority of India Act, 1985' is shown in the Table 28 below.

Class of Waterways	Self-propelled Vessel	Tug with barges
Class I	Carrying capacity -100DWT (Size - 32m LOA, 5m moulded breadth and 1m loaded draft)	1 Tug + 2 barges – 200DWT (Size – 80m LOA, 5m moulded breadth and 1m loaded draft)
Class II	Carrying capacity -300DWT (Size - 45m LOA, 8m moulded breadth and 1.2m loaded draft)	1 Tug + 2 barges – 600DWT (Size – 110m LOA, 8m moulded breadth and 1.2m loaded draft)
Class III	Carrying capacity -500DWT (Size - 58m LOA, 9m moulded breadth and 1.5m loaded draft)	1 Tug + 2 barges – 1000DWT (Size – 141m LOA, 9m moulded breadth and 1.5m loaded draft)
Class IV	Carrying capacity -1000DWT (Size - 70m LOA, 12m moulded breadth and 1.8m loaded draft)	1 Tug + 2 barges – 2000DWT (Size – 170m LOA, 12m moulded breadth and 1.8m loaded draft)
Class V	Carrying capacity -1000DWT (Size - 70m LOA, 12m moulded breadth and 1.8m loaded draft)	1 Tug + 4 barges – 4000DWT (Size – 170m LOA, 24m moulded breadth and 1.8m loaded draft)
Class VI	Carrying capacity -2000DWT (Size - 86m LOA, 14m moulded breadth and 2.5m loaded draft)	1 Tug + 2 barges – 4000DWT (Size – 210m LOA, 14m moulded breadth and 2.5m loaded draft)
Class VII	Carrying capacity -2000DWT (Size - 86m LOA, 14m moulded breadth and 2.5m loaded draft)	1 Tug + 4 barges – 8000DWT and above (Size – 210m LOA, 28m moulded breadth and 2.5m loaded draft or with higher dimensions)

Table 28: Types of vessels to be used in different Class waterways

All new structures to be constructed across the national waterways classified under these regulations shall conform to the respective criteria of horizontal and vertical clearances of the appropriate class of waterway as provided.

6.12 Dredging

Generally dredging works in river areas are carried out to create depth in case of new developments and to maintain the dredged depths in the already existing developments for the safe movement of barges / vessels.

Dredging quantity has been worked out for a channel width of 40m and a depth of 1.4m with a side slope of 1:5 and the preliminary dredging quantity is found to be 20million cubic meter for Mahanadi River and 3.5million cubic meter for Luna River.

The quantities worked out are based on preliminary assessment. Detailed dredging shall be worked out in the next stage of the project.

CHAPTER 7
MARKET ANALYSIS & TRAFFIC POTENTIAL

7 Market Analysis and Traffic Potential

7.1 Market Overview

Odisha has an agriculture-based economy which is in transition towards an industry and service-based economy. According to the 2011 Census of India, 61.8% of the working is engaged in agricultural activities. However, the agricultural contribution to the GSDP was 16.3% in the fiscal year 2013-14 and it was estimated to be 15.4% in 2014-15. The area under cultivation was 5,691 hectare in 2005-06 and it dropped to 5,424 hectare in 2013-14. Rice is the dominant crop in Odisha.

During 2013-14, the state exported 4.13 lakh tonnes and ₹1,800 crore worth of seafood. In 2014-15, the value of exports rose by 26% to ₹2,300 crore with 4.67 lakh tonnes being exported. Odisha is the fourth largest shrimp producing state in India.

Since the state is rich in mineral resources like bauxite, iron ore, lime stone, dolomite, chromite etc., more of mineral based industries came up. Orissa being a rich repository of major minerals like Coal, iron ore, Chromite ore, Manganese ore, Bauxite, Dolomite and lime stone etc., has become a prime destination for primary metallurgical industries.

Odisha has oldest coal mines at Talcher and Ib valley and after nationalization of coal in 1975 and the national policy on energy sector, many power plants have come up in Odisha.

7.1.1 Industrial setup of Odisha

Major industries in Odisha are concentrated in clusters of Rourkela, Kalinganagar, Jharsuguda, Angul, Dhenkanal, Cuttack, Sundargarh, Kendujhar, Khorda, Paradip and Koraput.

S.No.	Region	Type of Industries
1	Rourkela- Rajganpur	Iron & Steel, Sponge Iron, Cement, Secondary Steel melting and rooling Mill, Refractories, Chemicals and Engineering
2	Ib valley & Jharsuguda area	Thermal Power, Sponge Iron, Refractories and Coal Mines (Aluminium, Coal Washeries)
3	Sambalpur region	Thermal Power, Sponge Iron, Steel
4	Hirakud	Aluminium, Rolling Mill
5	Talchar - Angul	Thermal Power, Aluminium, Coal Washeries, Ferro Alloys, Coal Mines
6	Choudwar	Ferro Alloys, Thermal power, Pulp and Paper, Coke Oven
7	Balasore	Pulp and Paper, Ferro Alloys, Rubber Industries
8	Chandikol	Stone crusher, Coke oven
9	Duburi	Integrated Steel, Ferro Alloys, Mineral Processing
10	Paradip	Fertilizer, Sea Food Processing, Petroleum Coke
11	Khurda- Tapang	Stone Crusher
12	Joda - Barbil	Pig Iron, Sponge Iron, Ferro Alloys, Iron Ore Crusher, Mineral Processing
13	Rayagada	Pulp and Paper, Ferro Alloys

Table 29: Region wise major industrial clusters

Location of industrial clusters is given in figure below. The clusters highlighted in red are the relevant clusters for the whole study i.e. Jharsuguda, Sambalpur and Cuttack. These clusters are situated along the waterway. For the purpose of this report, Cuttack cluster is discussed in detail.

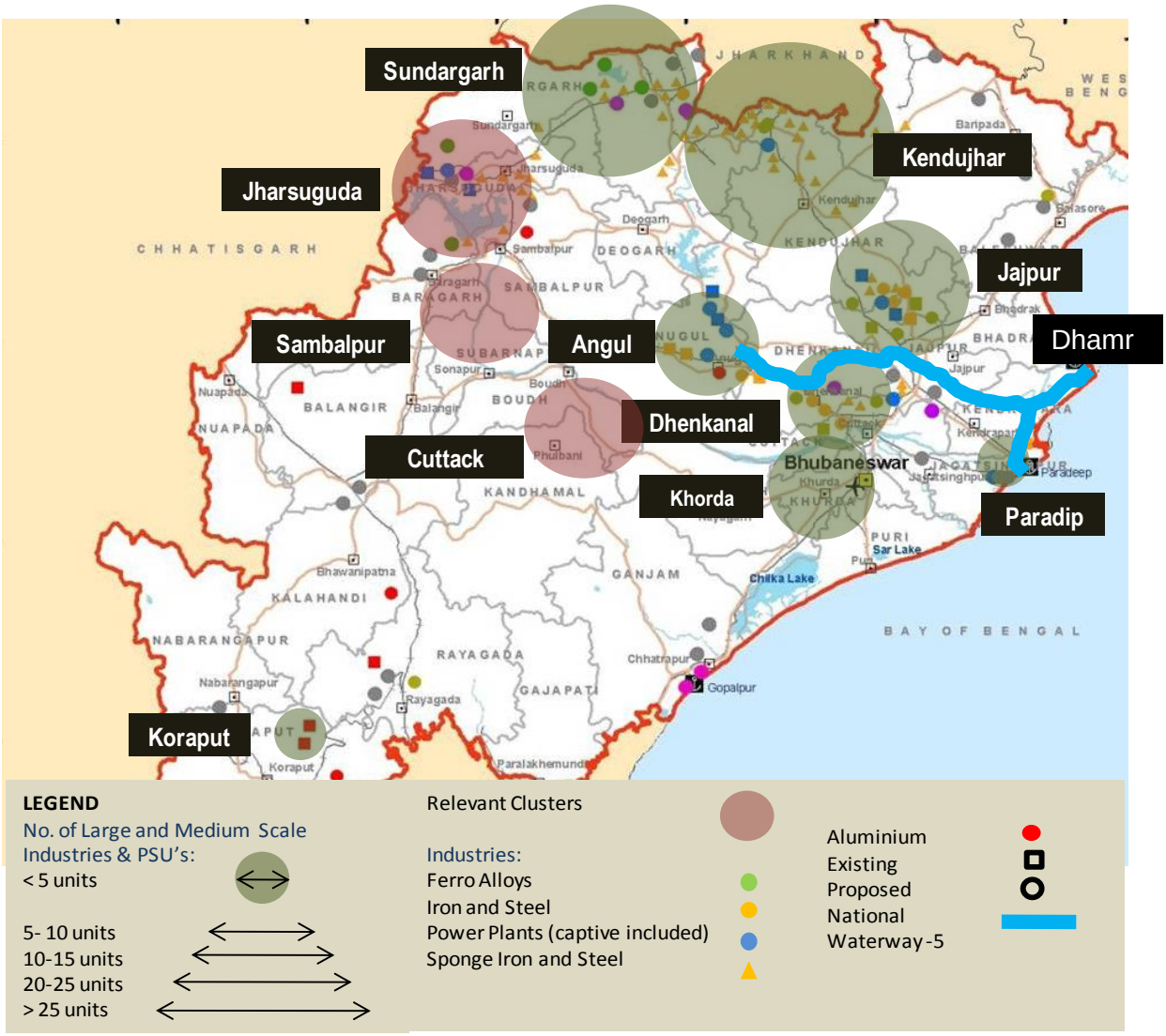


Figure 41: Industrial Clusters in Odisha

7.1.2 Existing Tourism Scenario in Odisha

Odisha is also enriched with enormous potentialities of tourism like: eco-tourism, rural tourism and agri- tourism. Day by day more and more tourists are attracted to come Odisha to witness and inculcate especially tribal culture, car festivals/ratha yatra, Konark sculpture, historical importance of Dhauli, Odishi dance, Chilika and other local festivals that strengthen the state economy as well as national economy by inflow of foreign currency.

The graph below shows the trend of tourist influx in Odisha from 2002-03 to 2011-12. Odisha has seen nearly linear growth in tourist traffic for this period.

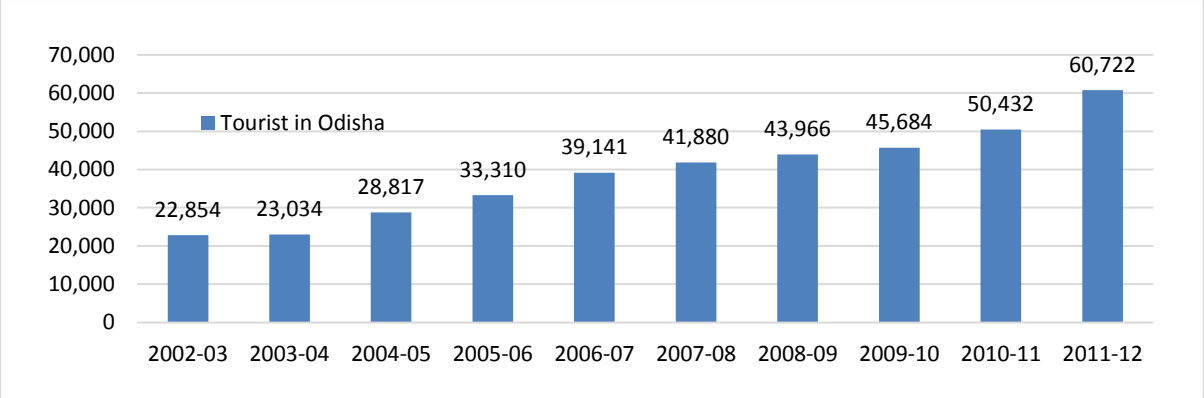


Figure 42: Tourist growth in Odisha

7.2 Market setup along waterway

7.2.1 Industries along the study stretch

Major industries along Mahanadi are in Jharsuguda, Sambalpur and Cuttack District. The type of industries include Sponge Iron, Steel and Aluminium. Figure 43 below shows the location of industrial clusters.

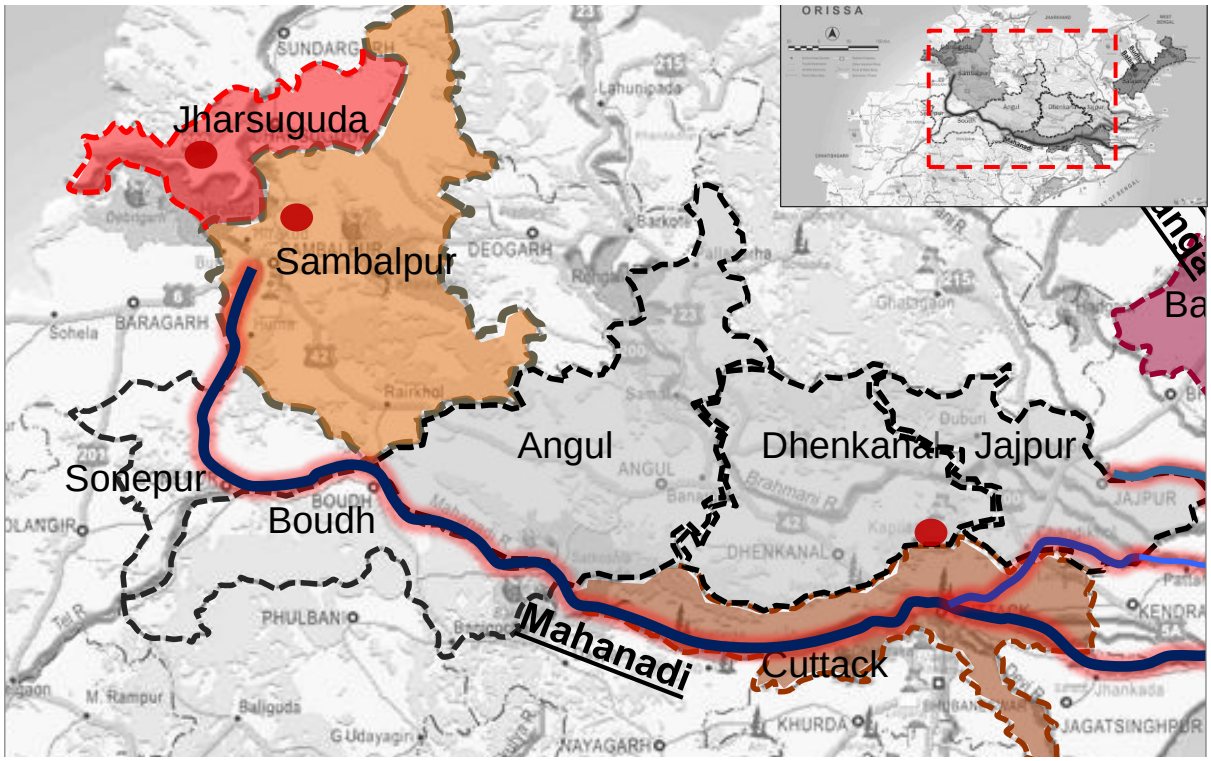


Figure 43: Industrial cluster along Mahanadi stretch

Jharsuguda District

Given below is the table showing industries at a glance.

S.No.	Head	Particulars (Units)
1	Registered Industrial Unit	730
2	Total industrial unit	1601

S.No.	Head	Particulars (Units)
3	Registered medium & large units	18
4	No. of industrial area	2

Table 30: Industrial units in Jharsuguda Cluster

Currently, there are 18 large and medium scale industries. The table below shows the existing large scale industries and PSUs with their installed capacity.

S.No.	Name of the unit	Major items of production	Installed capacity
1	Ultratech Cement ltd	Cement	0.5 .MTPA
2	IB Thermal Power Station, Banharpali	Electricity, Thermal	2 x 210 MW
3	SMC Power Generation Corporation	Electricity, Thermal	220 MW
4	LN Metallics Ltd	Sponge Iron	0.3 MTPA
5	Vedanta Aluminium ltd	Aluminium	0.2 MTPA
6	SPS Sponge Iron ltd	Sponge Iron	0.8 MTPA
7	Eastern Steel & Power ltd	Steel	1 MTPA
8	Seven Star Steel ltd	Steel	0.3 MTPA
9	Tata Refractories ltd	Steel	0.2 MTPA
10	IOC ltd	Petroleum	0.4 MTPA

Table 31: Large and Medium Scale Units and PSU's in Jharsuguda Cluster

Source: Brief Industrial Profile of Jharsuguda District, MSME; 2012-13 and Primary Research

Sambalpur District

The table below shows the details of industrial clusters.

S.No.	Head	Particulars (Units)
1	Registered Industrial Unit	1258
2	Total industrial unit	5990
3	Registered medium & large units	15
4	No. of industrial area	2

Table 32: Industrial units in Sambalpur Cluster

Source: Brief Industrial Profile of Sambalpur District, MSME; 2012-13 and Primary Research

Currently, there are 14 large and medium scale industries. The table below shows the list of existing large scale industries and PSUs with their installed capacity.

S.No.	Name of the unit	Major items of production	Installed capacity
1	Maa Samaleswari Sponge Iron Ltd.	Sponge Iron	1 MTPA
2	Hindalco Industries ltd, Captive Power plant	Electricity	467 MW
3	Samaleswari Ferro Metal Pvt Ltd.	Ferro Alloys	0.5 MTPA
4	Aryan Ispat & Power Projects Pvt Ltd.	Ferro Alloys	0.3 MTPA
5	Rathi Steel & Power Projects Ltd.	Steel, Electricity	0.4 MTPA, 100 MW
6	R B Sponge Iron Ltd.	Sponge Iron	1 MTPA
7	Jay Jagannath Steel & Power Ltd.	Steel, Electricity	150 MW
8	Shyam DRI Power Ltd.	Sponge Iron, Electricity	1.8 MTPA, 75 MW
9	Viraj Steel & Energy Ltd.	Steel, Electricity	0.08 MTPA, 50 MW
10	Aditya Aluminium Ltd.	Electricity	6 x 150 MW

Table 33: Large and Medium Scale Units and PSU's in Sambalpur Cluster

Cuttack District

S.No.	Head	Particulars (Units)
1	Registered Industrial Unit	5776
2	Total industrial unit	13126
3	Registered medium & large units	19
4	No. of industrial area	8

Table 34: Industrial units in Cuttack Cluster

Currently, there are 19 large and medium scale industries. The existing large scale industries and PSU's and their installed capacity is given in the table below.

S.No.	Name of the Unit	Major Item of Production	Installed Capacity
1	Arati Steel, Athagarh	Sponge Iron	0.4 MTPA
2	Indian Charge Chrome ltd, Chaudwar	Ferro Alloys	0.1 MTPA
3	Bajrangabali Alloys pvt ltd,	Ferro Alloys	0.2 MTPA
4	Maheswary Ispat ltd, Athagarh	Ferro Alloys	0.4 MTPA
5	Raw Met Industries ltd, Athagarh	Steel	0.4 MTPA
6	OCL India ltd, Tangi captive power plant	Electricity	150 MW
7	Sri Hardev Steel pvt ltd, Athagarh	Steel	0.2 MTPA
8	Biraja Steel and Power pvt ltd, Athagarh	Steel, Electricity	2.5 MTPA, 100 MW
9	COS Board pvt ltd, Jagatpur	Paper Board and news print	
10	Purvi Bharat Coke pvt ltd, Kuspangi	Coke	
11	Badamba Sugar India ltd	Sugar and Spirit	

Table 35: Large and Medium Scale Units and PSU's in Cuttack Cluster

7.2.2 Mineral reserves along the study stretch

Jharsuguda district is situated in the north western part of Odisha and is characterized by variety of economic mineral reserves including coal, chromite, quartzite, dolomite, iron ore, limestone and, quartz etc. Coal being the major mineral resource of the cluster is found in Ib valley coal field with a proven reserve of 11987.21 million tonnes. The minerals viz; Bauxite, Coal, Dolamite, Graphite and Coarse Crystal Quartz are found in Sambalpur District.

7.2.3 Agricultural scenario along the study stretch

Kharif is the main cropping season and rice is the principal crop of during kharif season. Cropping during Rabi season is mainly confined to the irrigated areas. Other important crops produced are pulses (Arhar, Mung, Biri, Kulthi), oil seeds (Groundnut, Til, Mustard and Nigar), Fibres (Jute, Mesta, Cotton), Sugarcane, Vegetables and Spices. In 2011-12, rice production in Cuttack, Jajpur and Kendrapara combined occupied 386040 Ha in the Kharif season and 8500 Ha in the Rabi season. The table below gives details of the other produces during 2011-12.

S.No.	Name of the district	Rice	Other cereals	Total cereals	Total pulses	Total food-	Total oilseeds	Total vegetables	Total fibres	Total Spices	Total cropped

						grains					area
1	Jharsuguda	38.04	1.9	39.94	14.16	54.1	4.15	3.2	0.07	1.09	62.61
2	Baragarh	234.79	0.86	235.65	65.03	300.68	24.98	6.18	1.33	1.94	335.11
3	Bolangir	170.4	6.88	177.28	77.67	254.95	9.4	19.15	37.15	1.09	321.74
4	Nowapara	95.09	11.32	106.41	60.51	166.92	25.06	6.03	4.22	1.96	204.19
5	Kalahandi	202.33	17.99	220.32	84.23	304.55	16.72	8.88	38	2.52	370.67
6	Cuttack	134.33	1.47	135.8	2.72	138.52	1.84	7.92	2.09	2.73	153.1
7	Khordha	95.94	0.9	96.84	2.3	99.14	0.17	5.55	0.14	0.68	105.68
8	Angul	78.36	4.53	82.89	58.64	141.53	37.79	5.47	0.62	3.01	188.42

Table 36: District wise Kharif cropped area (Mahanadi) in '000 Ha

S.No.	Name of the district	Rice	Other cereals	Total cereals	Total pulses	Total food grains	Total Oilseeds	Total vegetables	Total spices	Sugarcane	Total cropped area
1	Jharsuguda	0.66	0.57	1.23	8.99	10.22	5.6	2.48	0.76	0.2	19.26
2	Baragarh	70.54	1.01	71.55	16.83	88.38	11.16	4.87	2.41	1.16	107.98
3	Bolangir	4.29	1.85	6.14	66.81	72.95	12.32	22.17	2.29	2.61	112.34
4	Nowapara	3.55	0.57	4.12	44.25	48.37	8.76	7.08	1.28	0.04	65.53
5	Kalahandi	12.13	2.03	14.16	102.97	117.13	35.04	15.27	2.76	1.82	172.07
6	Cuttack	4.29	0.69	4.98	111.85	116.83	15.01	17.33	4.35	3.11	156.63
7	Khordha	0.87	0.21	1.08	29.88	30.96	6	17.53	0.91	1.34	56.74
8	Angul	0.75	0.82	1.57	50.66	52.23	20.1	18.13	5.94	0.26	96.72

Table 37: District wise Rabi cropped area (Mahanadi) in '000 Ha

7.3 Rail/Road Connectivity

Industries in the districts of Jharsuguda, Sambalpur, Cuttack and Jagatsinghpur are well connected to coal and iron ore mines and to Paradip and Dhamra port via rail and road.

Rail Connectivity: Cuttack is part of the East Coast Railway zone and is well connected to various cities of Odisha such as Puri and Bhubaneswar. Paradip Port is connected by a double, electrified line section with Cuttack which connects to the Howrah Chennai Trunk Line. The 155 km Daitari-Banspani rail line is also under construction. The 78 km Haridaspur-Paradip Rail Link to provide a dedicated corridor from the Port to the iron ore mines and steel plants is also under construction.
Dhamra port has acquired a 125 meter wide corridor from Dhamra to Bhadrak which can accommodate two rail tracks and a four lane road along with service lines viz. transmission line and pipe lines. Sambalpur and Jharsuguda clusters have a well-established rail connectivity to Vizag and Gangavaram Port in Tamil Nadu.

Road Connectivity: Paradip port is connected to NH-5 through a 2-lane road up to Chandikol and 4-laning of the road is in process. The two lane SH-12 from Paradip port to Cuttack provides network between the port and the mines. Jharsuguda and Sambalpur clusters connected to Paradip port through NH 200. Dhamra port is connected to NH5 through Jamujhadi Dhamra road which is proposed to be widen to four lanes.

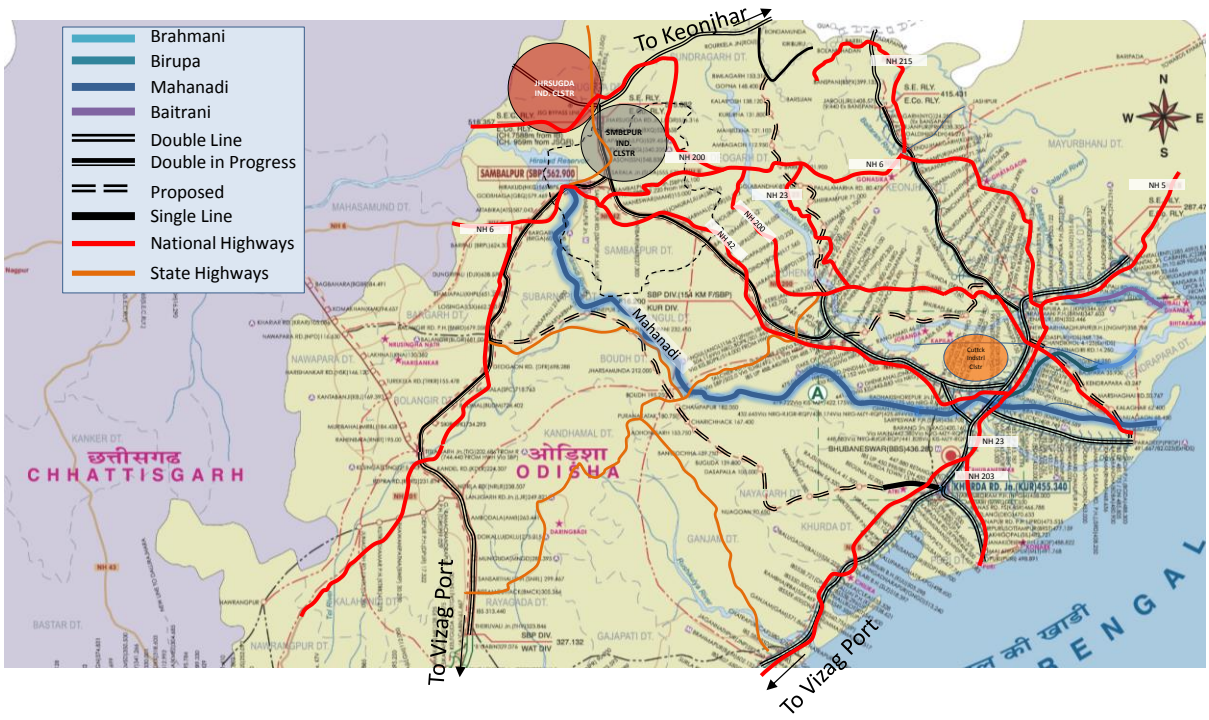


Figure 44: Rail-Road connectivity map

7.4 Traffic Potential

The **total traffic potential** in the hinterland of Birupa/Badi Genguti/Brahmani River stretches include the inbound and outbound traffic of all the industries in the Cuttack cluster , EXIM traffic at Paradip and Dhamra ports and possible passenger movement along the waterway. Of the total traffic in the region, the **relevant traffic potential** for these stretches is considered to be the portion of total traffic whose origin and/or destination points are in the vicinity of the river stretches, and whose direction of movement (or a part thereof) corresponds to the alignment of the waterway.

7.4.1 Approach & Methodology

The Consultants carried out preliminary analysis of the expected traffic for the waterway. The proposed approach and methodology has been depicted in the flowchart below.

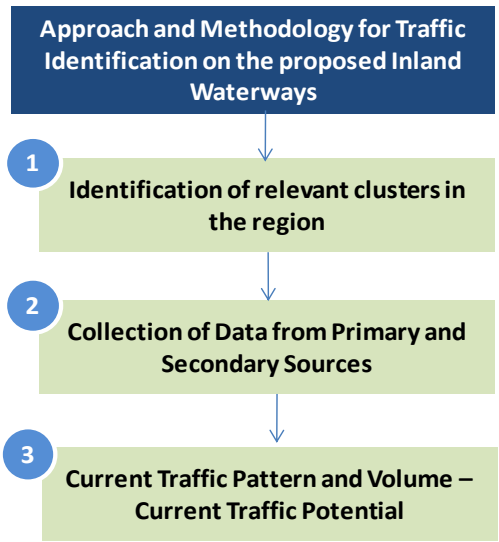


Figure 45: Flowchart showing approach and methodology for traffic identification

Each of the steps mentioned in the flowchart above have been described in detail as follows

Step 1: Identification of relevant clusters in the region

The relevant clusters include major industrial clusters and tourism locations such as temples, waterfalls, etc.

Major industries in Odisha are concentrated in the clusters of Rourkela, Jaipur, Jharsuguda, Angul, Dhenkanal, Sundargarh, Sambalpur, Cuttack, Keonjhar, Khorda, Paradip and Koraput. Out of these industrial clusters, traffic study was conducted for the relevant clusters along the waterway i.e. Angul, Dhenkanal, Jaipur, Jharsuguda Sambalpur and Cuttack. It is assumed that traffic from these clusters currently moving along the railway and roadway may shift onto the waterway. The clusters would be delineated according to district boundaries.

Odisha is also enriched with enormous potentialities of tourism like: eco-tourism, rural tourism and agri- tourism. Day by day more and more tourists are attracted to come to Odisha to witness and inculcate especially tribal culture. Tourist spots along the waterway can be utilized for water tourism.

Step 2: Collection of data from primary and secondary sources

This step involves carrying out interviews with the industries like steel plants, thermal power plants and related industrial associations to get estimates on quantum of inflow of raw materials and outflow of finished products, proposed expansion plans, probability of shifting cargo from existing modes i.e. rail and road to waterways

This step also includes collection of information about the major tourist spots along the waterway. Secondary data collection for industries was carried out from related websites and review of reports like

- Brief Industrial Profile of Districts, Ministry of MSME (Ministry of Micro, Small and Medium Enterprises)
- Orissa state Economic Survey Report
- Official websites of relevant districts
- Department of Steel and Mines, Govt. of Odisha
- Orissa Power Generation Company
- National Thermal Power Corporation
- Mahanadi Coal Fields Ltd

For tourism related information, the data was collected from the following sources.

- Orrisa Tourism web portal
- District websites
- Published literature to identify tourist places along the study stretch

Step 3: Study and analysis of the current and future traffic potential

Based on the data collected from primary and secondary sources, a preliminary traffic potential was worked out.

Thermal power plants and Steel plants are likely to be the key traffic generators, considering the first cut profile of existing industrial clusters.

For steel plants, current finished product off take would be estimated based on the installed capacity of steel plants and their current utilization levels. Assumptions like requirement of raw material per tonne of finished product would be made to estimate the raw material intake.

Similarly, coal requirement for thermal power plants would be estimated based on the installed capacity, current utilization levels and coal required per 1000 megawatt of power generated.

7.4.2 Cargo Potential

I. Existing traffic through the waterway

Presently, no cargo is moving through the study stretch.

II. Traffic potential

A. Total raw material requirement

For the purpose of stage-1, raw material requirement of the industries is taken as the prime traffic generator. This type of cargo is considered to be suitable for movement through waterway because of its bulk nature. The Cargo Potential for Mahanadi has been collectively considered from Jharsuguda, Sambalpur and Cuttack clusters. Depending upon the presence of major type of industries, total traffic is divided into raw materials for steel and iron industry; raw material for thermal power plants; finished goods. The traffic commodities mainly include coke, coking coal, thermal coal, iron ore, chrome ore, limestone and dolomite/quartzite. Potential of finished products as traffic commodity can also be explored for steel and aluminium industry.

Odisha being rich in minerals, large number of mineral based industries have come up. The industrial clusters of Jharsuguda, Sambalpur and Cuttack accommodate thermal plants, sponge iron plants, steel industries and ferro alloy industries.

As the bulk cargo is suited for movement through waterway, Coal, Iron Ore, Limestone, Dolomite, Chrome Ore and Thermal coal qualify as the potential cargo. The raw material requirement for the industries in relevant clusters is shown in the graph below:

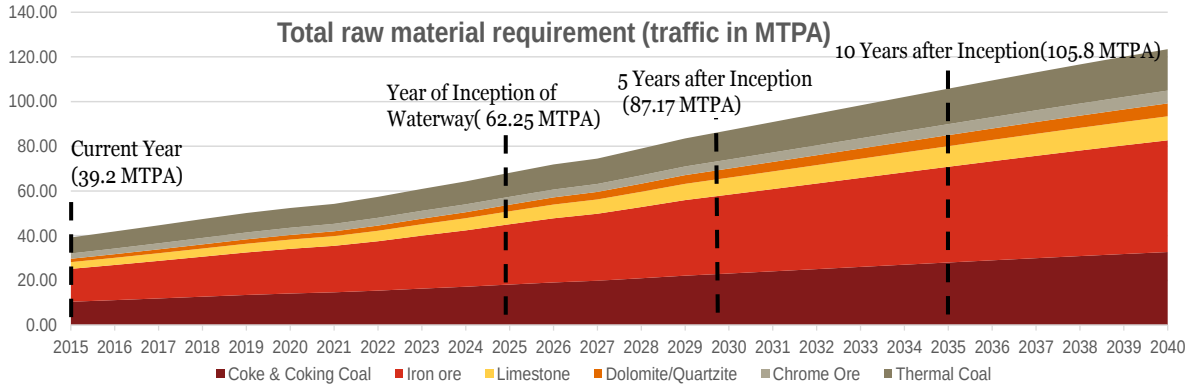


Figure 46: Total raw material requirement (traffic)

In 2015, the total raw material requirement for the industries comes out to be approximately 39 MTPA. Considering 2025 as the year of start of operations, the total requirement for raw material is estimated at 62.25 MTPA with Iron Ore requirement being highest at 26.98 MTPA.

B. Relevant traffic potential (potential cargo movement)

The cargo that has origin or destination at Paradip or Dhamra Port has been taken as 'divertible cargo' as this has the potential to be diverted from rail or road to the proposed waterway. Cargo OD patterns of the industries located in the relevant cluster were analysed using the East Coast Railways data and telephonic interviews with the industries. Coke, coking coal, Iron ore and Thermal coal are commodities found to be moving to and from ports.

The total divertible traffic for 2015 comes out to be 13.72 MTPA. Considering 2025, as the year of inception of the waterway, the total divertible cargo is estimated at 24.10 Million tonnes per annum.

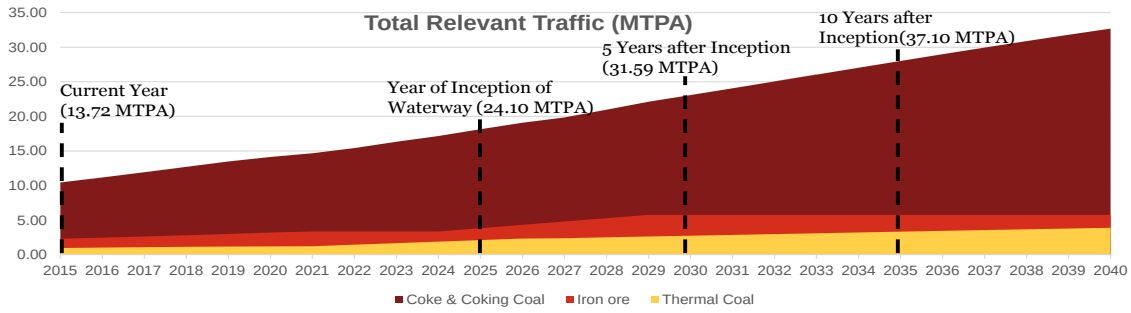


Figure 47: Divertible cargo traffic[1]

Further, cluster wise analysis reveals that Jharsuguda has the highest traffic generating potential followed by Sambalpur and Cuttack. According to 2015 figures, Jharsuguda has traffic generating potential of 6.37 Million tonnes and Sambalpur and Cuttack can generate 5.66 Million tonnes and 1.64 Million tonnes of traffic respectively.

[1] Note: All the estimates are preliminary in nature. Detailed potential will be worked out in stage 2 of the study

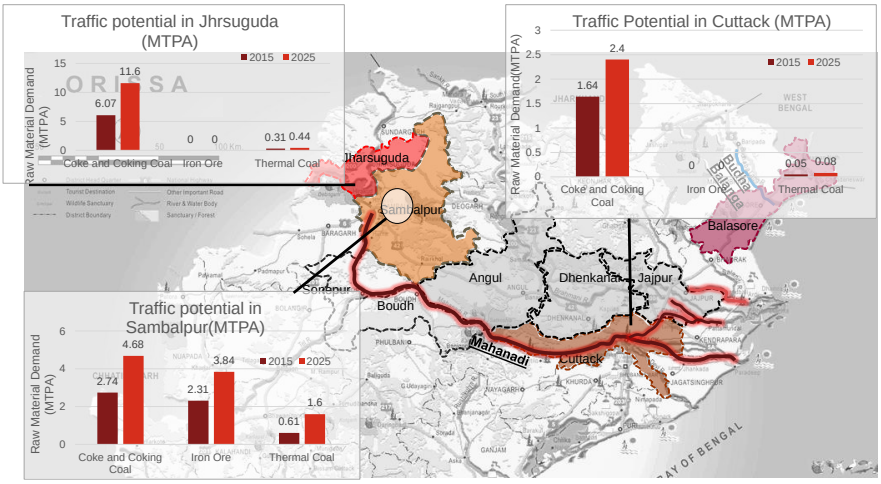


Figure 48: Cluster wise traffic potential

The estimated figures of 2025 (start of waterway operations) reveal that traffic generating potential of Jharsuguda cluster is 12 million tonnes. The figure above shows the commodity wise traffic potential for the relevant clusters.

7.4.3 Passenger traffic potential

I. Existing passenger movement through the waterway

Presently, the study stretch is not being utilized for any passenger movement.

II. Future traffic potential

The following water based tourism options have been explored, and suitable ones then narrowed upon, considering the catchment area and current tourist profile.

River Cruise	Riverfront	Riverside Wildlife	Waterfalls

There are two major tourist locations along the study stretch, Satkosia and Baisipali sanctuaries. These attractions can be potential traffic generators for passenger traffic as these destinations can be reached via waterway. This needs to be further studied in stage 2 of the study.

7.5 Summary

The table below shows the relevant traffic potential for the discussed river stretch.

Name of the River	Relevant Clusters (District)	Type of Industries	Potential commodities (anchor commodity)	Total raw material requirement (MTPA)		Relevant Traffic (Potential in MTPA)	
				2015	2025	2015	2025
Mahanadi/ Luna/Birupa/ Brahmani	Jharsuguda	Thermal Plants, Sponge Iron, Steel, Ferro Alloys	Coking coal and Coke	10.45	18.14	10.45	18.14
			Iron Ore	14.72	26.98	2.31	3.84
	Sambalpur		Limestone	3.00	5.80	--	--
			Dolomite	1.52	2.95	--	--
			Chrome Ore	2.37	3.52	--	--
	Cuttack		Thermal Coal (Imported)	0.97	2.12	0.97	2.12
			Thermal coal (Domestic)	6.19	8.63	--	--
			Total	**39.2**	**62.25**	**13.72**	**24.10**

Table 38: Summary of Traffic potential

CHAPTER 8
SWOT ANALYSIS

8 SWOT Analysis of Proposed Waterway

Swot Analysis (Strength Weaknesses Opportunities Threats) has been carried out and is presented in the following image.

	Helpful	**Harmful**
Internal	*STRENGTHS* - Traffic potential - Very wide river, no turning radius issue - Paradip port near to the estuary - Small scale and large scale industries exist along the river - Alternate route through Luna can bypass the dry area at Cuttack region to a large extent. - Connectivity to Dhamra Port can be achieved.	*WEAKNESSES* - Initial 80km from Sampalpur to Sonepur found to be rocky, navigation not possible - Maintaining navigational channel - Double handling of cargo
External	*OPPORTUNITIES* - Construction of terminals - Riverine tourism - Opportunity for small industry for a dedicated corridor - Traffic movement can be established between Paradip to Sonepur.	*THREATS* - Maintenance dredging will be more - Increase in irrigational requirement may affect the water levels - established rail network - Constraints in navigation in terms of size of the barges due to cross structures

Table 39: Swot Analysis

CHAPTER 9
OBSERVATIONS & SUGGESTIONS

9 Observations and Suggestions

9.1 Observations

Name	Waterway	Length	Cross Structures	Cargo/Passenger/ Tourism/RO-RO
Mahanadi	The Mahanadi study stretch can be made navigable from Paradip to Sonepur through technical interventions such as dredging, construction of locks, etc.	425km of the river length surveyed	15 bridges and 2 barrages observed across the study stretch	Presently no cargo movement
Luna	Most of the lune stretch found to be navigable. Rest can be made navigable through technical interventions	75km of the river length was surveyed	8 bridges were observed across the study stretch	Presently no cargo movement

Table 40: Observations

9.1.1 Suggestions

Following points are suggested for the navigability of the rivers

- Approx. 78 km of Mahanadi from Sambalpur to Sonepur is found to be rocky and navigation in this stretch is not possible.
- Navigation can be achieved for 345km of Mahanadi from Sonepur to Paradip mouth after technical interventions such as dredging, construction of barrages/locks, check dams, etc.
- Considering the availability of water depth, 75km of Luna River can be considered as an alternate route to Mahanadi from Tentola Village to Balidia Village.
- Downstream of Mahanadi from Cuttack can be developed as tourism hub and riverine tourism to be promoted.

CHAPTER 10
ANNEXURE

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