MAHANADI VIA LUNA RIVER – FINAL DETAILED PROJECT REPORT (DPR) OF

NATIONAL WATERWAY NO-64

FROM RIVER MOUTH, PARADIP (ODISHA) TO CUTTACK (ODISHA)

LENGTH 98.00 km

VOLUME I: MAIN REPORT

DATE OF SUBMISSION: 12 June 2020

CLIENT:

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Detailed Project Report (DPR) of National Waterway 64: Mahanadi Via Luna River Detailed Project Report (DPR) of National Waterway 64: Mahanadi Via Luna River Detailed Project Report (DPR) of National Waterway 64: Mahanadi Via Luna River

Stretch: From River Mouth, Paradip (Odisha) To Cuttack (Odisha)

Length 98 km

VOLUME – I DETAIL PROJECT REPORT

Prepared for	Inland Waterways Authority of India
Represented by	Hydrographic Chief

STRUCTURE OF DETAILED PROJECT REPORT

The report contains the following details/Volumes

Volume I – Main Report/Detailed Project Report

- Annexure I – Cost Estimate
- Annexure II – Construction Schedule
- Annexure III – Terms of Reference

Volume II - Drawings

Volume III – Hydrographic Survey

- Volume IIIA - Hydrographic Survey Report
- Volume IIIB - Hydrographic Survey Charts

Volume IV- Geotechnical Investigation Report

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LIST OF ABBREVATIONS

AD	:	After Death
AMHS	:	Admiralty Manual of Hydrographic Surveying
BGL	:	Below Ground Level
BM	:	Benchmark
BOCW	:	Building and Other Construction Workers
BOD	:	Build Own Operate
BOT	:	Build Operate Transfer
BOOT	:	Build Own Operate and Transfer
°C	:	Degree Celsius
CAPEX	:	Capital Expenditure
CD	:	Conservation Dependent
CH	:	Chainage
CP	:	Control Point
CPCB	:	Central Pollution Control Board
CPWD	:	Central Public Works Department
Cr.	:	Crore
CR	:	Critically Endangered
CRZ	:	Coastal Regulation Zone
CSD	:	Cutter Section Dredgers
CUM	:	Cubic Meter
dB	:	Decibels
DM	:	District Magistrate
DPR	:	Detailed Project Report
DG	:	Diesel Generator
DGLL	:	Directorate General of Lighthouses and Lightships
DGPS	:	Differential Global Positioning System
DPCL	:	Dharma Port Company Limited
DWT	:	Deadweight Tonnage
E	:	Easting
EIA	:	Environment Impact Assessment

EIRR	:	Economic Internal Rate of Return
EMP	:	Environment Management/Monitoring Plan
EN	:	Endangered
EPC	:	Engineering, Procurement and Construction
FACOR	:	Ferro Alloys Corporation
FIRR	:	Financial Internal Rate of Return
Fy	:	Yield Stress
G&D	:	Gauge & Discharge
GI	:	Galvanized Iron
GIS	:	Geographic Information System
GL	:	Ground Level
Govt.	:	Government
GPS	:	Global Positioning System
HC	:	Horizontal Crossing
HF	:	High Frequency
HFL	:	High Flood Level
HW	:	High Water
INR	:	Indian Rupees
IBAT	:	Integrated Biodiversity Assessment Tool
IS	:	Indian Standards
IWT	:	Inland Water Transport
IWAI	:	Inland Waterways Authority of India
IHO	:	International Hydrographic Organization
IMD	:	Indian Meteorological Department
IUCN	:	International Union for Conservation of Nature
Km	:	Kilo Meter
Kmph	:	Kilometer per Hour
kN	:	Kilo Newton
LAD	:	Least Available Depth
LAT	:	Latitude
LC	:	Least Concern

LOA	:	Length Over All
LONG	:	Longitude
LW	:	Low Water
LWL	:	Load Waterline Length
MDR	:	Major District Roads
M	:	Meter
MAX	:	Maximum
MARPO		
L	:	Marine Pollution
MHWS	:	Mean High Water Springs
MHWN	:	Mean High Water Neaps
MIN	:	Minimum
MLWS	:	Mean Low Water Springs
MoEF&C	:	Ministry of Environment, Forests and Climatic Change
MoWR	:	Ministry of Water Resources
Mpa	:	Mega Pascal
MT	:	Metric Tonne
MSL	:	Mean Sea Level
MTPA	:	Metric Tonnes Per Annum
N	:	Northing
NAAQ	:	National Ambient Air Quality
NBWL	:	National Board for Wildlife
NH	:	National Highway
NIC	:	National Informatics Center
NOC	:	No Objection Certificate
NPV	:	Net Present Value
NT	:	Near Threatened
NW	:	National Waterway
O&M	:	Operation & Maintenance
OPEX	:	Operational Expenditure
OPSCB	:	Odisha State Pollution Control Board

OSDMA	:	Odisha Disaster Mitigation Authority
OSWC	:	Odisha State Warehouses Corporation
OTDC	:	Odisha Tourism Development Corporation
p.a.	:	Per Annum
PM	:	Particulate Matter
PUC	:	Pollution Under Control
RCC	:	Reinforced Cement Concrete
RFP	:	Request for Proposal
RIS	:	River Information Services
RRC	:	Rice Receiving Centers
SBWL	:	State Board for Wildlife
SD/CD	:	Sounding Datum/ Chart Datum
SDM	:	Sub-Divisional Magistrate
SEIAA	:	State Level Environment Impact Assessment Authority
SH	:	State Highway
SONAR	:	Sound Navigation and Ranging
SPCB	:	State Pollution Control Board
STP	:	Sewage Treatment Plan
SPV	:	Special Purpose Vehicle
Sqm	:	Square Meter
SWOT	:	Strength Weak Opportunity Threat
TOR	:	Terms of Reference
TP	:	Transfer Point
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
VC	:	Vertical Crossing
VHF	:	Very High Frequency
VU	:	Vulnerable
WACC	:	Weighted Average Cost of Capital
WGS	:	World Geodetic System
WL	:	Wildlife

SALIENT FEATURES AT A GLANCE

<table>
<tr><th>.</th><th>PARTICULARS</th><th>DETAILS</th></tr>
<tr><td>1.</td><td>Name of Consultant</td><td>FEEDBACK INFRA PVT. LTD</td></tr>
<tr><td>2.</td><td>Region number & State(s)</td><td>Odisha</td></tr>
<tr><td>3.</td><td>Waterway stretch, NW #
(from 0.00 to 98 total length)</td><td>Mahanadi-Luna River, NW-64, From Mahanadi River Mouth to
<table>
<tr><th>Stretch</th><th>from</th><th>to</th><th>Kms</th><th>Location</th></tr>
<tr><td>1</td><td>0.00</td><td>10.00</td><td>10</td><td>Musadia to Madhusudanpur</td></tr>
<tr><td>2</td><td>10.00</td><td>20.00</td><td>10</td><td>Madhusudanpur to Benupal</td></tr>
<tr><td>3</td><td>20.00</td><td>30.00</td><td>10</td><td>Benupal to Godhan</td></tr>
<tr><td>4</td><td>30.00</td><td>40.00</td><td>10</td><td>Godhan to Tala gaon</td></tr>
<tr><td>5</td><td>40.00</td><td>50.00</td><td>10</td><td>Tala gaon to Balisahi</td></tr>
<tr><td>6</td><td>50.00</td><td>60.00</td><td>10</td><td>Balisahi to Kulabada</td></tr>
<tr><td>7</td><td>60.00</td><td>70.00</td><td>10</td><td>Kulabada to Kalanapur</td></tr>
<tr><td>8</td><td>70.00</td><td>80.00</td><td>10</td><td>Kalanapur to Bisurapur</td></tr>
<tr><td>9</td><td>80.00</td><td>90.00</td><td>10</td><td>Bisurapur to Andeisahi</td></tr>
<tr><td>10</td><td>90.00</td><td>98</td><td>8</td><td>Andeisahi to Cuttack</td></tr>
</table>
Cuttack, 98 Km</td></tr>
<tr><td>4.</td><td>Navigability status</td><td>Ferry services are available in Mahanadi River, Partly Navigable.</td></tr>
<tr><td>a)</td><td>Tidal & non-tidal portions
(from 0.00 to 98 length, average tidal variation)</td><td>Tidal Portion-
From Mahanadi Mouth, CH 0 Km to Dihabalarampur, CH 43 Km =(43 Km)
Non-Tidal Portion-
From Dihabalarampur, CH 43 Km to Cuttack Andeisahi near Jobra barrage, CH 98 KM= 55 Km</td></tr>
</table>

STRETCH	STRETCH 1 (0-10) KM	STRETCH 2 (10-20) KM	STRETCH 3 (20-30) KM	STRETCH 4 (30-43) KM
Tidal variation	2.30	2.00	1.80	1.2

b) LAD (Least Available Depth) wrt CD.

i) Survey period (08Mar 2017 to 27 Apr 2017)

LAD	STRETCH-1 (0-10.0 km)	STRETCH-2 (10-20 Km)	STRETCH-3 (20-30 Km)	STRETCH-4 (30-43 Km)	STRETCH-5 (43-50 Km)	STRETCH-6 (50-60 Km)	STRETCH-7 (60-70 km)	STRETCH-8 (70-80Km)	STRETCH-9 (80-90 Km)	STRETCH-10 (90-98.00 Km)	TOTAL
ii)<1.2	0	1.2	0.6	6.5	4	2.9	1.1	0	0	2.55	18.85
iii)1.2-1.4	0	0.6	0.75	1.8	0.4	1.05	0.3	2.05	0.95	1.7	9.6
iv)1.5-1.7	0.7	0.5	0.75	1.5	0.8	1.7	1.3	1.2	0.56	0.9	9.91
v)1.8-2.0	0.8	0.5	0.8	0.6	0.3	1.1	1.7	0.5	1.76	0.9	8.96
vi)>2.0	8.5	7.2	7.1	2.6	1.5	3.25	5.6	6.25	6.73	1.95	50.68
TOTAL	10	10	10	13	7	10	10	10	10	8	98

c)	Cross structures i) Dams, weirs, barrages etc (total number; with navigation locks or not) ii) Bridges, Power cables etc	i) **No Dams, Weirs or Barrages** are found in this zone of river. ii) Total number of Cross over Bridges – Thirteen (13) a) Total number of Rail Bridge- Two (02) b) Total number of RCC Road bridges – Eleven (11) c) Total number of Syphon- Two (02) at Chainage 65.8 Km and 78.0 Km iii) Total number of HTL Crossing – Eight (08)

	[total number; range of horizontal and vertical clearances]	The details of the vertical and Horizontal Clearance for above structures is provided in Para 2.15, 2.16, 2.17 and 2.18 o Hydrographic Survey report.
d)	Slope	Average Slope= 0.1927 The details of slope calculation are provided in Table 2.33 of the Hydrographic Survey Report.
5.	Traffic potential	No Present Traffic is available. However Huge potential for cargo traffic is foreseen considering its length and connectivity with the industrial hubs.
a)	Present IWT operations, ferry services, tourism, cargo, if any	Ferry services- By local dingy or boats Cargo – Nil
b)	Important industries within 50 km	IFFCO Fertilizer, ESSAR Fertilizers, IOCL Refinery, Paradip Phosphate Ltd
c)	Distance of Rail & Road from Industry	The Distance of Rail and Road from industry is near about 20km.
6.	Consultant's recommendation for going ahead with TEF / DPR preparation	1)Recommend for Dredging
7.	Any other information/ comment	NIL

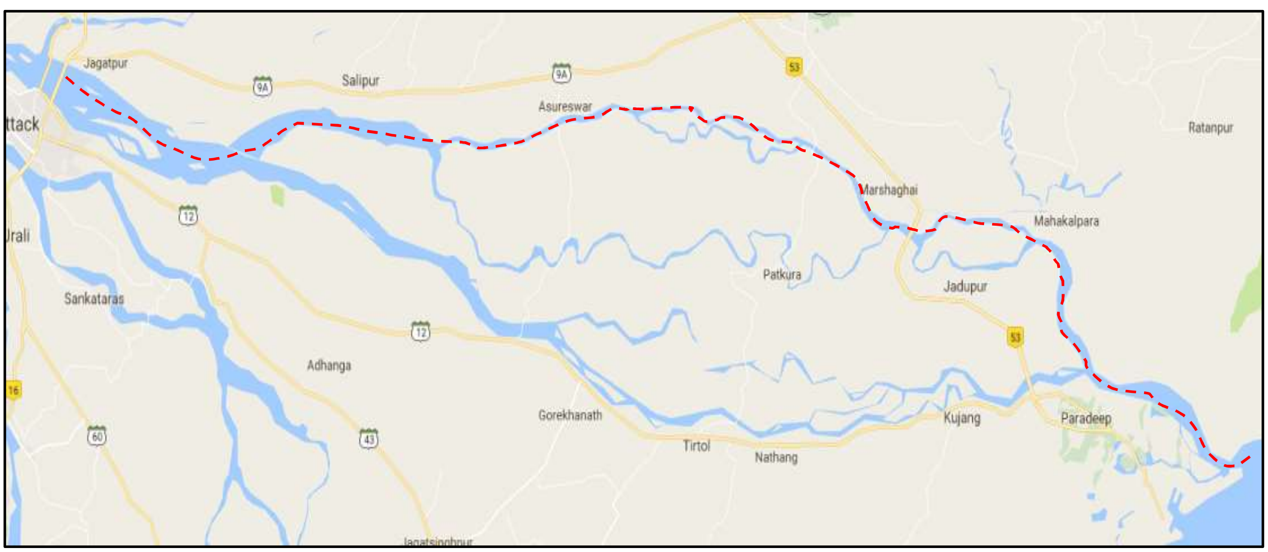
0. EXECUTIVE SUMMARY

0.1. Introduction

IWAI has initiated the development of around 53 waterways (out of 106 designated waterways of India) in 8 clusters and the present project NW 64, falls under cluster4, which includes 98 km of river stretch from Paradip Port (Latitude 20°19'38.12"N, Longitude 86°40'16.96"E) to Cuttack Barrage (Latitude 20°29'16.60"N, Longitude 85°54'18.17"E).In the reconnaissance survey during the months of February to April 2016, river stretches of about 425km from Paradip sea mouth (Latitude 20°19'38.12"N, Longitude 86°40'16.96"E) to Sambalpur Barrage (Latitude 21°27'34.33"N, Longitude 83°57'49.80"E) out of the total 494km of the river in Odisha was studied, along with Luna river from Tentol to Baladia village, which is a tributary of Mahanadi. It was observed that the stretch has good traffic potential and scope for tourism.

It was observed during the feasibility study that approximately 78km of Mahanadi from Sambalpur to Sonepur is found to be of rocky bed and navigation in this stretch is not possible. Hence for the DPR preparation, about 98 km of the river stretch from Paradip sea mouth to Cuttack Barrage was considered incorporating a bypass route via river Luna.

Figure 0.1:Stretch of the river considered for this project

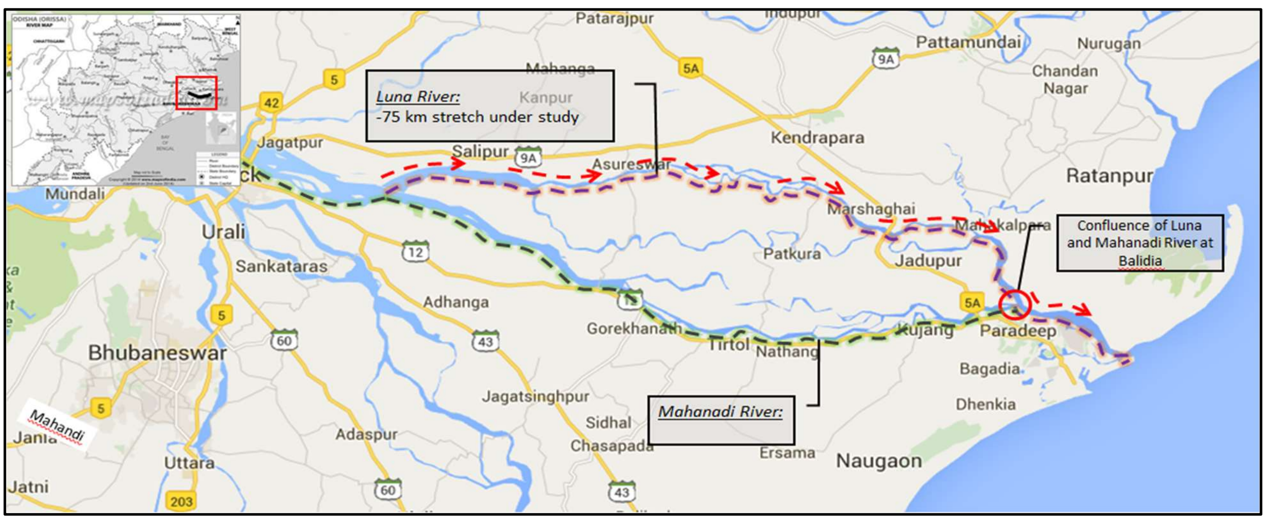


0.1.1. Project Location / Details of Study Area

Mahanadi 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 river, from Jobra Barrage to Paradip, of the total of 98 km in Orrisa has been earmarked for the detailed project report as shown in the following figure.

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 the fact that tidal water enters Luna and not Mahanadi in this stretch. The length of the alternate Luna path is nearly equal to the Mahanadi stretch i.e. 75 km.

Figure 0.2: Map showing stretch of river considered with routes marked via Luna and Mahanadi



During the survey conducted in February 2016, it revealed that most of the discharge of water from the barrage flows through the river Luna which is the tributary of Mahanadi.

0.1.2. Brief Scope of Work and Compliance statement

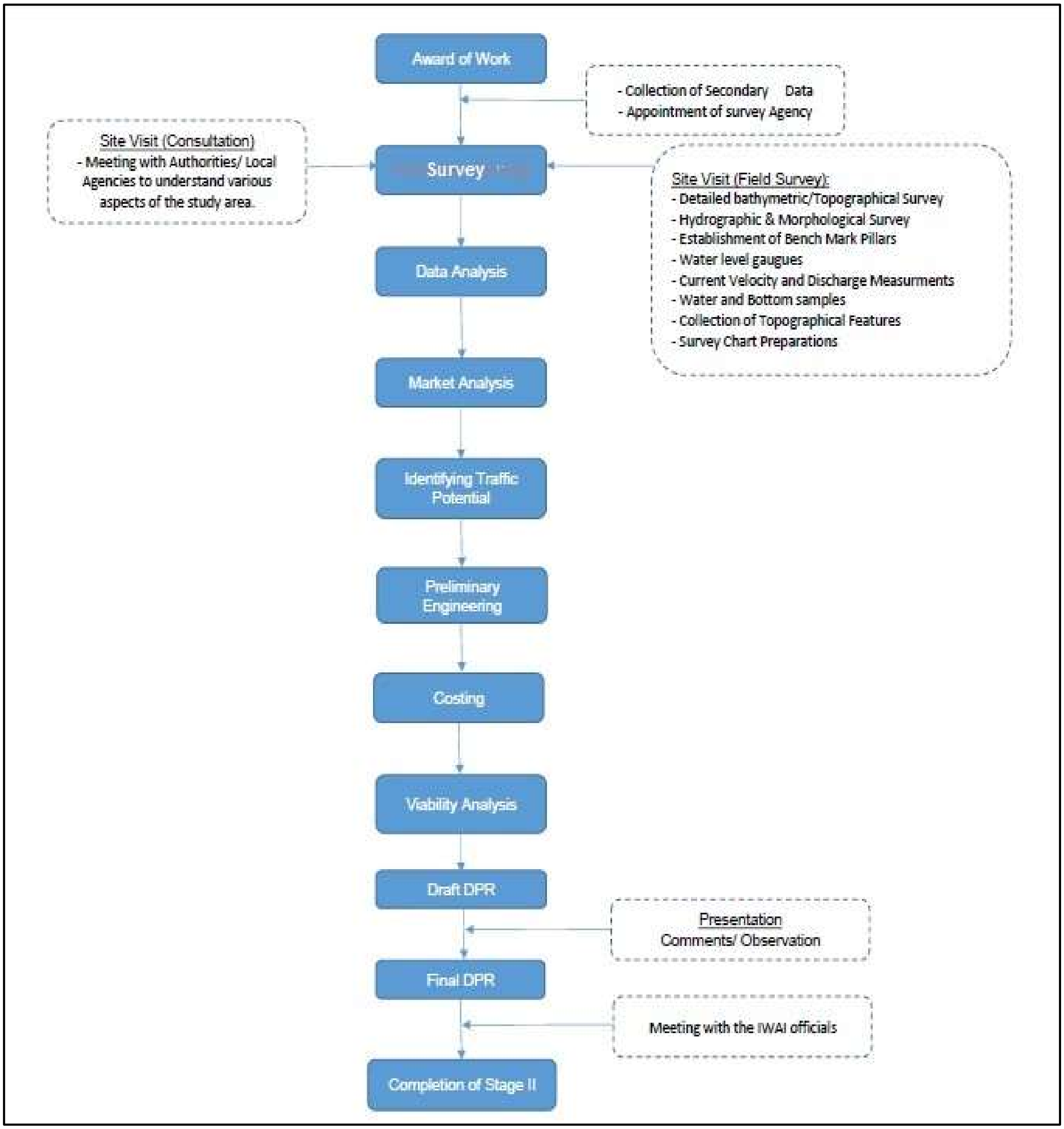
The scope of work in DPR preparation is as follows:

- Assessment of morphological, hydrological, hydrographical conditions and operation and maintenance requirements of the proposed waterways.
- Geo-tech investigation as per guidelines of Geological Survey of India.
- Preliminary engineering designs, drawings, estimates, for the waterway system in an EPC mode.
- River training and bank protection works anticipated.
- Preparation of construction schedule with phasing of expenditure.
- Cost estimate for different alternatives shall be considered and FIRR, EIRR, NPV and SWOT analysis are to be carried out.
- EIA study and suggesting EMP.
- Suggestions for VC and HC to be provided for crossing structures.

0.1.3. Brief Methodology & Approach

The Consultant has prepared a stepwise methodology, approach and delivery model as below:

Figure 0.3: The flow chart of the steps to be followed



0.2. Hydrographic Survey

0.2.1. Waterway in General and Hydro-morphological Characteristics

Detailed hydrographic survey was carried out from 08th Mar 2017 to 27th Mar 2017 from Paradip sea mouth towards inland which is near to south of the barrage at Cuttack was carried out. On conduct of Bathymetric survey from Paradip, it was found that the tidal effect is up to 43 km north and the discharge from the Barrage flows through the river Luna.

0.2.2. Existing Hydrological / Topographical Reference levels

For topographic survey, horizontal control was carried out from newly established IWAI Benchmark in NW-64 along the river coast from Paradip (BM 1) to Cuttack (BM 11). The Benchmarks are fixed by 25hrs observation and Real Time Kinematic with 01 PPU method.

Tide poles have been erected at every 10 km and water level was observed from 06:00 hrs to 18:00 hrs throughout the survey.

0.2.3. Chart Datum / Sounding Datum

- Datum values in tidal regions are with reference to Chart Datum transferred from Paradip Port and datum values in non-tidal regions are derived as explained below.
- 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 benchmarks are derived by interpolation method.

The average lowest water level as located at Naraj is 20.20 m with reference to MSL.BM Pillars and Tide gauges were erected at every 10km distance and leveled w.r.t. MSL. Sounding Datum at tide gauges was transferred from Naraj specified by IWAI in non-tidal zone and in tidal zone area from Mahanadi river mouth to Dihabalaram Pur (43Km), Sounding datum has been established by Transfer of sounding datum methodology specified in AMHS.

0.2.4. Existing Cross Structures

0.2.4.1. Bridges

The details of the crossing bridges are given in the table below.

Table 0-1: Existing bridges across the waterway

Sl no	Structure	CH (Km)	Location	Latitude	Longitude	Easting (m)	Northing (m)	Hz cl (m)	Present condition	Vertical Clearance from MHWS / HFL(m)
1	Road bridge UNC	25.13	Marsaghai	20°24'27.576"N	86° 29' 39.4932" E	447281.18	2256689.41	**30**	UNC	-
2	Road Bridge(haladiagada Bridge)	25.4	Marsaghai	20°24'31.79N	86° 29' 33.31" E	447077.35	2256841.58	45	In Use	5.9
3	Road Bridge(haladiagada Bridge)	25.45	Marsaghai	20°24'32.53"N	86° 29' 32.2108" E	447051.30	2256853.	45	In Use	5.9
4	Road Bridge(Kalapada bridge)	34.38	Mehindinagar	20° 27' 8.397"N	86° 25' 22.3486" E	440133.91	2261416.87	25	In Use	4.1
5	Road Bridge(jaisipur bridge)	43.8	Karilopatna	20° 27' 42.0619"N	86° 21' 31.013" E	433093.96	2262673.60	35	In Use	3.4
6	Road Bridge	52.7	Artamul	20 ° 28'17.914"N	86° 17' 42.9545" E	426472.00	2263809.00	30	In Use	4.2
7	Road Bridge(Asureswar bridge)	57.7	Koilirangi	20° 27' 41.7185"N	86° 14' 59.3415" E	421704.29	2262839.08	40	In Use	2.9
8	Road Bridge(Barapada bridge)	65.8	Jamunanagar	20°27'6.82"N	86°10'32.74"E	414026.76	2261705.32	35	In Use	2.0

Sl no	Structure	CH (Km)	Location	Latitude	Longitude	Easting (m)	Northing (m)	Hz cl (m)	Present condition	Vertical Clearance from MHWS / HFL(m)
9	Road Bridge(Sisua Bridge)	78.0	Murkundi	20° 27’ 56.5145 ”N	86° 4’ 27.5121” E	403433.49	2263245.28	20	In Use	4.6
After CH 98 Km										
10	Road Bridge	98.26	Jobra	20° 29’ 23.0985 ”N	85° 55’ 4.6925” E	387171.00	2266103.00	40	In Use	3.8
11	Road Bridge	98.30	Jobra	20° 29’ 23.6398 ”N	85° 55 2.9811” E	387148.00	2266139.00	40	In Use	4.2
12	Road Bridge	98.33	Jobra	20°29'25.98"N	85°55'3.13"E	387118.00	2266140.00	45	In Use	4.2
13	Rly Bridge	98.65	Jobra	20° 29’ 27.543” 5N	85° 54’ 51.3574” E	386815.00	2266315.00	50	In Use	4.3
14	Rly Bridge	98.7	Jobra	20° 29’ 28.0388 ”N	85 ° 54’ 49.9428” E	386788.00	2266344.00	25	In Use	4.2
15	Jobra Barrage	99.30	Jobra	20°29'11.16"N	85°54'15.62"E	385739.01 m E	2265694.45 m N	-	In Use	-

0.2.4.2. Electric Lines / Communication Lines

Table 0-2: Details of existing crossing cables

Sl no.	Structure	Chainage (Km)	Easting (m)	Northing (m)	Location	V Cl(m)	Clearance from HFL(m)
1	HTL	21.0	20° 24’50.2002” N	86° 31’ 44.8211” E	Badakula	15	12.612
2	EL CABLE	20.8	20°24'50.55"N	86°31'53.25"E	Badakula	5	2.1
3	HTL	25.2	20° 24’29.0481” N	86° 29’ 37.1884 “E	Marsha ghai	15	11.254
4	HTL	25.8	20°24'31.58"N	86°29'36.82"E	Marsha ghai	15	11.254
5	El Cable	35.6	20°26'59.89"N	86°24'55.17"E	Karandia patna	5	2.2
6	El Cable	36.5	20°26'54.68"N	86°24'32.12"E	Jamapara	6	3.2
7	El Cable	44.6	20° 27’ 21.4987”N	86° 21’ 12.981” E	Jateswar village	4	1.1
8	El Cable	46.78	20°27'35.42"N	86°20'27.53"E	Jalaoka	4	1.1
9	El Cable	48.13	20°27'12.73"N	86°19'55.76"E	Hurasahi	5	2.2
10	El Cable	49.83	20°27'34.06"N	86°19'6.75"E	Balisahi	4	1.2
11	El Cable	53.5	20°28'9.80"N	86°17'16.93"E	Girigolas asan	5	2.1
12	El Cable	53.53	20°28'9.37"N	86°17'16.45"E	Girigolas asan	6	3.2
13	HTL	65.77	20°27'7.08"N	86°10'33.41"E	Barapada	10	8.36
14	HTL	66.27	20°27'9.40"N	86°10'15.97"E	Barapada	15	12.2

0.2.4.3. Pipelines / Cables

Sl No	Description	Chainage (Km)	Position		Remark
01	Chitrotpala Syphon cum bridge	78.0	20°27'55.07"N 86° 4'26.86"E	403433.49 m E 2263245.28 m N	Major Irrigation Project Mahanadi Delta
02	Barapada Syphon	65.8	20°27'6.82"N 86°10'32.74"E	414026.76 m E 2261705.32 m N	Major Irrigation Project Mahanadi Delta
03	Stone wall (Broken Barrage)	51.12	20°27'51.31"N 86°18'26.98"E	427773.70 m E 2263009.49 m N	Near Mundalo

0.2.5. Dams / Barrages / Locks / Weirs / Anicuts

There are no Dams, Barrages, weirs, Anicut found in this zone of River. The details of Aqueducts are given

Sl no.	Structure	Chainage(Km)	Latitude Longitude	Easting (m) Northing (m)	Location
1	Pump House	34.46	20°27'10.21"N 86°25'31.68"E	440073.77 m E 2261698.43 m N	Mehendinagar
2	Barapada Syphon	65.8	20°27'6.82"N 86°10'32.74"E	414026.76 m E 2261705.32 m N	Major Irrigation Project Mahanadi Delta
3	Chitrotpala Syphon cum bridge	78.0	20°27'55.07"N 86° 4'26.86"E	403433.49 m E 2263245.28 m N	Major Irrigation Project Mahanadi Delta

There are no Dams, Barrage, Weirs, Anicuts found in this zone of the River.

0.2.6. Bends

0.2.6.1. Radius of Curvatures

An average bend radius of river Mahanadi has been observed as 900m. in some stretches, however, the bends radius is as low as 280m where smoothening and providing cut-off channels have been suggested.

0.2.6.2. Waterway description (stretch-wise of 10 km)

Table 0-3: Minimum and maximum available depth

Stretch (Km)	Min. Obs. Depth (average), m	Max. Obs. depth (average), m
01-10	0.7	18.8
10-20	1	20.0
20-30	0.7	19.9
30-40	0.9	19.4
40-50	1.2	19.7
50-60	0.7	19.3
60-70	0.8	13.1
70-80	0.7	17.6
80-90	0.7	17.0
90-98.0	0.7	17.1

Table 0-4: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: Tidal stretch is up to 43 km
c) Conditions of banks (protected, un-protected): Partially Protected
d) Hindrances: Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues do not exist.
e) Encroachment to the waterway: Nil
f) Obstruction (if any) for navigation, e.g. fishing stakes: Nil
g) NH/SH/MDR along and/or within 5 km from the waterways: Paradip – Kalinga Nagar – Daitari Express highway, NH-5A is situated 2 Km far from riverbank, NH 9 runs close to the proposed Terminal.
h) Railway Line and Stations in the vicinity: Cuttack – Paradip Rail is 7 Km far from the river.
i) Land Use Pattern along Waterway on visual assessment: Industrial use, Agriculture use
j) Crops / Agriculture in the region on visual assessment: Rice cultivation.
k) Availability of Bulk / Construction Material: Nil
l) Existing Industries along Waterway with their types and details: IFFCO fertiliser, ESSAR, Paradip Phosphate Ltd, Paradip Oil Refinery and other supportive industries are situated near riverbank within 05 km. No other industries located beyond this point along the river side

m)	Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Paradip port – 2Km, Fishing Jetty – 1 Km and small ferry Ghats are in operation.
n)	Existing Cargo Movement: Nil.
o)	Prominent City / Town / Places of Worship / Historical places for Tourism: - Paradip Town, Cuttack.

0.2.6.3. Dredging Quantities

Table 0-5: Dredge volume for classes

Class	FROM (km)	TO (km)	Dredging quantity (cum)
I	0.00	98.00	1938310.03
II	0.00	98.00	3248369.41
III	0.00	98.00	5463114.33
IV	0.00	98.00	6824753.29
V	0.00	98.00	12314785.16
VI	0.00	98.00	18460751.65
VII	0.00	98.00	24348447.7

0.2.7. Water and Soil Samples analysis and Results

Water and bottom soil sample are collected from the deepest route at every 10km interval and are tested.

Table 0-6: Analysis results of bottom samples taken at 10km interval

MAHANADI RIVER						
SL.NO.	**EASTING**	**NORTHING**	**LATITUDE**	**LONGITUDE**	**SAMPLES**	**RAW DEPTH**

01	465729.06	2247805.22	20° 19' 40.5608" N	086° 40' 18.1001" E	COURSE SAND	4.8
02	457334.17	2252042.46	20 °21' 57.7879" N	086° 35' 28.2284" E	COURSE SAND	8.2
03	451825.39	2257470.3	20 °24' 53.8795" N	086° 32' 17.6799" E	MUD SAND	4.3
04	443518.33	2258834.98	20° 25' 37.4461" N	086° 27' 30.8889" E	SILT &FINE SAND	2.8
05	435489.3	2261157.93	20° 26' 52.0857' N	086 °22' 53.5265" E	SOFT MUD SAND	3.2
06	428759.18	2262591.63	20° 27' 37.8525" N	086° 19' 1.0539 "E	SAND& SILT	2.2
07	419486.52	2262030.76	20 °27' 18.2701" N	086° 13' 41.1107" E	BROKEN SHELL & FINE SAND	2
08	410609.32	2262852.58	20° 27' 43.5667" N	086° 08' 34.594" E	SOFT MUD SAND	1.1
09	401561.57	2262966.08	20° 27' 45.6415 "N	086° 03' 22.31" E	SILT& SOFT CLAY	0.7
10	394436.95	2262344.5	20 °27' 24.0415" N	085° 59' 16.5577" E	SILT &FINE SAND	1.3
11	386589.9	2266461.53	20° 29' 36.3112'"N	085° 54' 44.8137" E	FINE SAND	2.4

Table 0-7: Water characteristics

MAHANADI_ LUNA RIVER								
Sl.no	Chainage		LATITUDE	LONGITUDE	Depth	Parameter	Units	Sediment concentration (MID Depth)
WS 1	0	10	20 19 40.5608 N	086 40 18.1001 E	4.8	Soil Content	mg/1	21
WS 2	10	20	20 21 57.7879 N	086 35 28.2284 E	8.2	Soil Content	mg/1	23
WS 3	20	30	20 24 53.8795 N	086 32 17.6799 E	4.3	Soil Content	mg/1	20
WS 4	30	40	20 25 37.4461 N	086 27 30.8889 E	2.8	Soil Content	mg/1	18
WS 5	40	50	20 26 52.0857 N	086 22 53.5265 E	3.2	Soil Content	mg/1	13
WS 6	50	60	20 27 37.8525 N	086 19 1.0539 E	2.2	Soil Content	mg/1	16
WS 7	60	70	20 27 18.2701 N	086 13 41.1107 E	2	Soil Content	mg/1	19
WS 8	70	98	20 27 43.5667 N	086 08 34.594 E	1.1	Soil Content	mg/1	24

0.3. Fairway Development

0.3.1. Proposed Class / Type of Waterway

Considering the possible divertible traffic of IFFCO (1.5-2.0 MMTPA) and other existing industries, the possible passenger traffic and the variation of dredging quantity, it is proposed to develop up to CH 07km as Class VII with minimum bottom width of 100m, bend radius of 900m and beyond that from CH 07 km to CH 98km as Class III with bottom width of 50m and limiting bend radius of 700m.

0.3.1.1. Dredging

The amount of dredging required for developing the waterway as Class VII up to CH 07 km is around 509.02 cum, and from CH 07 km to CH 98 km as Class III are around 5463623.35 cum. As per the survey report, the bed material is mostly sandy in nature. Hence closed grab dredger is recommended for dredging the channel. The dredge material can be used for embankment strengthening, road construction and maintenance.

0.3.1.2. River Training

River training is required to attain the minimum bend radius at regions of meandering. The techniques proposed for river training includes, cut-offs, at regions where the minimum bend radius criteria are not attained. The cut off length comes around 14.66km for the entire stretch of the river. The proposed locations of cut offs are shown in the table below.

Table 0.8: Cutoff for river training

LOCATION	PRESENT BEND RADIUS/ LOOP LENGTH	BEND RADIUS AFTER TRAINING/ CUT OFF LENGTH
CH 1.4 km to CH 2.4 km	355m (Radius)	1100m
CH 23.3 km to CH 24.7 km	415m (Radius)	988m
CH 39 km to CH 43 km	3714 m (loop length)	1975m

CH 44 km to CH 51 km	6800m (loop length)	4700m
CH 68.3 km to CH 69.75 km	280m (Radius)	800m
CH 73.18 km to CH 73.85 km	330m (Radius)	1000m
CH 84 km to CH 85.61 km	480m (Radius)	1900m
CH 86 km to CH 87.7 km	530m (Radius)	1400m
CH 89 km to CH 90 km	400m (Radius)	920m

0.3.2. Bank Protection / Embankment Strengthening

Bank protection works are to be taken up to protect land and property from flooding. Bank erosion problem due to turbulence would be more severe in the narrow stretches than in wider stretches. The banks close to the terminal location are affected by the wakes of the vessels, thus, these locations are proposed to be protected using riprap combined with vegetation. It is proposed to protect a minimum of 50m up and down stream beyond the extreme of the jetty structure and the region between the two jetties of different levels.

0.3.3. Navigation Markings / Navigation Aids

Channel markings for day navigation need to be erected and maintained in entire waterway. As of now, night navigation is not proposed, which may be considered in future if found required. It is proposed to have buoys to demarcate the channel boundaries and range to guide the ships through the center line of the channels. Apart from this, it is proposed to have at least monthly thawed surveys to ensure the navigability of the channel. As a general guide, as per IALA recommendation, red buoys mark the terminal side of the channel.

0.3.4. Modification Requirement in existing Bridges / Cables / Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

The vertical clearance as required by the IWAI Act 1985 for Class III and VII water way is 7m and 10m and horizontal clearance required is 50m and 100m respectively. From the hydrographic survey report, it is clear that all the bridges and other cross structures are located beyond CH 20km. Hence the specification of Class VII is not applicable. The cross structures which violate the specifications of Class III and proposed modifications are as shown in the table below.

Table 0.9: Proposed Modifications to crossing structures

Type of structure	Location (Chainage km)	Deviating parameter	Available value (m)	Proposed modifications
Road bridge	Marsaghai (25.4 km)	VC	5.9 from HFL	To have warning boards to caution the restriction on heights permitted
Road bridge	Marsaghai (25.45 km)	VC	5.9 from HFL	To have warning boards to caution the restriction on heights permitted
Road bridge	Mehindinagar (34.8 km)	HC, VC	40, 4.1	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Karilopatna (43.8 km)	HC, VC	40, 3.4	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Artamul (52.7 km)	HC, VC	40, 4.2	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Jamunapur (57.7 km)	HC, VC	40, 2.9	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Bhagabanpur (67.2 km)	HC, VC	30, 3.6	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Murkundi (Syphon bridge) (78 km)	HC, VC	20, 4.6	Demolishing existing structure and rearranging the spans to attain vertical clearance

It can be observed from the above table that the deviation from vertical and horizontal clearance criteria is observed for few bridges. The traffic in the waterway is also not too high. Thus, it is proposed to keep the bridges as it is w.r.t. the horizontal clearance and to have restriction on the height of the waterway wherever possible. Sufficient warning boards and signs shall be placed near the bridge location and on the side face of the bridge. For the bridges which do not meet the horizontal clearance criteria, it is proposed to have one-way traffic in adjacent spans with the vessels going in opposite direction through two consecutive spans. As can be seen from the table above, there exists horizontal clearance of minimum 30m in one span and the horizontal clearance required for Class III waterway is 50m, thus it is safe to move in one direction using one span. For the bridges where vertical clearance criteria is deviated with large margin, modifying the pier height and span arrangement utilizing maximum of existing structure is proposed. In future, once a justifiable traffic generates, after analyzing the age, structural and functional conditions of the bridge, reconstructing the bridges may be considered. For the syphon cum bridge at around CH 78km, from site investigation, it is observed that, the underwater structure is not obstructing the navigation as the minimum water depth during summer as per the survey report is around 1.6m. The bridge super structure lacks required horizontal and vertical clearance, so it is proposed to have replacement of the central piers with improved horizontal and vertical clearances with the pile foundation bridging across the siphon on either end. A central span of 50 clear span can be provided with the subsequent spans sloping down to the existing piers. For the siphon at Paika too, the vessel movement is observed to be possible during fair-weather season and here since no elevated superstructure is available, restriction due to clearance is not reported.

0.3.5. Proposed Dams / Barrages / Locks / Weirs to improve depth

Based on the hydrographic survey report, the river dries out during summer rendering the channel unnavigable. However, in the present situation no barrages are proposed. It is proposed to have vessel services during the fair season only and temporary shutdown during lean season.

it is suggested to have a barrage at around CH 44km with a height of around 19m from existing bed level and associated lock system along with three weirs are required, one at

CH50km, 4m height; at CH68km of 7.4m height and at CH85km of 9.5m height in the future, when the traffic generated revenue can compensate for the capex for the barrage system.

0.3.6. Land Acquisition

The land required for the terminal infrastructure in Jagatpur village near Cuttack is around 2.32 hectares. It is understood from the site investigation that around 23 acres of government owned land is available in the proposed location.

0.3.7. Fairway Costing

0.3.7.1. Capital Cost

Table 0.10: Capital cost for fairway

Sl. No.	Description	Amount
1	River training	₹ 42,51,40,000.00
2	Land acquisition	₹ 10,28,29,197.24
3	Dredging	₹ 1,09,27,24,670.00
4	Embankment protection	₹ 1,34,00,000.00
5	Aids to navigation	₹ 30,00,000.00
6	Modifications to 5 bridges to meets VC criteria	₹ 50,00,00,000.00
7	Modification to the bridge at Chitroptala	₹ 25,00,00,000.00
	Total	₹ 2,38,70,93,867.24

0.3.7.2. O&M Cost

The operation and maintenance cost are as shown in the table below.

Table 0.11: Operation and Maintenance Cost

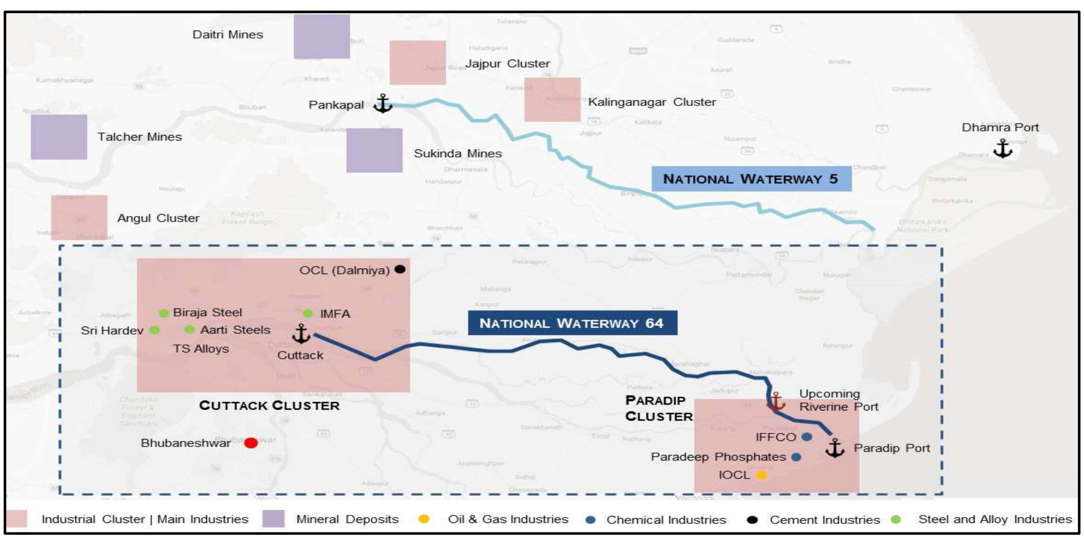
Sl. No.	Description	Percentage of Capex	Amount
1	Dredging	5	₹ 5,46,36,233.50
2	Embankment protection repair	1	₹ 1,34,000.00
3	Aids to navigation	2	₹ 60,000.00
4	River training	5	₹ 5,48,25,143.3

0.4. Traffic Study

0.4.1. Traffic Study

Traffic study has been conducted for the subject waterway stretching from Paradip to Cuttack Bridge (~98 km). The catchment of NW 64 has been defined to comprise of Paradip and Cuttack industrial clusters. Several major industrial clusters nearby the waterway including Angul, Dhenkanal, Jajpur, Kalinganagar etc. have been excluded from the catchment since NW 5 (along the Brahmani river) is better suited to service these clusters. The catchment is shown below

Figure 0.4: Catchment Area



The catchment area of the waterway is characterized by well-developed transport infrastructure. Major highways NH-55, NH-16, NH-316 connect Cuttack with rest of India.

Cuttack also serves as a major transit point for railways in the region. A significant amount of industrial cargo transits through Cuttack on account of Paradip port. The port is a major traffic centre and handled ~90 MTPA of traffic in 2016-17. However, due to heavy traffic, the connectivity infrastructure between Paradip and Cuttack remains congested with significant scope for upgradation. The waterway catchment also witnesses agricultural production (mainly rice) due to its fertile soil and mineral rich river basin. Major cities in the catchment include Cuttack, Bhubaneswar and Paradip only. Rest of the waterway stretch has only small sporadic villages.

A **Riverine Port is also proposed along the waterway (at ~Chainage 7 km) at Akhadashili village** in Mahakalpada block, Kendrapada. The port intends to capitalize on the vast mineral wealth in its hinterland and the wide array of major industrial development in its vicinity. Its developed would be spread over 2 phases – with capacity increasing from 18 MTPA in Phase 1 to ~45 MTPA in Phase 2. The port is projected to handle Iron ore, coal, pellets, crude Oil and steel cargo. As Panamax vessels (>65,000 DWT) would be handled at the port, it would require channel depth of 14 to 16 m. The state government approved financial bidding process for the port in June-2018.

0.4.2. Industrial Cargo

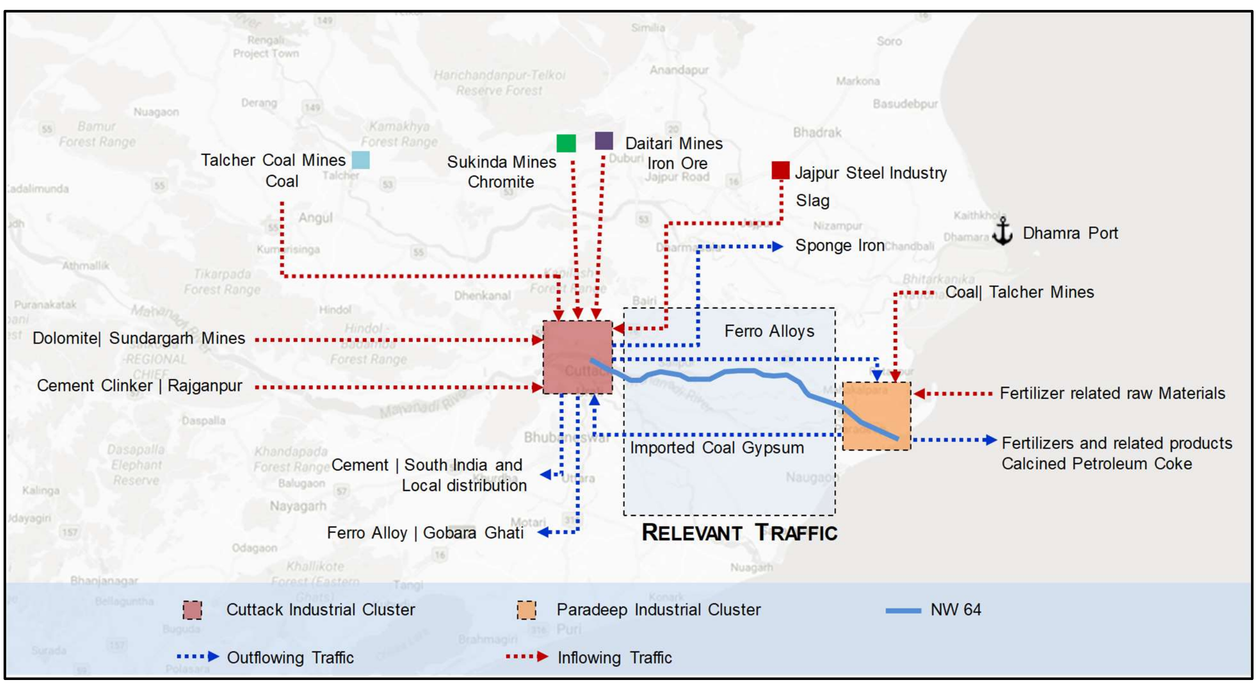
Cuttack Industrial Cluster houses medium scale iron & steel units, cement units and several small / micro scale industrial units. Paradip Industrial Cluster hosts several large-scale industrial units in petrochemical, fertilizer, chemicals sector. The following table summarizes the major industrial units:

Table 0-12: Industrial clusters along the stretch

S.No.	Industrial Unit	Major Industries	Major Commodities
1	Cuttack Industrial Cluster	OCL India, Aarti Steels, Sri Hardev Steel, Biraja steel and power, T.S. Alloys Limited, IMFA, Choudwar	Iron & Steel, Cement, Sponge Iron, Ferro Chrome, Coal & Coke, Iron Ore, Gypsum
2	Paradip Industrial Cluster	IFFCO Fertilizers, Paradip Carbons, Paradip Phosphates, Essar Steels	Fertilizers (raw material), Sponge Iron, Fertilizers Steel Pellets, Chemical, Marine Products, Coal &Coke

The following map shows the major movements of the above-mentioned commodities in the hinterland.

Figure 0.5: Commodity Flow in Hinterland



For estimation of relevant traffic, only commodity flow between Paradip and Cuttack has been considered. Hence, significant traffic inflow of coal, iron ore, chrome, dolomite from nearby mines as well outflow to Odisha's hinterland has not been considered. As the inland waterways system is economically suited to carry large volumes of bulk commodities, hence **only large and medium scale industries with EXIM potential & bulk commodities moving in the direction of the proposed waterway have been considered as relevant traffic** and is as summarized in the table below.

Table 0-13: Relevant traffic along proposed waterway

S.No.	Commodity	Quantity in MMTPA
Finished Goods		
1	Gypsum	0.13
2	Ferro Chrome	0.10
Raw Materials		
1	Coal / Coke	0.39
Total		**0.62**

The following points should be noted:

- **Gypsum**: Gypsum is consumed by cement plant (OCL India) and brick kilns in Cuttack. It is sourced from Fertilizer factors in Paradip where it is produced as a by-product. Due to highly segregated demand and lack of any major players, gypsum is transported by traders / fertilizer companies using trucks only.
- **Ferro Chrome**: ~0.25 MTPA of ferro chrome is produced in Cuttack (IMFA and TS Alloys Ltd). The ferro chrome is majorly export via Vishakhapatnam Port (~0.15 MTPA) and Paradip Port (**0.10 MTPA)**. For Paradip port, it is transported by truck from the industrial plants.
- **Coal / coke**: As highlighted above, total movement of imported coal/coke between Cuttack and Paradip Port is **~0.4 MTPA**. This is mainly contributed by demand of major sponge iron and ferro chrome plants which rely on imported coal.Coal/ Coke is majorly transported through rail. Large industries have private railway sidings and hence prefer to use railways over trucks. Smaller players use trucks to transport coal due to lower quantities.

In addition to above, 1.5 – 2 MTPA of fertilizer traffic (IFFCO plant at Paradip) can also be potentially captured onto the waterway for a small stretch at the Paradip end.

0.4.3. Divertible Traffic

Waterways is advantageous placed as compared to road transport in the region due to high truck freight rates. However, rail transport still remains the cheapest transport mode as all the major players have private rail sidings which provide door to door connectivity.

Traffic divortiality for the relevant commodities identified above is calculated based on a Binary Logit Model. For the purpose of analysis, five influencing factors namely- logistics cost, handling, mode of convenience, product type and speed are considered and given relative weights. The traffic divertiblity of waterways from both rail and road have been calculated under two scenarios

- Waterway traffic under Moderate scenario
  - 8% of rail traffic
  - 40% of road traffic
- Waterway traffic under Aggressive scenario
  - 24% of rail traffic
  - 79% of road traffic

Table 0-14: Divertible traffic

S.No.	Commodity	Relevant Traffic (MMTPA)	Divertible Traffic (MMTPA)	
			Moderate	Aggressive
Finished Goods				
1	Gypsum	0.13	0.05	0.10
2	Ferro Chrome	0.10	0.04	0.07
Raw Materials				
1	Coal / Coke	0.39	0.05	0.13
Total		**0.62**	**0.14**	**0.31**

Industrial growth in the region has been muted with lack of clarity on macro-parameters and limited pipeline capacity (<50,000 tons for Aarti and Hardev steels). However, the industrial activity is expected to increase in the long run with restored mining operations and industrial development at Paradip. Waterways would also benefit from government promotion, evolution of technology and establishment of waterway transportation concept. Hence, for projecting future waterway traffic, an initial growth rate (till 2025) of 4% p.a. has been considered. For long term, following growth rates have been take for the two scenarios:

- Moderate scenario: Growth rate of **5% p.a.**(based on growth in Odisha's manufacturing GSVA since 2014)
- Aggressive scenario: Growth rate of **8% p.a.**(based on favourable manufacturing climate – with restored mining operations, industrial development driven by PCPIR, improved connectivity etc.)

In addition, traffic buildup (80% of divertible traffic in initial years) and seasonality factor of 50% (non-navigation during pre-summer and summer months) has been integrated in traffic projections.

Table 0-15: Divertible traffic projections

Waterway Divertible Traffic	2019	2020	2030	2040	2050
Moderate Scenario	0.03	0.06	0.11	0.19	0.30
Aggressive Scenario	0.06	0.13	0.29	0.62	1.34

Viability of 43-km Stretch (from Paradip River Mouth to Chainage 43 km – at Karilopatna)

The present waterflow downstream of Cuttack barrage is mainly due to leakage in the structure. As per the information provided by the state government officials, the leakage in barrage would be corrected, thereby leaving negligible water in the subject stretch from Cuttack Barrage to Paradip River Mouth. In such a scenario, the navigation would only be possible in the monsoon season and nearby months. As an alternate, Feedback analyzed the viability of developing 43km waterway stretch (from Paradip to Karilopatna) in Phase 1. However, this development is not feasible due to the following challenges –

- Lack of Traffic – The industrial catchment of waterway is limited to Cuttack and Paradip. In such a scenario, establishing the terminal at 43 km, reduces the travel length of waterway freight. This in turn reduces the competitiveness of waterway as the main USP of waterways is cheapest freight movement. This changes the overall cost economics of waterway – total cost via waterway increases to INR 716 per ton as compared to ~INR 700 per ton. Moreover, there is no local passenger traffic as there in no population centre nearby.
- Competition from Truckers - A trucker earns ~INR 650 for carrying cargo from Cuttack to Paradip. The same trucker would get ~INR 480 from Cuttack to Karilopatana, which is ~INR 170 less than direct route. Hence, there is no incentive for truckers to lose out on its revenues and transport cargo to Karilopatana terminal instead. Given, the strong trucking association in the region, convincing truckers to transport from factory to the IWT terminal at Karilopatana would be a major challenge.
- **Road Access Quality to Karilopatana** – Access to Karilopatana terminal would require travel via SH-9 followed by village roads. While SH-9 is 2-laned metaled highway, the terminal would need **expansion and strengthening of ~12 km of village roads**. For providing seamless flow of traffic, this would require additional ~INR 20 crore of expenses
- **High Development Cost** – As per initial estimate of waterway development costs till Chainage 43, the cost would be ~INR 100 Cr (~INR 60 Cr for fairway, ~INR 10 for modification of a bridge, ~INR 20 Cr for improving quality of village roads).

Hence, based on the above considerations, development of waterway till tidal influence / Chainage 43 km is not viable, mainly because of higher waterway transports costs in this alternate. Hence, Feedback has considered development of entire 98 km stretch. If development of waterway till 43 km is to be considered as Phase 1 of waterway development, it would require heavy government subsidies. Moreover, this option would fail to achieve the desired outcome of multi-modal traffic shift as it is not sustainable, and the operations would eventually shift to 98 km terminal with development of Phase-2.

0.4.4. Tourist Traffic

While no tourism traffic exists on the waterway, it has significant waterway related tourism potential. Multiple factors including pleasant weather, picturesque surrounding, large tourist inflow (Puri, Konark, Bhubaneswar, Bhitarkanika etc.), large population base (~14 lakh population of Cuttack, Bhubaneswar) support development of waterway tourism. This can include, riverfront development, water sport activities, river cruises etc. Cuttack itself has some nearby attractions, which are amenable for waterway access. The annual footfall of these attractions, totals ~10 lakh tourists / visitors as shown below –

- Dhabaleswara Temple – 7,40,000
- Naraj (Peakcock Valley, Viewpoints) – 68,000
- Anshupa Lake – 66,000
- Barabati Fort, Deer Park, Cuttack Maritime Museum

Thus, on a conservative estimate **5% of the tourists** can be considered to use the waterway leisure rides for accessing these sites. This translates to **<u>~50,000 annual tourist</u>** footfall on the waterway.

However, majority of tourist traffic for NW-64 is expected to be reliazed from local populace only, who might take leisure boat rides to either view the pictureseque surroundings and enjoy the pleasant weather. As the trips would be located upstream of jobra barrage, sufficient water is expected to be available for small boats. Considering an immediate catchment population of ~8 lakhs (Cuttack) and nearby catchment population of ~10 lakhs (Bhubaneswar), and conservative estimate of population using waterway once a year as 2% and 1% respectively, total **<u>~25,000 local population</u>** can be expected to use the waterway for tourism purposes. Considering, the tourist traffic at closest waterway (Bhitarkanika National Park / Baitarani River) is ~1.1 lakh tourists (2015), the projected traffic for NW-64 is only ~70% of it. Considering the size of catchment and multiple local attractions, the arrived traffic is reasonable. A moderate traffic growth of

6% has been considered based on industry standards. In comparison, tourist footfalls in Odisha have been growing at 9% annually for past couple of years. Buildup of tourist inflows has been phased over initial 5 years. **Further capturing of tourist traffic has been considered in the Aggressive Scenario only.**

0.4.5. Other Commodities

Agricultural, Passenger, Ro-Ro traffic has not been captured for waterway traffic due to the following reasons:

- Agricultural Commodity
    - **Distributed Production**: The production is highly distributed over the waterway stretch
    - **Cost Savings:** Considering small transport distances, it is preferable for the farmer to directly use road network for taking and selling the food grains in the market. The region has well-developed road network.
- **Passenger Traffic** – The waterway has negligible ferry movement due to non-navigability, well developed road infrastructure. Fishing activities are also limited to Paradip only without any waterway travel.

Ro-Ro - While the waterway currently has no Ro-Ro traffic, operation of Ro-Ro barges for transport of industrial cargo would be economically unviable and is not recommended due to lower utilization (Ro-Ro barge carries half the cargo as compared to similar sized bulk barge) and high indirect costs (truck driver costs, maintenance costs and truck hiring charges still continue to be incurred)

0.5. Terminals

0.5.1. Terminal Layout / Master Planning Including Phases of Development

The present study stretch starts from Paradip to Cuttack Barrage. The major industrial cluster in this area is Cuttack Cluster and it is situated in the left bank of the river Mahanadi. There needs to be minimum two terminals to handle the cargos, one near Paradip and one at Cuttack. A green field terminal to be constructed at Cuttack. Site selection for the same has been carried out extensively and a location for the terminal has been identified at Jagatpur village of Cuttack District. (Jagatpur is an industrial town located in the Cuttack district of Odisha, India.)

The proposed terminal location at 1.5 km downstream from left side of the Cuttack barrage. The land required for the terminal infrastructure in Jagatpur village near Cuttack is around 2.32 hectares and from the preliminary investigation it was found to be a government land. The proposed site is close to NH-09. The location is shown in the figure 5.1.

The terminal for Paradip is to be arranged within the existing port premise with creation of a connecting channel from the waterway to the port. It is observed that there exist sand bars in the estuary and hence dredging is likely to be involved. Detailed study required for the terminal at Paradip port, is to be managed by IWAI separately.

Figure 0.6: Proposed terminal location at Jagatpur and back up area

0.5.1.1. Terminal Layout Phase – I / Master Plan

The course of development of a port or port terminal usually undergoes phases, which also indicate its age. Evolution of an inland terminal is specifically gradual. However, it is distinguishable into qualitative changes that take place in specific periods throughout the overall life of the port. The drawing of land side and waterside facility master plan for phase 1 is enclosed in Vol. II. The phase-I considered in the present project includes:

0.5.1.1.1. Land side facility

- ✓ Storage area: The storage area is calculated considering the expected cargo of gypsum, ferrochrome, coal/coke. The stowage factor considered is 1.08 to 1.39 cub.m. per tonne, and an angle of repose of around 30-45 degrees. The covered storage capacity required is arrived as 30m X 60m X 6m, open storage requirement is 30m X60m area.
- ✓ Office premise: An office building of plan area 6mX6m, housing administrative and operational blocks. The security staffs may also be house initially.
- ✓ Water supply: Wash water supply of total capacity 50,000 liters and fresh water supply of 1 lakh liters are proposed.
- ✓ Loading and unloading areas of 5m width are proposed.
- ✓ Sewage treatment plant of 50,000 lit capacity.
- ✓ Truck and car parking area and repair facility.
- ✓ A passenger amenity building with basic facilities like toilets, rest lounges, luggage counters, cafeteria, etc.
- ✓ Arterial and feeder roads connecting the amenities in the terminal premise and connecting to the NH09.
- ✓ Entrance gate with security checks.

0.5.1.1.2. Water side facility:

- ✓ Provided with rubber fenders, single-headed bollards, and a typical mooring arrangement as shown below.
- ✓ Turning circle: Circle of diameter120m.
- ✓ Dredged and developed fairway matching the depth requirements and bend radius criteria.

0.5.2. Land Details

The location is well connected by road network NH9. Cuttack is the judicial and commercial capital of Odisha with many trading and business houses in and around the city. The identified location is within a 23-acre government land having good connectivity and sufficient waterfront area. Apart from industrial clusters, the region is a good tourist destination with huge potential once promoted.

0.5.3. Geotechnical Investigation

0.5.3.1. Sub-surface Investigations

Two boreholes were taken at the terminal location during the month of May 2017. At each point rotary type boring rig was shifted, assembled and erected.

Table 0-16: Bore hole locations

BH No.	Lat	Long
BH 1	20^0 29'26.65"N	85^0 55' 8.63"E
BH 2	20^0 29'29.47"N	85^0 55' 14.82"E

Recommendations for footing in the considered location

Table 0-17: Suggested footing types on land

Sl.No	Structure Type	Suggested Foundation Scheme
1	Structures without basement	Isolated Footings
2	Structures with one, two or three basements	Raft Footings
3	Structures having high height from ground surface.	Pile foundation

Table 0-18: Summary of depth of foundation and SBC

Borehole No	Depth of Foundation in m.	Footing size BXL in m.	Allowable Bearing Capacity in Ton/m2.
01	3.00	3.00 X 3.00	16.4
	4.50	4.50 X 4.50	34.8
02	3.00	3.00 X 3.00	16.4
	4.50	4.50 X 4.50	34.7

0.5.4. Berthing Structure

Berthing structure is a facility where vessels are moored. Berths provide a vertical front which allows safe and secure mooring that can then facilitate the unloading or loading of cargo or people from vessels. The berthing structures proposed are RCC fixed structures to cater the expected cargo.

Figure 0.7: Typical general cargo & dry bulk cargo RCC berths

The structural details of the berth are as mentioned below:

- Piles: RCC piles of about 1m diameter and 25m length are proposed based on the expected soil type and structural requirements.
- Pile caps: Single pile caps are proposed with size around 1.5m X 1.5m square.
- Longitudinal Beams: Long secondary beams along the length of the structure.
- Cross Beams: Main beams connecting the pile caps.
- Deck Slab: 300mm thick in-situ slab is proposed.

The berthing structure in general should provide with the following:

- Fenders
- Bollards

0.5.5. Terminal Infrastructure Including Equipment

- Berth
- Grab cranes and lifting cranes
- Dumpers
- Storage Area
- Administration Building
- Operation cum control building
- Security building

The port planning should ensure through connectivity internally and with the hinterland. The following general principles are considered in the layout of internal roads:

- ✓ Through routes are provided wherever it is possible, to avoid lorries being forced to turn around.
- ✓ There are as few railway crossings as possible.
- ✓ Road junctions or intersections with other routes are reduced to a minimum, and in any case, are placed only in situations where the temporary stoppage of lines of traffic does not obstruct other intersections or cross routes.
- ✓ Adequate parking places are ensured for vehicles which must wait for loads or to unload, due to various circumstances. It is an advantage to have, nearby staff canteens for the supply of meals, water, etc.
- ✓ The main entrances to docks must be carefully planned as to width and space.
- ✓ During peak hours, some degree of traffic control at strategic points should be established, and it is an advantage in congested docks for the control points to be in telephonic communication with each other and with the main gate.
- ✓ Routes should be adequately signposted

- ✓ If the provision of through routes is not possible, adequate turning areas must be provided.

  It is good to have a map of the road network exhibited in the premise.
- ✓ Firefighting Equipment.

0.5.5.1. Capital Cost

Table 0-19: Terminal costing

Structure	Amount (INR Crore)
Berthing structure	6.97
Terminal building of 225 sqm floor area for housing operation, administration, security and passenger amenities.	0.31
Storage with provision for covered storage, open storage	1.67
Landscaping (paving's, lawn, etc.)	0.05
Auxiliary items (firefighting, water supply, safety gadgets, lightings, road networks, etc.)	2.55
Mechanical equipment	2.05
Navigation and Communication	1.15
Utility Shifting	0.50

For operation and maintenance, 1% of initial cost is considered for structural and other auxiliary items.

Table 0-20: Operation and maintenance costing

Structure	Amount (INR Crore)
Berthing structure	0.14
Terminal building 225 sqm housing operation, administration, security and passenger amenities.	0.003

Structure	Amount (INR Crore)
Storage with provision for covered storage, open storage	0.02
Landscaping (paving's, lawn, etc.)	0.00005
Auxiliary items (firefighting, water supply, safety gadgets, lightings, road networks, etc.)	0.003
Mechanical equipment	0.1025
Navigation and Communication	0.06

0.6. Preliminary Engineering Designs

0.6.1. River Training

In the present case, training is done to provide sufficient depth for navigation during low stage of water. The preliminary design is based on the Class III criteria of waterway and vessel size of maximum 58m LOA, 9m beam and loaded draft of 1.5m.

Dredging of the river channel is a requisite. Since the sediment materials are observed to be sandy soil with small amounts of silt and clay, maintenance dredging at intervals is to be considered.

The details of the proposed river training and conservancy works can be read from the drawings enclosed of Vol. II

0.6.2. Bank Protection

From the survey report, it is observed that few stretches of the embankment are protected but the rest are left unprotected. The erosion prone areas demand some precaution measures against the action of water especially during flood. Thus, it is suggested to have bank protection adjacent to the terminal location. It is recommended to have relatively soft solutions for bank protection. At critical locations, like the ones very close to terminal or the one with very severe velocities are suggested to have stone protections. Thus, the proposal is for laying riprap with vegetal cover.

0.6.3. Aids to Navigation

The following navigating aids are proposed:

- Day beacon: An unlit aid primarily used to assist the ship during the daylight hours where sight navigation is practical or, when it is not practical to operate a light.
- Range: An aid which consists of two or more fixed navigation marks situated at different elevations to provide a leading line for ship navigation. The range may or may not exhibit lights.

The buoys are proposed to be placed at a spacing of 1000 to 1500m along straight stretches of the channel on both the boundaries and in curves to enable proper navigability; they are proposed to be placed at a spacing of 300 to 500m. The ranges are placed along the center line of the channels along straight stretches so that the vessels can align themselves within the channel in reference to them. The arrangements and spacing of the proposed markings are shown in the drawings enclosed as Vol. II

0.6.4. Cargo Terminals and River Ports

The codes referred for arriving at the preliminary design of the structure includes IS 456, 875/3, 4651, etc. The design vessel size is 58m LOA, beam of 9m and draft of 1.5m.

0.6.4.1. Berth Structure

The berthing quay is designed as RCC structure using precast members. The berth is to have short beams resting on the pile cap and the long beams makes the secondary beams. Portions of beams can be precast and laid in place for easy execution. The top slab can be cast-in-situ. The facia beam to receive the fender is designed specially to accommodate the increased impact load. Live load considered on the deck is uniformly distributed load of 5t/ sq.m. The piles are to be of friction type.

From the min and maximum water levels in Mahanadi for around last 10 years, and assuming summer season from March to June, monsoon from July to October, it can be arrived that the average high-water value comes around +25.5m w.r.t MSL, excluding scattered exceptionally high values indicating flood. The average low water level except for very severe summer is around + 21.5m wrt MSL. Thus, with a freeboard of 1m, the deck elevations are proposed as +26.5m MSL and +22.5m MSL for high and low-level jetty respectively. The pile layout, beam arrangement and sizing of members are given in the drawings of Vol. II.

0.6.4.2. Fender Design

The selection of fender system is based on the following factors:

- ✓ The fender system must have sufficient energy absorption capacity
- ✓ The reaction force from the fender system does not exceed the loading capacity of the berthing system
- ✓ The pressure exerted from the fender system does not exceed the ship's hull pressure capacity
- ✓ The capital construction cost and maintenance costs are considered during the design of both the berth structure and fender system

0.6.4.3. Terminal Building

This building serves the functions of operation, administration, security, etc. It is a suggested to have a 15m X 15m single storey framed building in the first phase, which may be made multi storied subsequently. The basic loads considered for the building is 5kN/sq.m. live load including 1 kN/ sq.m. for light weight partitions. Open foundations are suggested. From the soil investigation report, it is observed that at around 4m below ground level, an SBC of around 30tonnes/ sq.m. can be obtained. Hence it is proposed to have the footing at 4m below the ground level.

0.6.4.4. Storage area

Provisions for a transit shed is proposed for easy handling of expected cargo. The cargo handling area is expected to accommodate a crane of 10 tonnes handling capacity. The storage area is designed for 75% of design vessel capacity, ie., 75% of 500 tonnes or 375 tonnes. The dry bulk is proposed to be placed as heaps of maximum height 3m and base radius maximum 10m and a minimum spacing of around 3m between heaps. Closed and open storage are proposed. For the storage area, a live load of 5 t/sq.m. is considered apart from the load contribution by the crane. It is proposed to have open footing for the storage area, founded 4m below the ground surface.

0.6.5. Construction Schedule

The sequence of construction activities for phase I shall be as mentioned below:

a). Dredging of the entire channel and site clearance at the terminal location and at locations of cut-offs proposed.
b). Temporary works for piling activities to be initiated and foundation for terminal and storage building to be constructed.
c). Insitu casting and installation of piles for jetty, construction of substructure for terminal building and storage area.
d). Modifications to bridges.
e). Land based casting for semi precast beams and fabrication of steel truss for storage building.
f). Insitu casting and installation of pile muff and procurement of fenders and bollards for the berth.
g). Installation of semi-precast transverse beams for wharf.
h). Installation of semi-precast longitudinal beams for wharf.
i). Insitu casting of beams and slabs for wharf.
j). Demarcating the channel and fixing aids to navigation.
k). Laying the road networks and installing other infrastructure amenities (water, light, etc.)
l). Installation of fixtures and superstructure elements like warehouse roof.
m). Setting the landscape and opening for public.

0.7. Vessel Design

0.7.1. Design Basis

The vessel dimensions are arrived at primarily based on the horizontal and vertical dimensions of the water way under consideration. The design also considers the safety aspects while maneuvering in the shallow waters and the availability of local resources. The vessel dimensions applicable to the considered channel specifications can be arrived based on the ‘The Inland Waterways Authority of India Act 1985’. The design is based on the channel dimensions of the terminal location as minimum depth 1.7m, bottom width 50m and bend radius 700m.Also, the vessel is required to carry cargoes.

0.7.2. Type of proposed Vessels

Vessels or barges that can accommodate bulk cargo like cement, iron, minerals, fertilizers, etc, are proposed. At the same time criteria for draft of 1.7m must be satisfied.

Table 0-21: Proposed vessel dimensions

Type	LOA (m)	Beam (m)	Draft (m)
Cargo vessels/ barges	40-58	Max. 9	1-1.5
Country boat	30-45	5-8	1.0-1.2

0.7.3. Number of Vessel Required

The number of vessels to be deployed to serve the hinterland is arrived at based on the projected traffic data. In the present scene since the focus is on shifting the modes of existing cargo movements to the waterways, as beginning 2 vessels of dry bulk carrying type are proposed.

0.8. Navigation and Communication System

0.8.1. General Requirements

Communication stations (base stations for RIS) are proposed to be established at locations shows in the map below. Each communication station is effective within a radius of 25 km. Hence, **4 such stations** have been proposed for the length of the waterway (98 km).

The following equipment is proposed for navigation and communication equipment –

a) **DGPS (Differential Global Positioning System)** – Enhancement over convention GPS System, it provides much accurate location (precise within 10 cm)

b) **River Information Service (RIS) System)** – This latest technology consists of VHF, Automatic Identification System (AIS), Meteorological System installed at combination of Control and Base stations. The control station would be established at Cuttack, complemented by 3 base stations along the waterway. The control system hosts RIS software and hardware and acts as the command centre which collects data, processes it and passes on instructions to other base stations.

c) **Survey Equipment** – Total Station, Auto-level, Echo-sounder, Current Meter, Hypack Software, ATG, DGPS receiver, PC & Workstation.

0.8.2. Existing System

No system exists.

0.8.3. Additional requirement

The above said systems are very essential for a properly established terminal and waterway system. No additional navigation and communication system are proposed.

0.8.4. Costing

0.8.4.1. Capital Cost

Total expenditure of ~INR 10 Crore is proposed as follows –

Table 0-22: CAPEX on Navigation and Communication Equipment

Sr. No.	Equipment	Qty	Unit Price	Total
Base Station, Control Station				
1	AIS Base Station	8	30,00,000	2,40,00,000
2	Meteorological Sensor	4	8,00,000	32,00,000
3	ATG	4	11,00,000	44,00,000
4	VHF	4	5,00,000	20,00,000
5	DG Set 10 KVA	4	7,00,000	28,00,000
6	UPS	8	5,00,000	40,00,000
7	DGPS Station	1	2,50,00,000	2,50,00,000
8	RIS Software	1	65,00,000	65,00,000
9	RIS Hardware	1	1,20,00,000	1,20,00,000
10	Installation Testing & Commissioning	4	20,00,000	80,00,000

11	Porta cabin	8	12,00,000	96,00,000
12	Monopole Tower	4	7,50,000	30,00,000
13	Survey Equipment			39,80,000
			Total	**10,84,80,000**

0.8.4.2. O&M Cost

Operation and maintenance cost are **~5% of the installation cost**. In addition, each of the **base stations** is manned 2 operators and 1 security staff. As **Cuttack would double as Base cum Control station**, it would require 1 Engineer, 3 operators and 3 security staff. The security personnel requirement can be accommodated with staffing proposed in Institutional Requirements. The operated should be IALA trained and can be effectively utilized for ensuring proper running of RIS system and other equipment. As highlighted above, an area of **~1 hectare would be leased out** at the proposed base station locations. The expected rental is INR 25,000 per annum per base station. If required, operations of base and control stations can be outsourced through comprehensive AMAC contracts.

Table 0.3: Manpower Requirement for Operations of Communication and Navigation Equipment

Sr. No.	Description	CTC (INR lakh)	Staffing Requirement	Total Cost (INR lakh)
1	Engineer	4.8	1	4.8
2	Operator	3.0	9	27.0

0.9. Environmental and Social aspects

0.9.1. Environmental settings in project area

The Mahanadi River is located in the Central part of Odisha. Length of total river stretch under project scope is about 98 km (including part of Mahanadi and Part of Luna River after feasibility assessment Luna River was found more feasible to develop as Inland Waterways, and, hence scope of environment assessment is focused in on Luna River stretch. Project river stretch is the part of Cuttack, Kendrapara and Jagatsinghpur District.

Odisha is always vulnerable to cyclones in April-May and September-November.

Based on analysis of Forest Map available at GIS website of Odisha (http://gis.ori.nic.in/) developed and run by NIC, no forest land is located alongside the project river stretch.

The project river stretch under study is not crossing any National Park, Wildlife Sanctuaries and Conservation Reserves as per data collected from secondary sources. The same will be verified during joint inspection with forest and wildlife department.

0.9.2. Estuary and Coastal zone

Coastal zone area of the Mahanadi River is notified under CRZ-I, II & III. Map of CRZ area along project river stretch is presented in the report. CRZ clearance from MoEFCC is required before starting any construction activities on the proposed river stretch.

0.9.3. Potential Environmental and Social Impacts of the Project

Proposed project is likely to change the prevailing environment condition of the project region. Considering some of the adverse impacts associated with project, these impacts have to be mitigated and necessary mitigation measures need to be incorporated in the engineering design. Environmental mitigation measures represent the project's endeavour to reduce its environmental footprint to the minimum possible. These are conscious efforts from the project to reduce undesirable environmental impacts of the proposed activities and offset these to the degree practicable. Enhancement measures are project's efforts to gain acceptability in its area of influence. They reflect the pro-active approach of the project towards environmental management.

0.9.4. Need for Environmental Clearance

Environmental Clearanceis Not Applicable, as EIA Notification 2006 does not classify terminals on river or dredging in the river requiring environmental clearance. The applicability of this legislation should be reconfirmed during commencement stage. In addition, following clearances are required:

- CRZ Clearance is required,
- Forest Clearance if revenue forest is required to be acquired during commencement
- Tree felling permission from DFO/ District Collector Is required if any tree cutting is involved.

0.9.5. Social Profile of the project area:

Project river stretch under study is the part of three districts namely, Kendrapara, Cuttack and Jagatsinghpur. There are about 57 villages along the project river stretch. The livelihood of the project stretches dependent on agricultural activities.

0.10. **Institutional Requirements**

It has been found that Govt. of India promulgated direction under section 111 of the Major Port Trusts Act 1963 to the selected Major Port Trusts for allocations of National Waterways (NWs) for undertaking the development of the National Waterways through release of grants by the IWAI. The Major Port Trusts are to be the implementing agency for development of the National Waterways. As per the above directions of Govt. of India, the River Mahanadi – Luna (NW-64) has been allocated to the Paradip Port Trusts for development.

a) Since, the River Mahanadi (NW-64) has been allocated to Paradip Port Trust for development, the manpower requirement for maintenance under the present scenario shall be an Officer at the level of Assistant Director (T.) and Junior Account Officer may be posted at Head Quarter, Noida and Bhubaneswar to monitor the various development works and fund utilization.

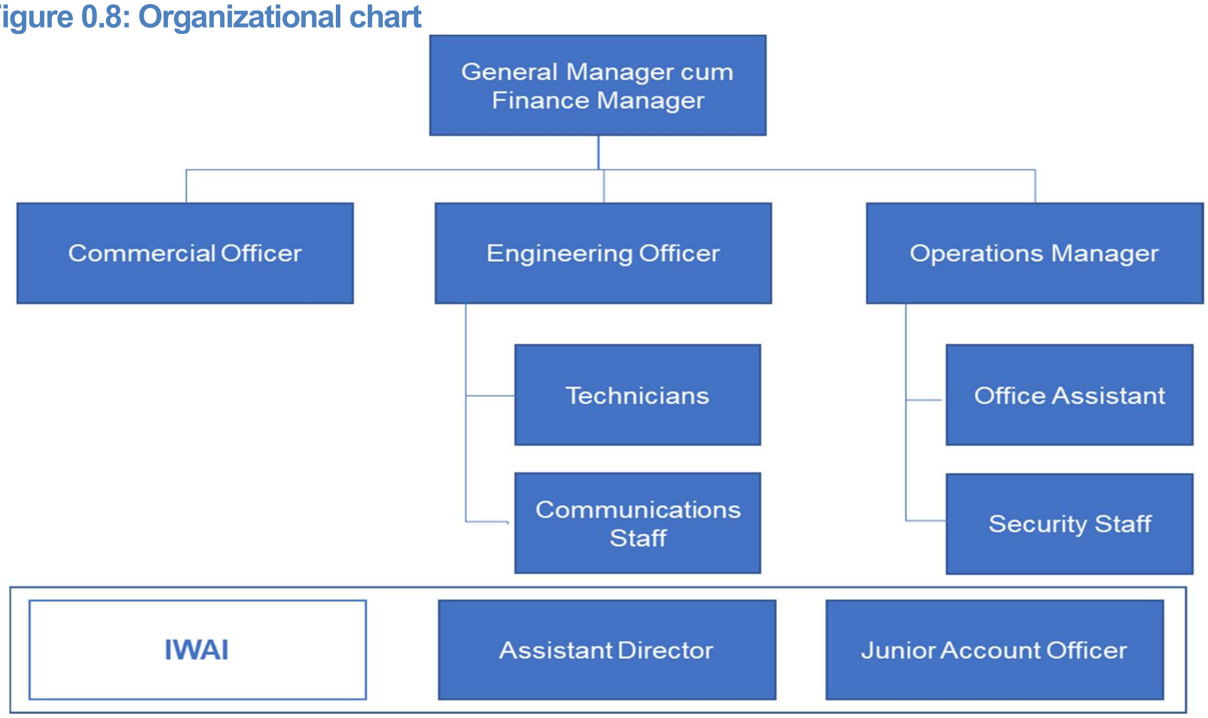
b) Since the manpower will be deployed by the Paradip Port Trust for maintenance and development of the River Mahanadi (NW-64), the training of personnel shall not be required at the terminals

0.10.1. Organizational Set up / Establishment

Proposed organizational set up for the waterway operation is shown in the following Figure10.1. The hierarchical designations that can be used may be drawn from the IWAI / Paradip Port Trust organization structure and worked out accordingly.

Feedback has considered that cost of employees of Pardeep Port Trust that would be appointed for the waterway. While this cost does not relate to IWAI but would still be allocated to this project. Proposed organizational set up for the waterway operation is shown below.

Figure 0.8: Organizational chart



0.10.2. Manpower Requirement

Following manpower requirement is proposed for the project –

Table 0-23: Costing of Staff Structure

Labour	Nos.	Wage per annum per position (Rs.)
General Manager cum Finance Manager	1	12,00,000.00
Assistant Director (IWAI)	1	10,00,000.00
Commercial Manager	1	8,00,000.00
Operational Manager	1	8,00,000.00
Engineering Head	1	6,00,000.00
Accounts Officer	1	3,60,000.00
Office Assistant	1	2,40,000.00
Security officer	3	2,40,000.00
Electrician	1	2,40,000.00
Mechanic	1	2,40,000.00
Communication Engineer	1	4,80,000.00
Communication Operators	9	3,00,000.00
Total		**93,80,000.00**

0.10.3. Training Requirement / Capacity Building

Since the manpower will be deployed by the Paradip Port Trust for maintenance and development of the River Mahanadi – Luna (NW-64), the training of personnel shall not be required at the terminals.The employees of each department must be capable doing the work assigned to them. Also, each department are required to provide necessary trainings for the employees if needed like terminal operation, ticketing operation, repair &maintenance, operation of communication systems,etc. Infrastructure

0.11. Project Costing

0.11.1. Basis of Costing

The estimate of capital costs has been worked out based on the project components as detailed in the previous sections and the schematic drawings presented in the appendix.

Detailed bill of quantities is worked out and the total project cost is derived from the following schedule of rates:

- Delhi schedule of Rates 2014 by CPWD
- Standard Data Book 2014 by Ministry of Road Transportation and Highways

Table 11.1: Summary of Capital Expenditure for Proposed Option 1

Sl. No.	Description	Minimum cost incurred (Rs.)
1	Berthing structure	₹ 6,97,28,251.30
2	Terminal building	₹ 30,62,287.00
3	Storage	₹ 1,67,03,347.59
4	Fairway development (including aids to navigation)	₹ 1,62,36,93,867.24
5	Utility shifting	₹ 50,00,000.00
6	Auxiliary items	₹ 2,55,00,000.00
7	Mechanical equipment	₹ 2,05,00,000.00
8	Land scaping	₹ 5,00,000.00
9	Navigation and communication	₹ 10,84,80,000.00
10	Modification to existing crossing bridges	₹ 75,00,00,000.00
	Total (Cr.)	**₹ 263.66**

Table 11.2: Summary of Operation and Maintenance Expenditure

Sl. No.	Description	Percentage of capex	Amount
I	**Fairway**		
1	Dredging	5	₹ 5,46,36,233.50
2	Bank maintenance	1	₹ 1,34,000.00
3	River training	5	₹ 2,12,52,650.00
4	Auxiliary items	1	₹ 2,55,000.00
5	Aids to navigation	2	₹ 60,000.00
II	**Terminals**		
1	Terminal operations (salary of staffs)	Chapter 10	₹93,80,000.00 PA
2	Terminal building maintenance	1	₹ 30,622.87

Sl. No.	Description	Percentage of capex	Amount
3	Mechanical equipment	5	₹ 10,25,000.00
4	Landscaping	1	₹ 5,000.00
5	Navigation and communication	5	₹ 54,24,000.00
6	Berthing structure	2	₹ 13,94,565.03
7	Storage area	1	₹1,67,033.48

0.12. IMPLEMENTATION SCHEDULE

It is planned that the development of waterway system will take place in a single phase. It includes all development works including fairway development and terminal infrastructure development. A total of 18 months is required for the whole project.

Fig 12.1: Implementation Schedule of the Project

		Months																		
Sl No	Item	6 Months	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	All clearances including land acquisition and utility shifting																			
1	Dredging of entire channel: 3 dredgers of grab type working simultaneosly at the rate of 300 cum / hr, working for 15 hours a day and 15 days per month																			
2	Construction of terminal building at Cuttack																			
2.1	Site clearing and construction of foundation																			
2.2	Superstructure wor, electrification and water connection																			
3	Construction of berthing structure																			
3.1	High level jetty																			
3.1.1	Pile foundation																			
3.1.2	Superstructure																			
3.1.2.1	Pre-Cast																			
3.1.2.2	Cast in situ																			
3.1.3	Procurement of fixture like fenders and bollards for both jetties																			
3.1.4	Electrification and plumbing works																			
3.2	Low level jetty																			
3.2.1	Pile foundation																			
3.2.2	Superstructure																			
3.2.2.1	Pre-Cast																			
3.2.2.2	Cast in situ																			
3.2.3	Electrification and plumbing works																			
4	Construction of ware house																			
4.1	Site clearance and construction of foudation																			
4.2	Construction of superstructure																			
4.3	Fabricatinon of roof truss																			
4.4	Procurement and fabrication of shutters for doors																			
4.5	Fixing fabricated elements																			
4.6	Electrification and plumbing																			
5	Procurement of auxillary items as, safety gadgets, firefighting systems, communication systems, aids to navigation etc																			
6	Fairway development working for 15 hours a day and 25 days a month																			
6.1	River training and modification of crossing bridges																			
6.2	Embankment protection near the terminal location																			
6.3	Installation aids to navigation																			
7	Terminal area development																			
7.1	Internal road connectivity																			
7.2	Installation of other amenities as fire fighting, safet gadges, fresh water supply lines, STP, communication system etc																			
7.3	Landscaping																			
8	Selection and arranging of private operators for vessel operation																			
9	Commissioning																			

0.13. Economic and Financial Analysis

0.13.1. Revenue

Following revenue scenario have been considered

- Moderate Scenario – Current IWAI tariff structure, lower traffic growth rate, no tourism related revenues
- Aggressive Scenario
    - Higher fairway charges (0.1/GRT/km as opposed to 0.02/GRT/km as per current tariffs)
    - Higher Cargo related charges (INR 5/ton as opposed to INR 1/ton as per current tariffs)
    - Higher Storage charges – double of current storage charges
    - Higher Traffic Growth Rate (8% p.a.) considered in initial years till steady state is achieved

Revenues in both scenarios is as shown below:

Moderate Scenario

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Waterway Usage Charges	**-**	**-**	**0.01**	**0.02**	**0.03**	**0.03**	**0.04**	**0.04**	**0.08**	**1.03**
Vessel Related Charges	**-**	**-**	**0.01**	**0.03**	**0.04**	**0.05**	**0.05**	**0.06**	**0.12**	**1.51**
Berthing	-	-	0.01	0.01	0.02	0.02	0.02	0.02	0.05	0.64
Towage	-	-	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.39
Pilotage	-	-	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.48
Cargo Related Terminal Charges	**-**	**-**	**0.00**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.26**
Storage Charges	**-**	**-**	**0.01**	**0.03**	**0.04**	**0.04**	**0.05**	**0.05**	**0.11**	**1.39**
Revenue Share	**-**	**-**	**0.04**	**0.10**	**0.14**	**0.16**	**0.18**	**0.20**	**0.42**	**5.15**
Miscellaneous Charges	**-**	**-**	**0.00**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	**0.29**
Total Revenues	**-**	**-**	**0.08**	**0.19**	**0.26**	**0.29**	**0.33**	**0.37**	**0.78**	**9.63**

Aggressive Scenario

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Waterway Usage Charges	-	-	0.24	0.55	0.77	0.86	0.97	1.08	2.63	57.13
Vessel Related Charges	-	-	0.07	0.16	0.22	0.25	0.28	0.32	0.77	16.78
Berthing	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.14
Towage	-	-	0.02	0.04	0.06	0.06	0.07	0.08	0.20	4.28
Pilotage	-	-	0.02	0.05	0.07	0.08	0.09	0.10	0.25	5.36
Cargo Related Terminal Charges	-	-	0.06	0.14	0.19	0.21	0.24	0.27	0.66	14.28
Storage Charges	-	-	0.17	0.39	0.54	0.61	0.69	0.77	1.87	40.56
Revenue Share	-	-	0.24	0.55	0.77	0.86	0.97	1.08	2.63	57.13
Miscellaneous Charges	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.28
Total Revenues	-	-	0.82	1.84	2.59	2.91	3.26	3.67	8.89	193.17

Aggressive Scenario + Tourism Revenues

- INR 75 per tourist as terminal / waterway charges

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Waterway Usage Charges	**-**	**-**	**0.24**	**0.55**	**0.77**	**0.86**	**0.97**	**1.08**	**2.63**	**57.13**
Vessel Related Charges	**-**	**-**	**0.07**	**0.16**	**0.22**	**0.25**	**0.28**	**0.32**	**0.77**	**16.78**
Berthing	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.14
Towage	-	-	0.02	0.04	0.06	0.06	0.07	0.08	0.20	4.28
Pilotage	-	-	0.02	0.05	0.07	0.08	0.09	0.10	0.25	5.36
Cargo Related Terminal Charges	**-**	**-**	**0.06**	**0.14**	**0.19**	**0.21**	**0.24**	**0.27**	**0.66**	**14.28**
Storage Charges	**-**	**-**	**0.17**	**0.39**	**0.54**	**0.61**	**0.69**	**0.77**	**1.87**	**40.56**
Revenue Share	**-**	**-**	**0.24**	**0.55**	**0.77**	**0.86**	**0.97**	**1.08**	**2.63**	**57.13**
Miscellaneous Charges	**-**	**-**	**0.03**	**0.07**	**0.10**	**0.11**	**0.12**	**0.14**	**0.33**	**7.28**
Add. Tourism Revenues	**-**		**0.25**	**0.46**	**0.89**	**1.20**	**1.38**	**1.57**	**3.52**	**52.78**
Total Revenues	**-**	**-**	**1.07**	**2.30**	**3.48**	**4.11**	**4.64**	**5.24**	**12.42**	**245.95**

0.13.2. Financial Assumptions

- Capital Costs escalation: 5% p.a.
- Operational Expenditure escalation: 5% p.a.
- Interest Rate: 9% p.a.
- Cost of Equity: 16%
- Discount Rate (WACC): 10%

0.13.3. Operations & Maintenance Expenditure

O&M expenses comprises mainly of manpower and various maintenance charges (dredging, bank, navigation aids, terminal. The total OPEX in Option 1 is ~INR 9 Crore. OPEX escalation at 5% p.a. (7% p.a. for manpower) has been considered.

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Dredging	-	-	6.02	6.32	6.64	6.97	7.32	7.69	10.30	27.34
Bank maintenance	-	-	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.07
River Training			2.34	2.46	2.58	2.71	2.85	2.99	4.01	10.64
Auxiliary items			0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.13
Aids to navigation			0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06
Terminal operations (salary of staffs)			1.03	1.09	1.14	1.20	1.26	1.32	1.77	4.69
Terminal building maintenance	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
Mechanical equipment			0.11	0.12	0.12	0.13	0.14	0.14	0.19	0.51
Landscaping	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navigation and communication	-	-	0.60	0.63	0.66	0.69	0.73	0.76	1.02	2.71
Berthing structure	-	-	0.15	0.16	0.17	0.18	0.19	0.20	0.26	0.70
Storage area	-	-	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.08
Total OPEX	**-**	**-**	10.34	10.85	11.40	11.97	12.57	13.20	17.68	46.94

0.13.4. Net Cashflows

Moderate Scenario (Current Tariff Structure)

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Revenues	-	-	0.1	0.2	0.3	0.3	0.3	0.4	5.8	2.7	9.6
Less: CAPEX	263.7	-	-	-	-	-	-	-	-	-	-
Less: O&M Costs	-	-	10.3	10.9	11.4	12.0	12.6	13.2	38.6	28.8	46.9
Pre-Tax Cash Flows	-263.7	-	-10.3	-10.7	-11.1	-11.7	-12.2	-12.8	-32.8	-26.1	-37.3

The above cash flows yield **NPV of INR -364.95 Cr**

Aggressive Scenario (Proposed Tariff Structure)

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Revenues	-	-	0.8	1.8	2.6	2.9	3.3	3.7	8.9	41.4	193.2
Less: CAPEX	263.7	-	-	-	-	-	-	-	-	-	-
Less: O&M Costs	-	-	10.3	10.9	11.4	12.0	12.6	13.2	17.7	28.8	46.9
Pre-Tax Cash Flows	-263.7	-	-9.5	-9.0	-8.8	-9.1	-9.3	-9.5	-8.8	12.6	146.2

The above cash flows yield **NPV of INR (-259.49) Cr and an IRR of 2.09%.**

Aggressive Scenario + Tourism Activities

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Revenues	**-**	**0.1**	**1.1**	**2.3**	**3.5**	**4.1**	**4.6**	**5.2**	**12.4**	**55.1**	**246.0**
Less: CAPEX	**263.7**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Less: O&M Costs	**-**	**-**	**10.3**	**10.9**	**11.4**	**12.0**	**12.6**	**13.2**	**17.7**	**28.8**	**46.9**
Pre-Tax Cash Flows	**-263.7**	**0.1**	**-9.3**	**-8.6**	**-7.9**	**-7.9**	**-7.9**	**-8.0**	**-5.3**	**26.3**	**199.0**

The above cash flows yield **NPV of INR (- 221.91) Cr and IRR of 4.07% p.a**.

0.13.5. Economic Analysis

The waterway provides several direct and indirect benefits

0.13.5.1. Direct Benefits

- Employment Generation – job creation through waterway infrastructure and allied activities
- Creation of Business Opportunity – boost to local economy
- Vessel Operating Cost – cheaper transport
- Various Environmental and Social Benefits - Carbon saving, air/noise pollution

0.13.5.2. Indirect Benefits

- Traffic Congestion Solution – additional transport capacity reduces load on existing road and rail networks
- Economic Boost - economic benefit in the form of property premiums beyond the average rent or sale of residential and commercial property

- Operational Safety – fewest number of accidents, fatalities, and injuries in waterway
- Land Usage and social impact – right of way is natural, minimal disturbance to civil life

The following socio-economic impact is envisaged by the development of the waterways.

- Operation Efficiency (cost savings) – INR 1.44 per ton-km
- Job Creation during Construction – 1000 jobs per $ 100 Mn (INR 700 Cr)
    - Total Project Investment: ~INR 260 Cr
    - Job Creation: ~400
    - Economic Impact: ~INR 18 Cr
- Job Creation during Operations – 50 jobs per MTPA traffic

The Economic cash flows for the project is shown below for the different scenarios:

OPEX same as Aggressive Scenario.

Economic Cashflows – Moderate Scenario (Current Tariff Structure)

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Financial Cash Flows	-263.7	-	-10.3	-10.7	-11.1	-11.7	-12.2	-12.8	-32.8	-26.1	-37.3
Economic Impact											
Operational Efficiency	-	-	0.3	0.6	0.7	0.8	0.8	0.8	1.1	1.8	2.9
Job Creation	9.0	9.0	-	-	0.0	0.1	0.1	0.1	0.2	0.5	1.3
Economic Cash Flows	**-254.7**	**9.0**	**-10.0**	**-10.1**	**-10.4**	**-10.8**	**-11.3**	**-11.9**	**-16.0**	**-23.8**	**-33.1**

There is not IRR calculatable for this scenario

Economic Cashflows – Aggressive Scenario (Proposed Tariff Structure)

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Financial Cash Flows	-263.7	-	-9.5	-9.0	-8.8	-9.1	-9.3	-9.5	-8.8	12.6	146.2
Economic Impact											
Operational Efficiency	-	-	1.5	3.1	4.1	4.2	4.4	4.6	7.0	15.0	32.5
Job Creation	9.0	9.0	-	-	0.2	0.4	0.5	0.6	1.1	3.9	13.8
Economic Cash Flows	**-254.7**	**9.0**	**-8.0**	**-5.9**	**-4.6**	**-4.5**	**-4.4**	**-4.4**	**-5.5**	**31.6**	**192.5**

The above cash flows yield **an EIRR of 4.99%.**

Economic Cashflows – Aggressive Scenario + Tourism Activities

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Financial Cash Flows	-263.7	0.1	-9.3	-8.6	-7.9	-7.9	-7.9	-8.0	-5.3	26.3	199.0
Economic Impact											
Operational Efficiency	-	-	1.5	3.1	4.1	4.2	4.4	4.6	7.0	15.0	32.5
Job Creation	9.0	9.0	-	-	0.2	0.4	0.5	0.6	1.1	3.9	13.8
Economic Cash Flows	**-254.7**	**9.1**	**-7.8**	**-5.4**	**-3.7**	**-3.3**	**-3.0**	**-2.8**	**-3.7**	**45.2**	**245.3**

The above cash flows yield **an EIRR of 6.42% p.a**.

Comparison of the three Scenarios is as below:

Project FIRR & EIRR

Scenario	FIRR	EIRR
Moderate Scenario	-	-
Aggressive Scenario	2.09%	4.99%
Aggressive Scenario + Tourism Activities	4.07%	6.42%

0.14. Conclusions and Recommendations

From study of Mahanadi river via Luna for the development of navigation channel, it can be concluded that:

- The stretch under study is 100 km up to downstream of Jobra barrage, of which up to 43km alone is under the influence of tide. The rest of the river is susceptible to drying during summer. No major hindrance to navigation in the stretch like barrages, dams, etc., is noted. The vertical and horizontal clearances of bridge crossing structures deviate from the clearance criteria for the specified class III, but the horizontal clearance criteria can be managed by some soft measures as one-way traffic, however, to meet vertical clearance criteria, the central spans are to be modified.
- It is evident that the waterway has only limited traffic potential at present due to lack of industrial development and small stretch (~100 km) considered. But the traffic can be expected to increase in future with upcoming Industrial developments such as PCPIR, riverine port, relaxation on mining restrictions and overall prevalence of waterway transport etc. etc.
- Building a terminal at 43 km chainage, where the river has tidal influence, is not viable due to lack of traffic. All the cargo traffic is concentrated nearby Cuttack and transporting cargo by road till 43 km Chainage and thereafter using waterway till Paradip, is not economically viable for freighters. Moreover, the proposed terminal location at Karilopatna (Chainage 43) has poor road access, further adding to the cost. The total cost of waterway infrastructure development (terminal, fairway, navigation equipment, roads etc.) till Chainage 43 km is ~INR 260 Crore.

- The river requires training at few stretches, the channel needs dredging to maintain the depth of 1.7m corresponding to Class III waterway features, embankments near the terminal requires immediate protection owing to vessel wakes. In all, the waterway can be used during fair weather season only between July and December when the river has water.
- The expected traffic potential is through diversion from other modes. Cuttack being an industrial area with a major seaport at Paradip, it can be assumed that about 0.14 to 0.30 MMTPA of cargo can be diverted to the new waterway. Also, passenger ferry services can also be entertained.
- The waterway is also characterised by a large IFFCO plant at ~3 km chainage (very close to river mouth at Paradip). The plant is desirous of building a captive waterway terminal for transporting fertilizers. Moreover, the state has cleared development of a riverine port at Akhadasali village under Mahakalapada block in Kendrapada district on PPP. The port would handle Panamax vessels, with proposed channel width of 14-16 m. Thus, the initial ~7 km of waterway (till Chainage 7 km) is proposed to be developed as Class VII waterway to enable developments at IFFCO and Riverine Port.
- The region is flood prone hence the terminal structure should be of that type which can accommodate the water level fluctuations. Considering the dry bulk cargo, it is proposed to have one high-level and a low-level jetty at Jagatpur village, near Cuttack.
- Vessels/ barges of up to 500 DWT seems sufficient for the present traffic.
- It is proposed to have DGPS station and RIS network (including VHF and AIS) for the safe managing of the vessels along with facilities for receiving weather forecasts from IMD or other similar organizations.
- The river is already having ferry service and the proposed terminal is beyond 10km lateral distance from the sea mouth, hence environmental clearance is not required.
- The cost for developing the river as Class III with terminal at Cuttack is around Rs. 263.66 crore, with no navigation during summer.

- It is proposed to complete the work within a period of 18 months, including 6-month time to obtain all clearances.
- It is observed that EPC mode of implementation is suitable for this kind of works.
- Based on the socio-economic analysis, the project remains unviable due to low financial returns.

0.14.1. Recommendation

The projects seem unviable from socio-economic analysis, this being a green field project and a public infrastructural project, it may be considered to develop the river as Class III waterway. No navigation during summer is recommended, because to have hydraulic structures like barrages to aid all weather navigation, investment escalates highly and that cannot be justified by the present traffic potential.

With the IFFCO plant setting up a waterway terminal (Chainage 3 km) for fertilizer transport and riverine port coming up at Akhadasali village (Chainage 7 km), the initial 7 km of waterway can be developed as Class VII waterway in Phase 1 of the project. This section of waterway also connects to NW-5 confluence. Being situated at sea mouth, the investment requirement is minimal (~INR 5 crore in navigational aids, communication & navigation equipment).

1. INTRODUCTION

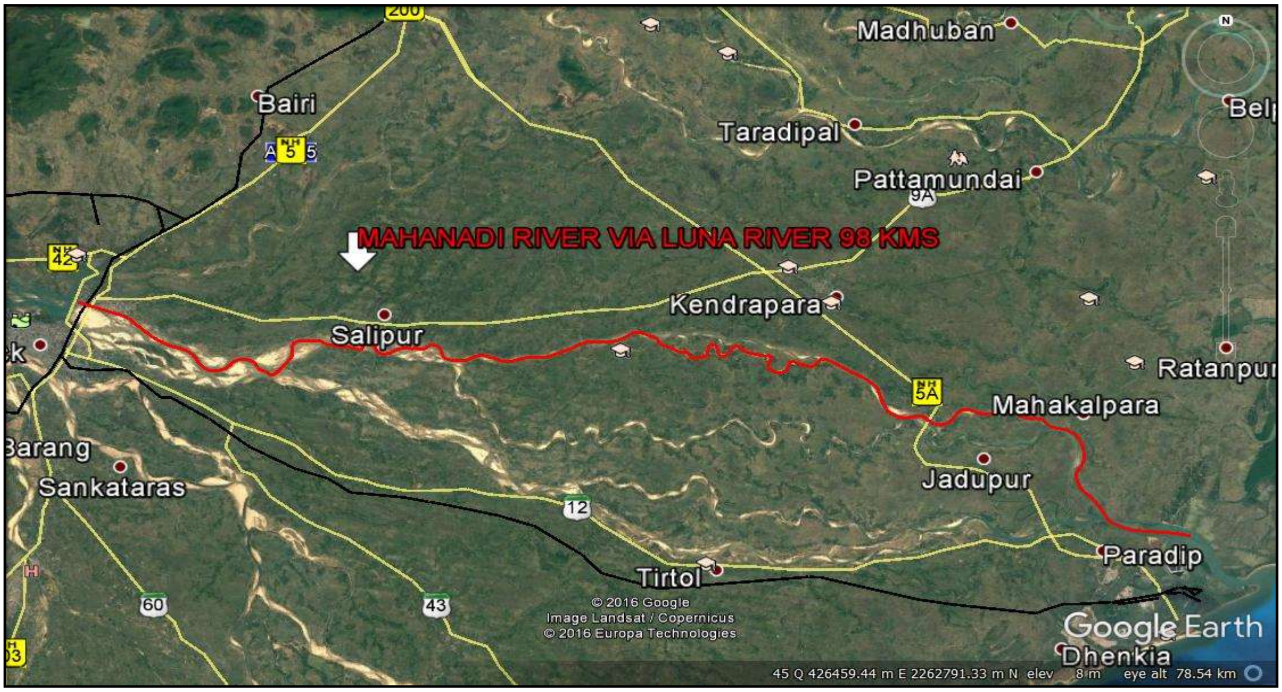
1.1. Project Background and Summary of previous study

For an economically and socially progressing country, good transportation infrastructure is a must. With that in the priority, India is focusing on improving her traditional system of transportation, the waterways. Inland Waterways Authority of India is the nodal agency responsible for development and maintenance of National Waterways and associated infrastructures. The IWAI has initiated the development of around 53 waterways (out of 106 designated waterways) in 8 clusters and the present project falls under cluster4, NW 64, which includes 98 km of river stretch from Paradip (Latitude 20°19'38.12"N, Longitude 86°40'16.96"E) to Cuttack barrage (Latitude 20°29'16.60"N, Longitude 85°54'18.17"E).

In the reconnaissance survey during the months of February to April 2016, river stretches of about 425km from Paradip sea mouth (Latitude 20°19'38.12"N, Longitude 86°40'16.96"E) to Sambalpur Barrage (Latitude 21°27'34.33"N, Longitude 83°57'49.80"E) out of the total 494km in Odisha was studied, along with Luna river from Tentol to Baladia village. It was observed that the stretch has good traffic potential and scope for tourism despite the need for technical interventions like need for dredging, bank protection, channel demarcation, etc. It was noted during the feasibility study that approximately 78km of Mahanadi from Sambalpur to Sonepur is found to be rocky and navigation in this stretch is not possible.

Hence for the DPR preparation, up to 99.5 km of the river stretch from Paradip sea mouth to the downstream of Cuttack barrage was considered incorporating a bypass route via river Luna.

Figure 1.1: Stretch of the river considered for this project



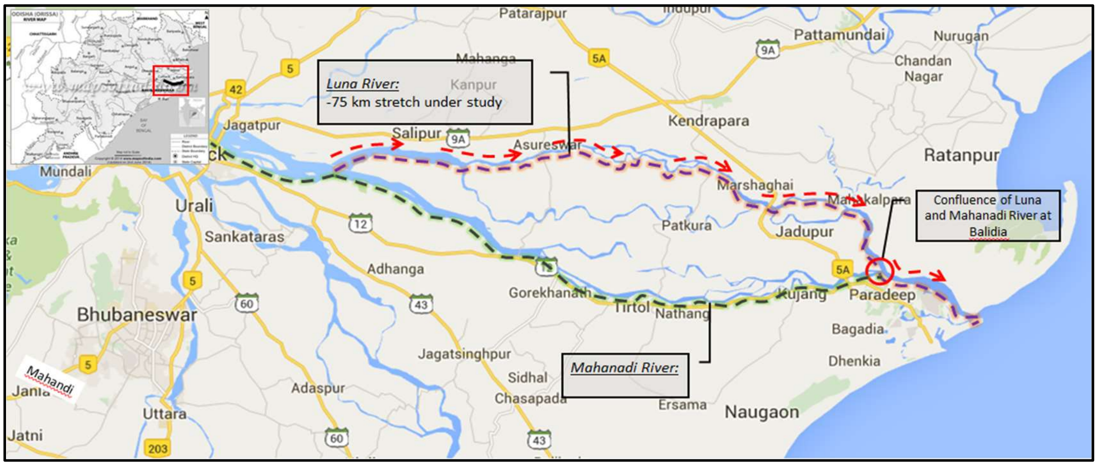
1.2. Project Location / Details of Study Area

Mahanadi river 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 Badagenguti. All the major branches and subbranches including Mahanadi falls into Bay of Bengal except Daya & Bhargavi which fall into Chilika Lake.The river, from Jobra Barrage at Latitude 20°29'16.60"N, Longitude 85°54'18.17"E to Paradip at Latitude 20°19'38.12"N, Longitude 86°40'16.96"E, of the total of 98 km in Orrisa has been earmarked for the detailed project report as shown in the following figure.

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.

Figure 1.2: Map showing stretch of river considered with routes marked via Luna and Mahanadi



During the survey conducted in February 2016, 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 about43km. 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.

1.3. Brief Scope of Work and Compliance statement

In Stage II, it is expected to conduct detailed hydrographic/ topographic/ traffic surveys and arrive at suitable terminal locations. The activities to be carried out under Stage II to ascertain the potential of proposed waterway includes:

- Hydrographic survey & hydro-morphological survey
- Traffic survey & techno economic feasibility
- Preparation of DPR

The detailed hydrographic survey is to be carried out in WGS’84 datum and the horizontal control is to be made using DGPS with minimum 24 hours’ observations. The vertical control is to be established w.r.t. the chart datum/ sounding datum. The following standards are to be used:

- RCC Benchmark pillars to be constructed at every 10km interval with its location and details clearly noted in the DPR.
- Water level gauges are to be erected and are to be connected to the nearest BM by levelling. The readings are to be taken at 1-hour interval for 12 hours or for the entire period of survey. At least 2 gauges are read simultaneously.
- Bathymetric and topographic survey of minimum 100m wide corridor is to be surveyed.
- Cross-section sounding lines/ levelling are to be run from bank to bank at spacing of 200m.
- The soundings are to be reduced to the CD/ SD established at every gauge station.
- The current velocity and discharge at an interval of 10km shall be observed once in a day during the survey period. The TOR specifications are to be strictly adhered.
- Water and bottom samples are to be collected from the deepest route at every 10km interval and are to be tested and results enclosed in the DPR. The tests to ascertain the following parameters are to be conducted:
  - ✓ Grain size distribution
  - ✓ Specific gravity
  - ✓ pH value
  - ✓ Cu, Cc
  - ✓ Clay silt %
  - ✓ Sediment concentration for water samples
- The topographical features to be collected and enclosed in DPR includes:
  - ✓ Photographs of prominent features
  - ✓ Permanent structures along the corridor
  - ✓ Details of cross structures and other prominent shore features
  - ✓ Details about availability of location for terminal infrastructure

- ✓ Details about the requirement of bank protection, land availability, usage pattern along the stretch
- ✓ Approach details and charts

- Norms for preparing survey charts

In traffic survey and techno economic feasibility, it is expected to make a forecast of the traffic prospects to facilitate the projection of the most promising route. Modality of conducting traffic survey shall be based on industrial surveys and a traffic projection for a horizon period (say 5, 10, 15 and 20 years) must be forecasted along with the divertible traffic to waterway.

The scope of work in DPR preparation is as follows:

- Assessment of morphological, hydrological, hydrographical conditions and operation and maintenance requirements of the proposed waterways.
- Geo-tech investigation as per guidelines of Geological Survey of India.
- Preliminary engineering designs, drawings, estimates, for the waterway system in an EPC mode.
- River training and bank protection works anticipated.
- Preparation of construction schedule with phasing of expenditure.
- Cost estimate for different alternatives shall be considered and FIRR, EIRR, NPV and SWOT analysis are to be carried out.
- EIA study and suggesting EMP.
- Suggestions for VC and HC to be provided for crossing structures.

Compliance statement is as follows:

- Hydrographic survey conducted, and report submitted to IWAI for approval.
- Geotechnical investigation undertaken, and report attached as Volume IV.
- Preliminary engineering designs, drawings, estimate are attached as chapter 6, Vol. II and Annexure II respectively.
- River training and bank protection works proposed in chapter 3 and 6 and details marked in drawings attached as Vol. II.

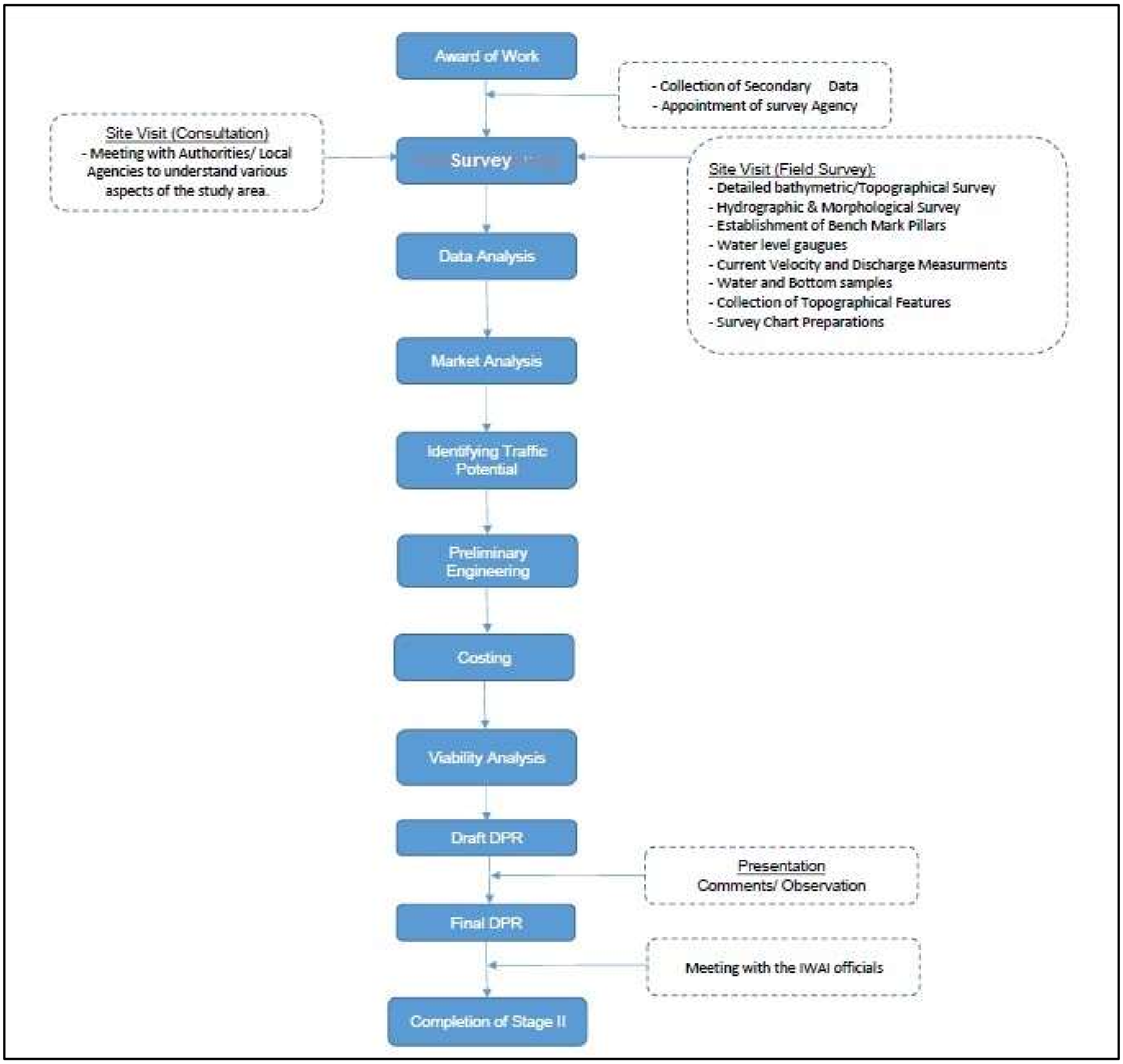
- Cost estimate and financial modelling done.
- EIA study conducted.
- Suggestions for VC and HC to be provided for crossing structures given in chapter 3.

1.4. Brief Methodology & Approach

To successfully deliver the project requirements, the Consultant has prepared a stepwise delivery model. Stage – II of the delivery is divided into five critical steps. The steps involved in StageII of the proposed methodology for the assignment is as follows:

- Step 1 - Acceptance of Final Feasibility and Stretches for DPR
- Step 2 - Hydrographic and Hydro-morphological surveys, Bathymetric and Topographic surveys, Geotech Survey, Discharge Measurement and Survey Charts and Reports
- Step 3 - Analysis of Survey Charts, Traffic, Infrastructure Planning, Design, EMP, CAPEX and Draft DPR
- Step 4 - Comments on Draft DPR by IWAI
- Step 5 - Final DPR

Figure 1.3 The flow chart of the steps to be followed



Survey: With the award of the work, the tentative temporal targets were fixed. All the available secondary data was collected, and sophisticated survey agencies were identified and consulted. The requirements and expected outputs were made clear to the agency. The local authorities and public and private agencies in and around the locality were consulted to gather information relating to various aspects of the study area. The hydrographic survey was carried out in WGS-84 datum and tide data was observed at 10km interval. The projection used was Transverse Mercator and the grid used was

Universe Transverse Mercator Grid (Zone 45). Differential signal corrections for the DGPS system were automatically obtained from the nearest DGLL Beacon at Paradip Port. HYPACK Ver.2012 was used for sounding data processing. The benchmark and sounding datum was established as per the TOR specifications. The traffic study was conducted considering the Paradip and Cuttack industrial clusters and the market potential in the area was studied. After thorough desk studies and discussions, required tables and charts of the survey outputs were finalized.

Data/ Market Analysis: From the output of the studies conducted, a picture of the requirement of facilities, the amount of developmental activities to be provided, locations of the infrastructures, etc., were obtained. The traffic survey gave an idea about the commodity movements and their potential route. This led to finalizing the number and extend of terminals required. The hydrographic survey helped in arriving at the Class of waterway to which the proposed stretch is to be developed and the type of terminals needed. Each element of the proposed project was thus arrived at based on one of the or a combination of the data obtained.

Identifying Traffic Potential: The cargo/ passenger in the area was accessed to confirm that the developmental work is justified. The long-term opportunities of the area and divertible traffic to waterways were considered.

Preliminary Engineering: Based on the requirements, the preliminary dimensions and structural arrangements were arrived at.

Costing: Estimate of structural components, waterway development, environmental management plans, etc., were considered for costing.

Viability Analysis: The weakness and opportunities of each option was considered and compared.

DPR: A draft copy is now being submitted. Upon receiving comments from IWAI, the final report shall be submitted.

2. WATERWAY / DETAILED HYDROGRAPHIC SURVEY

2.1. Hydrographic Survey

2.1.1. Waterway in General and Hydro-morphological Characteristics

The survey was carried out from 08th Mar 2017 to 27th Mar 2017. The river Mahanadi is one of the major rivers of Odisha. It is the sixth largest river in India and having various tributaries. The biggest of the tributaries is Kathajodi river and it originates from north of Cuttack city at Naraj. It has a historical connection. It originates from the Maipal range in Chhatisgarh popularly known as the Amarkantak plateau. Then it enters the north west of modern Odisha in the Sambalpur district near Padigan, a little above Hirakud. At Hirakud the longest dam in the world has been built across the river. It is a Hydro Electric project and one of the major contributors of Electricity to the state of Odisha. Survey of 98 kmof waterway from Paradip sea mouth towards inland which is near to south of Jobra barrage at Cuttack was carried out. On conduct of Bathymetric survey from Paradip, it was found that the tidal area is up to 43km north. The maximum area (nil tide area) of river Mahanadi is dried due to lean season. On field observation, it was found that the discharge of water from JobraAnikut flows through the river Luna which is the tributary of Mahanadi.

Figure 2.1: Considered stretch of river

The riverbed of Stretches is mainly sandy in nature. No prominent Dams and Barrages are present in the survey stretches. Fishing is an active profession in this river.

2.1.2. Existing Hydrological / Topographical Reference levels

For topographic survey, horizontal control was carried out from Newly established IWAI Benchmark in NW-64 along the river coast from Paradip (BM 1) to Cuttack (BM 11). The Benchmarks are fixed by 25hrs observation and Real Time Kinematic with 01 PPU method.

Table 2-1: Benchmark details

BM No.	Location	Chainage (km)	Latitude (N)	Longitude (E)	Easting (m)	Northing (m)	BM Height above MSL(m)	BM Height above SD(m)
BM1	Musadia	1.8	20°19'24.4261"N	086°39'12.7889"E	463834.21	2247313.11	3.464	5.124
BM2	Madhusudanpur	9.9	20°21'52.6457"N	086°35'24.1504"E	457215.56	2251884.68	1.953	3.202
BM3	Benupal	20.0	20°24'58.8566"N	086°32'16.3721"E	451787.92	2257623.41	3.352	4.151
BM4	Godhan	30.3	20°25'51.9443"N	086°27'36.0448"E	443669.21	2259280.18	5.154	5.474
BM5	In front of Hanuman Temple Talagaon,	40.1	20°26'51.4355"N	086°22'50.6412"E	435405.62	2261138.26	10.124	7.886
BM6	Inside of Balisahi UP school campus	49.8	20°27'25.9032"N	086°19'00.6692"E	428746.50	2262224.33	9.115	5.895
BM7	Kulabada Temple	60.8	20°27'25.0156"N	086°13'17.6400"E	418807.45	2262241.35	11.470	4.598
BM8	Kalanapur	71	20°27'52.1766"N	086°07'57.7738"E	409543.90	2263122.89	15.610	5.349
BM9	Bisurapur	80	20°27'50.4517"N	086°03'14.9821"E	401350.10	2263115.19	16.781	3.533
BM10	Jamalpur to Andeisahi road side, inside a horticulture farm	91.3	20°27'54.9474"N	085°58'45.5386"E	393544.07	2263300.25	21.674	4.675
BM11	Near the Cuttack Mahanadi Bridge	98.2	20°29'27.6083"N	085°55'08.0879"E	387262.37	2266189.49	25.267	5.977

Table 2-2: Details of erected tide gauges

Tide Gauge no.	Location	Chainage (km)	Easting	Northing	Zero of Tide Gauge w.r.t. BM (m)	Sounding datum w.r.t. MSL (m)	Period of observation
TP 1	Musadia	1.8	463901.15	2247593.4	4.490	-1.660	06:00 HRS TO 18:00 HRS
TP 2	Madhusudanpur	9.9	457328.98	2251902.47	2.920	-1.249	06:00 HRS TO 18:00 HRS
TP 3	Benupal	20	451791.94	2257530.9	4.050	-0.799	06:00 HRS TO 18:00 HRS
TP 4	Godhan	30.3	443497.41	2259220.12	5.557	-0.320	06:00 HRS TO 18:00 HRS
TP 5	In front of Hanuman Temple Talagaon, Kalapatna	40.1	435478.87	2261174.43	9.373	2.238	06:00 HRS TO 18:00 HRS
TP 6	In front of Gualigaon temple	49.8	428977.46	2262349.92	6.625	3.220	06:00 HRS TO 18:00 HRS
TP 7	Kulabada Temple	60.8	418690.5	2262091.4	6.374	6.872	06:00 HRS TO 18:00 HRS
TP 8	Kalanapur	71	409671.07	2262869.72	6.612	10.261	06:00 HRS TO 18:00 HRS
TP 9	Bisurapur	80	401517.39	2262989.72	5.587	13.248	06:00 HRS TO 18:00 HRS
TP 10	Jamalpur	91.3	393194.65	2263109.49	5.832	16.999	06:00 HRS TO 18:00 HRS
TP 11	Near the Cuttack Mahanadi Bridge	98.2	387255.43	2266167.4	8.490	19.290	06:00 HRS TO 18:00 HRS

2.2. Chart Datum / Sounding Datum

As per Scope of work, BM Pillars and Tide gauges were erected at every 10km distance and levelled w.r.t. MSL. Sounding Datum at tide gauges was transferred from Naraj specified by IWAI in non-tidal zone and in tidal zone area from Mahanadi river mouth to

Marsaghai (40Km), Sounding datum has been established by Transfer of sounding datum methodology specified in AMHS.

Table 2-3 Chart datum/ Sounding datum and reductions details

BM	LOCATION	Chainage (km)	CD wrt MSL(m)	CD wrt BM(m)	Reduction(m)
BM1	Musadia	1.8	-1.660	5.124	0.634
BM2	Madhusudanpur	9.9	-1.249	3.202	0.282
BM3	Benupal	20	-0.799	4.151	0.101
BM4	Godhan	30.3	-0.320	5.474	-0.083
BM5	In front of Hanuman Temple Talagaon, Kalapatna	40.1	2.238	7.886	-1.487
BM6	Inside of Balisahi UP school campus	49.8	3.220	5.895	-0.73
BM7	Kulabada Temple	60.8	6.872	4.598	-1.776
BM8	Kalanapur	71	10.261	5.349	-1.263
BM9	Bisurapur	80	13.248	3.533	-2.054
BM10	Jamalpur to Andeisahi road side, inside a horticulture firm	91.3	16.999	4.675	-1.157
BM11	Near the Cuttack Mahanadi Bridge	98.2	19.290	5.977	-2.513

Table 2-4: Transfer of sounding datum (TP2)

Transfer of Sounding datum (Paradip – TP2)									
Established Gauge					New Gauge				
Heights above art datum					Heights above zero of tide pole				
High Water	**Low water**	**Factor**	**HW**	**LW**	**High Water**	**Low water**	**Factor**	**HW**	**LW**
	0.9	1		0.9		0.52	1		0.52
2.05		1	2.05		1.76		1	1.76	
	0.88	3		2.64		0.5	3		1.5
2.32		2	4.64		1.73		2	3.46	
	0.84	3		2.52		0.51	3		1.53
2.15		1	2.15		1.76		1	1.76	
	0.78	1		0.78		0.47	1		0.47
Sum			8.84	6.84				6.98	4.02
MEAN			2.2	0.9				1.7	0.5
Range Observed Mean Tide		**R**	1.36				**r**	1.24	
		M'	1.53				**m'**	1.12	
Formula 1	Where MHWS and MLWS at established gauge are known								
	MHWS	**0**		**M**	0		1.12		
	MLWS	**0**		**d**	0	-0.4	1.5325		
							0		
Value of Sounding datum				**0.000**		**Above zero of tide pole**			
Formula 2	**Where "True mean tide level at springs" at established pole is not known**								
d			-0.2815						
Value of Sounding datum			**-0.282**		**Below zero of tide pole**				

Table 2-5: Transfer of sounding datum (TP2-TP3)

Transfer of Sounding datum (TP2 – TP 3)									
Established Gauge					**New Gauge**				
Heights above art datum					**Heights above zero of tide pole**				
High Water	**Low water**	**Factor**	**HW**	**LW**	**High Water**	**Low water**	**Factor**	**HW**	**LW**
	0.85	1		0.85		0.52	1		0.52
2.14		1	2.14		1.76		1	1.76	
	0.78	3		2.34		0.5	3		1.5
2.42		2	4.84		1.73		2	3.46	
	0.73	3		2.19		0.51	3		1.53
2.27		1	2.27		1.76		1	1.76	
	0.67	1		0.67		0.47	1		0.47
Sum			9.25	6.05				6.98	4.02
MEAN			2.3	0.8				1.7	0.5
Range		**R**	1.56				**r**	1.24	
Observed Mean Tide		**M'**	1.53				**m'**	1.12	
Formula 1	Where MHWS and MLWS at established gauge are known								
	MHWS	**0**		**M**	0		1.12		
	MLWS	**0**		**d**	0	-0.4	1.534375		
							0		
Value of Sounding datum				**0.000**		**Above zero of tide pole**			
Formula 2	**Where "True mean tide level at springs" at established pole is not known**								
d			-0.1013						
Value of Sounding datum			**-0.101**		**Below zero of tide pole**				

Table 2-6: Transfer of sounding datum (TP3-TP4)

Transfer of Sounding datum (TP3 – TP 4)									
Established Gauge					**New Gauge**				
Heights above art datum					**Heights above zero of tide pole**				
High Water	**Low water**	**Factor**	**HW**	**LW**	**High Water**	**Low water**	**Factor**	**HW**	**LW**
	0.66	1		0.66		0.52	1		0.52
2.3		1	2.3		1.76		1	1.76	
	0.64	3		1.92		0.5	3		1.5
2.5		2	5		1.73		2	3.46	
	0.57	3		1.71		0.51	3		1.53
2.38		1	2.38		1.76		1	1.76	
	0.6	1		0.6		0.47	1		0.47
Sum			9.68	4.89				6.98	4.02
MEAN			2.4	0.6				1.7	0.5
Range Observed Mean Tide		**R**	1.81				**r**	1.24	
		M'	1.52				**m'**	1.12	
Formula 1	Where MHWS and MLWS at established gauge are known								
	MHWS	**0**		**M**	0		1.12		
	MLWS	**0**		**d**	0	-0.4	1.515625		
							0		
Value of Sounding datum				**0.000**	**Above zero of tide pole**				
Formula 2	**Where "True mean tide level at springs" at established pole is not known**								
		d	0.0826						
Value of Sounding datum				**0.083**		**Above zero of tide pole**			

Table 2-7: Transfer of sounding Datum (TP4- TP5)

Transfer of Sounding datum (TP4 – TP 5)									
Established Gauge					**New Gauge**				
Heights above art datum					**Heights above zero of tide pole**				
High Water	**Low water**	**Factor**	**HW**	**LW**	**High Water**	**Low water**	**Factor**	**HW**	**LW**
	0.66	1		0.66		1.49	1		1.49
2.3		1	2.3		1.5		1	1.5	
	0.64	3		1.92		1.49	3		4.47
2.5		2	5		1.5		2	3	
	0.57	3		1.71		1.49	3		4.47
2.38		1	2.38		1.5		1	1.5	
	0.6	1		0.6		1.49	1		1.49
Sum			9.68	4.89				6	11.92
MEAN			2.4	0.6				1.5	1.5
Range Observed Mean Tide		**R**	1.81				**r**	0.01	
		M'	1.52				**m'**	1.50	
Formula 1	**Where MHWS and MLWS at established gauge are known**								
	MHWS	**0**		**M**	0		1.50		
	MLWS	**0**		**d**	0	0.0	1.515625		
							0		
Value of Sounding datum				**0.000**		**Above zero of tide pole**			
Formula 2	Where "True mean tide level at springs" at established pole is not known								
d			1.4866						
Value of Sounding datum				**1.487**	**Above zero of tide pole**				

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Table 2-8: Tidal variation with chainage

Tide pole #	Chainage (km)	Tidal variation (m)
1	1.8	2.3
2	9.9	2
3	20	1.8
4	30.3	1.2
5	40.1	1

2.3. Existing Cross Structures

2.3.1. Bridges

The details of the crossing bridges are given in the table below.

Table 2-9: Existing Bridges crossing the waterway

Sl no	Structure	CH (Km)	Location	Latitude	Longitude	Easting (m)	Northing (m)	Hz cl (m)	Present condition	Vertical Clearance from MHWS / HFL(m)
1	Road bridge UNC	25.13	Marsaghai	20°24’27.576”N	86° 29’ 39.4932” E	447281.18	2256689.41	**30**	UNC	-
2	Road Bridge(haladiagada Bridge)	25.4	Marsaghai	20°24’31.79N	86° 29’ 33.31” E	447077.35	2256841.58	45	In Use	5.9
3	Road Bridge(haladiagada Bridge)	25.45	Marsaghai	20°24’32.53”N	86° 29’ 32.2108” E	447051.30	2256853.	45	In Use	5.9
4	Road Bridge(K	34.38	Mehindinagar	20° 27’ 8.397”N	86° 25’ 22.3486” E	440133.91	2261416.87	25	In Use	4.1

Sl no	Structure	CH (Km)	Location	Latitude	Longitude	Easting (m)	Northing (m)	Hz cl (m)	Present condition	Vertical Clearance from MHWS / HFL(m)
	alapada bridge)									
5	Road Bridge(jaisipur bridge)	43.8	Karilopatna	20° 27' 42.0619"N	86° 21' 31.013" E	433093.96	2262673.60	35	In Use	3.4
6	Road Bridge	52.7	Artamul	20 ° 28'17.914"N	86° 17' 42.9545" E	426472.00	2263809.00	30	In Use	4.2
7	Road Bridge(Asureswar bridge)	57.7	Koilirangi	20° 27' 41.7185"N	86° 14' 59.3415" E	421704.29	2262839.08	40	In Use	2.9
8	Road Bridge(Barapada bridge)	65.8	Jamunanagar	20°27'6.82"N	86°10'32.74"E	414026.76	2261705.32	35	In Use	2.0
9	Road Bridge(Sisua Bridge)	78.0	Murkundi	20° 27' 56.5145"N	86° 4' 27.5121" E	403433.49	2263245.28	20	In Use	4.6
After CH 98 Km										
10	Road Bridge	98.26	Jobra	20° 29' 23.0985"N	85° 55' 4.6925" E	387171.00	2266103.00	40	In Use	3.8
11	Road Bridge	98.30	Jobra	20° 29' 23.6398"N	85° 55 2.9811" E	387148.00	2266139.00	40	In Use	4.2
12	Road Bridge	98.33	Jobra	20°29'25.98"N	85°55'3.13"E	387118.00	2266140.00	45	In Use	4.2
13	Rly Bridge	98.65	Jobra	20° 29' 27.543"5N	85° 54' 51.3574" E	386815.00	2266315.00	50	In Use	4.3
14	Rly Bridge	98.7	Jobra	20° 29' 28.0388"N	85 ° 54' 49.9428" E	386788.00	2266344.00	25	In Use	4.2
15	Jobra Barrage	99.30	Jobra	20°29'11.16"N	85°54'15.62"E	385739.01 m E	2265694.45 m N	-	In Use	-

2.3.2. Electric Lines / Communication Lines

Table 2-10: Details of existing crossing cables

Sl no.	Structure	Chainage (Km)	Easting (m)	Northing (m)	Location	V Cl(m)	Clearance from HFL(m)
1	HTL	21.0	20° 24'50.2002" N	86° 31' 44.8211" E	Badakula	15	12.612
2	EL CABLE	20.8	20°24'50.55"N	86°31'53.25"E	Badakula	5	2.1
3	HTL	25.2	20° 24'29.0481" N	86° 29' 37.1884 "E	Marshaghai	15	11.254
4	HTL	25.8	20°24'31.58"N	86°29'36.82"E	Marshaghai	15	11.254
5	El Cable	35.6	20°26'59.89"N	86°24'55.17"E	Karandia patna	5	2.2
6	El Cable	36.5	20°26'54.68"N	86°24'32.12"E	Jamapara	6	3.2
7	El Cable	44.6	20° 27' 21.4987"N	86° 21' 12.981" E	Jateswar village	4	1.1
8	El Cable	46.78	20°27'35.42"N	86°20'27.53"E	Jalaoka	4	1.1
9	El Cable	48.13	20°27'12.73"N	86°19'55.76"E	Hurasahi	5	2.2
10	El Cable	49.83	20°27'34.06"N	86°19'6.75"E	Balisahi	4	1.2
11	El Cable	53.5	20°28'9.80"N	86°17'16.93"E	Girigolasasan	5	2.1
12	El Cable	53.53	20°28'9.37"N	86°17'16.45"E	Girigolasasan	6	3.2
13	HTL	65.77	20°27'7.08"N	86°10'33.41"E	Barapada	10	8.36
14	HTL	66.27	20°27'9.40"N	86°10'15.97"E	Barapada	15	12.2

2.3.3. Pipelines / Cables

Sl No	Chainage (Km)	Description	Position		Remark
01	Chitrotpala Syphon cum bridge	78.0	20°27'55.07"N 86° 4'26.86"E	403433.49 m E 2263245.28 m N	Major Irrigation Project Mahanadi Delta
02	Barapada Syphon	65.8	20°27'6.82"N 86°10'32.74"E	414026.76 m E 2261705.32 m N	Major Irrigation Project Mahanadi Delta
03	51.12	Stone wall (Broken Barrage)	20°27'51.31"N 86°18'26.98"E	427773.70 m E 2263009.49 m N	Near Mundalo

2.3.4. Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

There are no Dams, Barrages, weirs, Anicut found in this zone of River. The details of Aqueducts are given

Sl no.	Structure	Chainage(Km)	Latitude Longitude	Easting (m) Northing (m)	Location
1	Pump House	34.46	20°27'10.21"N 86°25'31.68"E	440073.77 m E 2261698.43 m N	Mehendinagar
2	Barapada Syphon	65.8	20°27'6.82"N 86°10'32.74"E	414026.76 m E 2261705.32 m N	Major Irrigation Project Mahanadi Delta
3	Chitrotpala Syphon cum bridge	78.0	20°27'55.07"N 86° 4'26.86"E	403433.49 m E 2263245.28 m N	Major Irrigation Project Mahanadi Delta

2.4. Bends

2.4.1. Radius of Curvatures

In the hydrographic survey, it is stated that average bend radius of river Mahanadi has been observed 900m.

2.5. Velocity and Discharge Details

Table 2-11: Current Meter Observations

Current Meter Observation in Mahanadi via Luna river												
Sl No.	Date	Chainage	Location	Easting	Northing	Lat	Long	Depth	Velocity (m/s)			Discharge cu.m/sec
									0.5d	0.3d	d	
1	08.03.2017	0.0	Musadia	465729.06	2247805.22	20° 19’ 40.5608” N	086° 40’ 18.1001” E	4.8	1.99	1.93	1.9	254.14
2	09.03.2017	10.0	Madhusudanpur	457334.17	2252042.46	20 °21’ 57.7879 “N	086° 35’ 28.2284” E	8.2	1.89	1.83	1.8	2046.08
3	10.03.2017	20.0	Benupal	451825.39	2257470.3	20° 24’ 53.8795 ” N	086°32’ 17.6799” E	4.3	1.03	0.98	0.9	178.48
4	11.03.2017	30.0	Bara Tunga	443518.33	2258834.98	20° 25 37.4461 ”N	086° 27 30.8889 “E	2.8	0.92	0.83	0.8	163.2
5	17.03.2017	40.0	Talagan	435489.3	2261157.93	20° 26’ 52.0857 ” N	086° 22’ 53.5265” E	3.2	0.62	0.6	0.6	18.199
6	17.03.2017	50.0	Alisahi	428759.18	2262591.63	20° 27’ 37.8525 ” N	086° 19’ 1.0539” E	2.2	0.72	0.68	0.6	19.4
7	16.03.2017	60.0	Sahadebpur	419486.52	2262030.76	20° 27’ 18.2701 ” N	086° 13’ 41.1107 “E	2	0.53	0.51	0.5	12.319
8	16.03.2017	70.0	Ampatipatana	410609.32	2262852.58	20° 27’ 43.5667 ” N	086° 08’ 34.594” E	1.1	0.63	0.61	0.6	2.146
9	15.03.2017	80.0	Tentol	401561.57	2262966.08	20° 27’ 45.6415 ” N	086° 03’ 22.31” E	0.7	0.64	0.62	0.6	13.02
10	14.03.2017	90.0	Pasimakaha	394436.95	2262344.5	20° 27’ 24.0415 ” N	085° 59’ 16.5577” E	1.3	0.72	0.63	0.6	2.6
11	14.03.2017	98.0	Near JobraAnikut	386589.9	2266461.53	20° 29’ 36.3112 ” N	085° 54’ 44.8137” E	2.4	0.63	0.62	0.6	508.74

Waterway description (stretch-wise of 10 km)

2.5.1. Stretch I

Stretch 1 starts from Musadia, where IFFCO plant is on left bank. There is a proposal for developing a pontoon jetty for IFFCO plant. BM 1 is at ch 0.000. End of stretch is at ch 10.000 near Srirampur village. BM 2 is at ch10.000. Riverbank is cultivated area. Near Musadia village there is a ferry halt station for small fishing boats and ferries.

Figure 2.2: Google image of the stretch

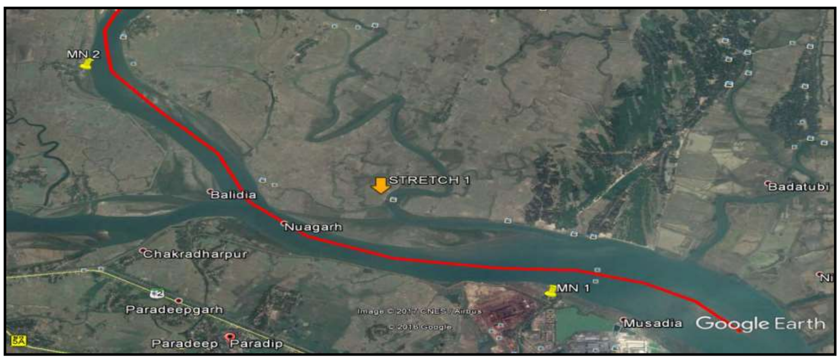


Table 2-12: Minimum and maximum available depth

Range (from – to) Km	Min. Observed Depth(m)	Max. Observed depth(m)
0 to 1	5.6	11.9
1 to 2	6.2	8.3
2 to 3	9.2	11.8
3 to 4	8.9	13.4
4 to 5	8.5	12.9
5 to 6	8.8	13.0
6 to 7	4.9	8.9
7 to 8	7.0	10.4
8 to 9	7.0	11.5
9 to 10	7.2	12.5

Table 2-13: Features along the stretch

p) Prominent Dams / Barrage:No Dam and Barrage in this stretch
q) Tidal stretch: full stretch is tidal stretch
r) Conditions of banks (protected, un-protected): Partially Protected
s) Hindrances: Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues.
t) Encroachment to the waterway: Nil
u) Obstruction (if any) for navigation, e.g. fishing stakes: Nil
v) NH/SH/MDR along and/or within 5 km from the waterways: Paradip – Kalinga Nagar – Daitari Express highway, NH-5A is situated 2 Km far from river bank.
w) Railway Line and Stations in the vicinity: Cuttack – Paradip Rail is 7 Km far from the river.
x) Land Use Pattern along Waterway on visual assessment: Industrial use
y) Crops / Agriculture in the region on visual assessment: Rice cultivation IFFCO, ESSAR etc companies.
z) Availability of Bulk / Construction Material: Nil
aa) Existing Industries along Waterway with their types and details:IFFCO fertiliser, ESSAR, Paradip Phosphate Ltd, Paradip Oil Refinery and other supportive industries are situated near river bank.
bb) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Paradip port – 2Km, Fishing Jetty – 1 Km and small ferry Ghats are in operation in this stretch.
cc) Existing Cargo Movement: Nil.
dd) Prominent City / Town / Places of Worship / Historical places for Tourism: Paradip Town.

SHOAL AND DREDGING INFORMATION TABLE STRETCH- I.

STRETCH - I (0 TO 10)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	0	10	3.2	12.5	0	0
II	0	10	3.1	12.5	0	0
III	0	10	3.1	12.5	0	0
IV	0	10	3.1	12.5	0	0
V	0	10	2.5	12.5	0	0
VI	0	10	2.5	12.5	0	300.94
VII	0	10	2.5	12.5	0	509.02

2.5.2. Stretch II

Stretch starts from ch 10.000 at Srirampur village and ends at Benupal village. BM 3 is at ch 20.000. Both banks are cultivated area.

Figure 2.3: Google image of the stretch

Table 2-14: Minimum and Maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
10 to 11	7.9	10.9
11 to 12	1.5	9.3
12 to 13	1.6	2.7
13 to 14	2.5	4.1
14 to 15	3.9	6.7
15 to 16	7.8	11.6
16 to 17	4.6	10.4
17 to 18	2.9	3.8
18 to 19	2.4	5.4
19 to 20	3.4	6.1

Table 2-15: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: Full stretch is tidal stretch
c) Conditions of banks (protected, un-protected): Partially protected
d) Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes.: Nil
e) Encroachment to the waterway: Nil
f) NH/SH/MDR along and/or within 5 km from the waterways: NH5A 7Km far from riverbank. (Paradip - Kaling Nagar – Daitari)
g) Railway Line and Stations in the vicinity: Nil

h) Land Use Pattern along Waterway on visual assessment: Nil
i) Crops / Agriculture in the region on visual assessment: Rice cultivation
j) Availability of Bulk / Construction Material: Nil
k) Existing Industries along Waterway with their types and details:Nil
l) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Small ferry ghats are in use in this stretch.
m) Existing Cargo Movement: Nil
n) Prominent City / Town / Places of Worship / Historical places for Tourism: Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-II.

STRETCH- 2 (10 TO 20)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M³)**
I	10	20	0	10.9	2200	103391.79
II	10	20	0	11	2400	160817.61
III	10	20	0	11	2750	253629.18
IV	10	20	0	11	2750	319385.91
V	10	20	0	11	4,000	512619.3
VI	10	20	0	11	5800	869442.4
VII	10	20	0	11	6200	1121003.54

2.5.3. Stretch – III

Stretch starts from ch 20.000 at Benupal where we have BM3 and ends at ch 30.000 at Bara Tunga, where BM4 is there on left bank. Both sides of river are cultivated area. At ch 25.130 Rly bridge is under construction and at ch 25.400 Haladiagada bridge is crossing the river. Kalapadamarshaghai road is going along right bank of the river. Few boats are also available for fishing near bridge.

Figure 2.4: Google image of the stretch

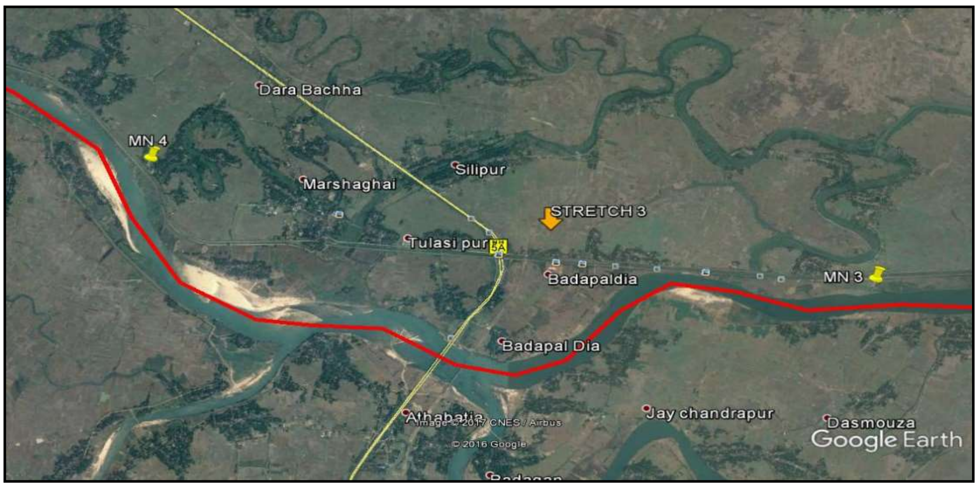


Table 2-16: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
20 to 21	2.6	9.6
21 to 22	3.4	8.5
22 to 23	3.4	12.1
23 to 24	2.6	8.1
24 to 25	1.1	3.5
25 to 26	2.9	9.2
26 to 27	1.7	9.1

27 to 28	0.8	4.3
28 to 29	2.4	7.4
29 to 30	1.4	5.7

Table 2-17: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: full stretch is tidal stretch
c) Conditions of banks (protected, un-protected): Stretch is partially protected
d) Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
e) Encroachment to the waterway: Nil
f) NH/SH/MDR along and/or within 5 km from the waterways: NH 5 A is crossing the river near Marsaghai..
g) Railway Line and Stations in the vicinity: Railway Bridge under construction near Marsaghai
h) Land Use Pattern along Waterway on visual assessment: Nil
i) Crops / Agriculture in the region on visual assessment: Rice cultivation
j) Availability of Bulk / Construction Material: Nil
k) Existing Industries along Waterway with their types and details: Nil
l) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
m) Existing Cargo Movement: Nil
n) Prominent City / Town / Places of Worship / Historical places for Tourism: Kendrapara Town

SHOAL AND DREDGING INFORMATION TABLE STRETCH-III.

STRETCH - 3(20 TO 30)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M³)
I	20	30	0	12.3	2000	119299.71
II	20	30	0	14.3	3050	190423.9
III	20	30	0	14.3	3660	312924.28
IV	20	30	0	14.3	3660	404175.54
V	20	30	0	14.3	8200	653029.96
VI	20	30	0	14.3	9200	1087049.23
VII	20	30	0	14.3	9800	1417473.48

2.5.4. Stretch IV

Stretch starts from Badatungaatch 30.000. Road bridge is there at ch 34.385 at mehindinagar. End of stretch is at ch 40.000 near Talagan. Both sides of the river are cultivated land.

Figure 2.5: Google image of the stretch

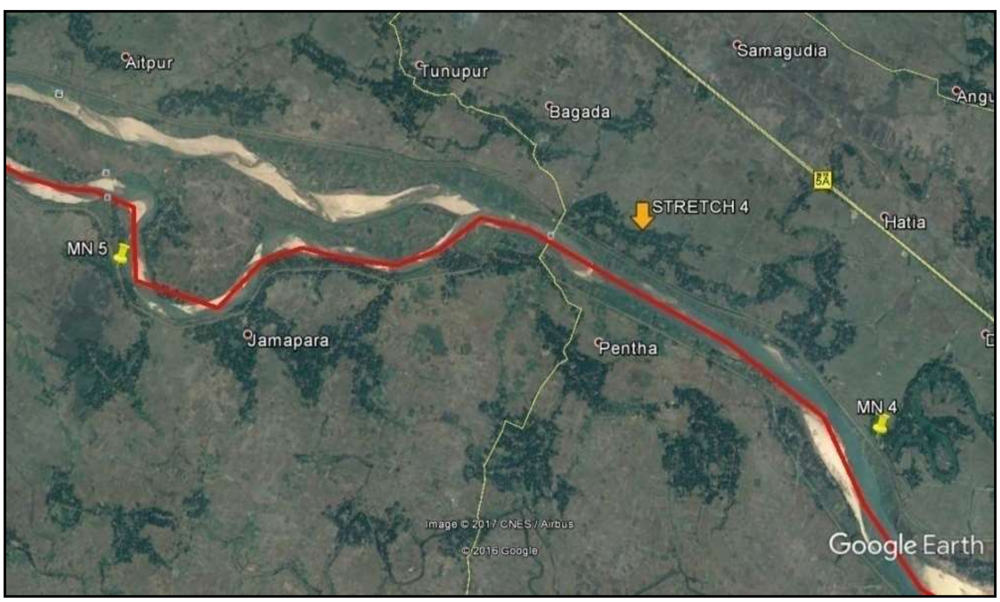


Table 2-18: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
30 to 31	0.8	4.5
31 to 32	0.8	2.3
32 to 33	0.8	3.1
33 to 34	1.3	2.9
34 to 35	0.8	3.0
35 to 36	0.8	2.5
36 to 37	0.9	2.6
37 to 38	0.8	2.9
38 to 39	0.9	2.2
39 to 40	0.8	3.1
40 to 41	0.8	4.5
41 to 42	1.0	6.2
42 to 43	0.8	3.1

Table 2-19: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: full stretch is tidal stretch
c) Conditions of banks (protected, un-protected): Partially Protected.
d) Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
e) Encroachment to the waterway: Nil
f) NH/SH/MDR along and/or within 5 km from the waterways: NH 5 A crossing the river.
g) Railway Line and Stations in the vicinity: Nil
h) Land Use Pattern along Waterway on visual assessment: Nil
i) Crops / Agriculture in the region on visual assessment: Rice cultivation
j) Availability of Bulk / Construction Material: Nil
k) Existing Industries along Waterway with their types and details: Nil
l) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Local ferry ghats.
m) Existing Cargo Movement: Nil
n) Prominent City / Town / Places of Worship / Historical places for Tourism: - Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-IV.

STRETCH- 4 (30 TO 43)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	30	43	0	6.8	10250	1010650.67
II	30	43	0	8.7	10400	1507936.92
III	30	43	0	8.7	10630	2208534.59
IV	30	43	0	8.7	10630	2539698.38
V	30	43	0	8.7	12000	4203614.28
VI	30	43	0	8.7	13,000	5466335.47
VII	30	43	0	8.7	13,000	6972749.69

2.5.5. Stretch V

Stretch starts from ch 40.000 at Talagan. Road bridge is at ch43.750 near Karilopatna village. There are too many bends of river in the stretch. Both the sides of the river are cultivated land. Stretch ends at ch 50.000 near Balisahi village. The tidal zone ends at ch 43.000.

Figure 2.6: Google image of the stretch

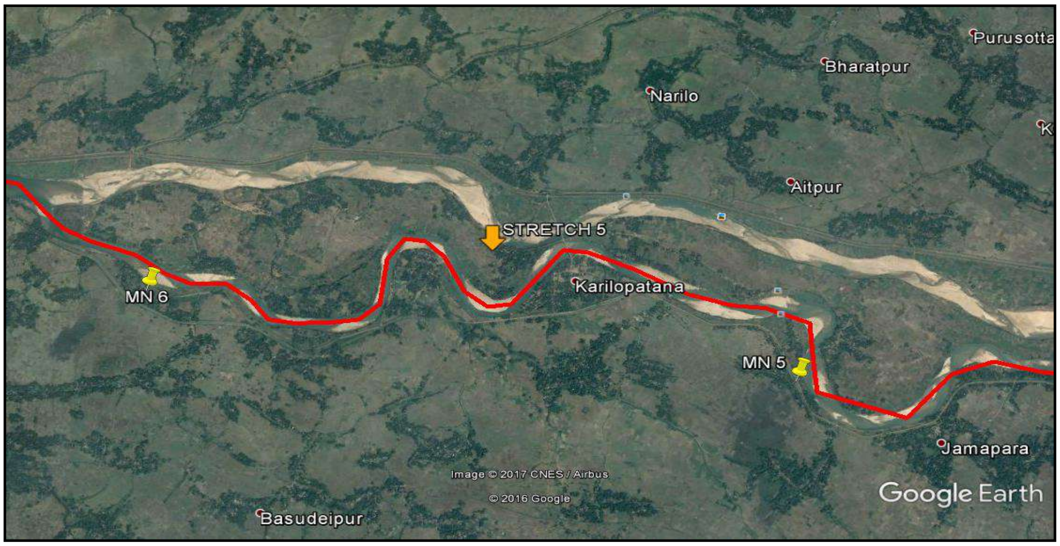


Table 2-20: Minimum and maximum available depth

Range (from – to KM)	Min. Observed Depth	Max. Observed depth
43 to 44	0.8	3.7
44 to 45	0.8	13.5
45 to 46	1.8	4.8
46 to 47	0.9	4.6
74 to 48	0.9	2.5
48 to 49	0.9	6.4
49 to 50	0.9	4.5

Table 2-21: Features along the stretch

a)	Prominent Dams / Barrage: No Dam and Barrage in this stretch
b)	Tidal stretch: Tidal effect ends at ch 43.000
c)	Conditions of banks (protected, un-protected): Full stretch is unprotected
d)	Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
e)	Encroachment to the waterway: Nil
f)	NH/SH/MDR along and/or within 5 km from the waterways: Nil
g)	Railway Line and Stations in the vicinity: Nil
h)	Land Use Pattern along Waterway on visual assessment: Nil
i)	Crops / Agriculture in the region on visual assessment: Rice cultivation
j)	Availability of Bulk / Construction Material: Nil
k)	Existing Industries along Waterway with their types and details: Nil
l)	Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
m)	Existing Cargo Movement: Nil
n)	Prominent City / Town / Places of Worship / Historical places for Tourism: Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-V.

10						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	43	50	0	8.7	5700	207715
II	43	50	0	14	5850	341680.2
III	43	50	0	14	5870	569392.38
IV	43	50	0	14	6405	704655.43
V	43	50	0	14	7,000	1307156.66
VI	43	50	0	14	7,000	1907466.26
VII	43	50	0	14	7,000	2573047.97

2.5.6. Stretch VI

Stretch is from Balusahi at ch 50.000 to Ch 60.000 at Damodarpur, where BM 7 is there. Koilirani road bridge is at Ch 57.710. Asureswardakabangala is at ch 57.000. It's a small tributary of Mahanadi with flow of water.

Figure 2.7: Google image of the stretch

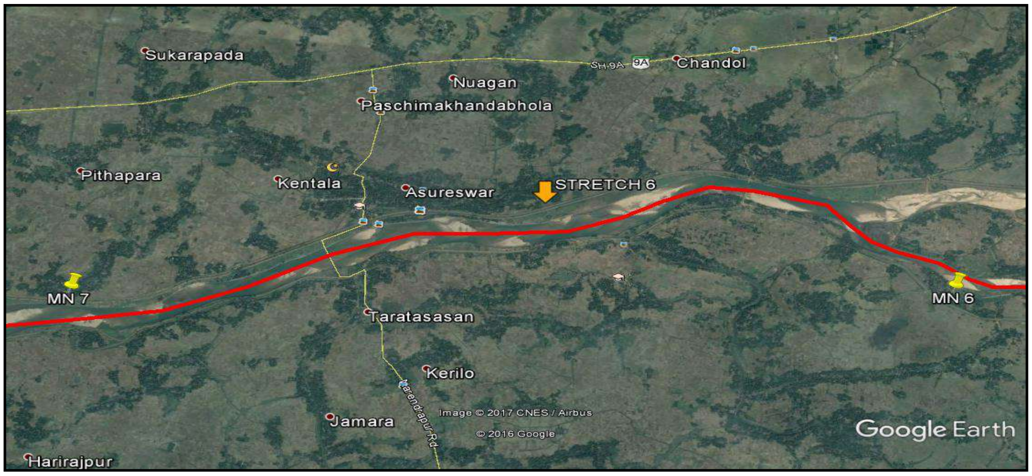


Table 2-22: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
50 to 51	0.8	2.4
51 to 52	0.8	10.4
52 to 53	0.8	6.2
53 to 54	0.8	1.6
54 to 55	0.8	2.1
55 to 56	0.8	2.8
56 to 57	0.8	1.7
57 to 58	0.8	2.9
58 to 59	1.6	2.9
59 to 60	0.9	3.6

Table 2-23: Features along the stretch

a)	Prominent Dams / Barrage: No Dam and Barrage in this stretch
b)	Tidal stretch: Full stretch is Non – tidal.
c)	Conditions of banks (protected, un-protected): Full stretch is unprotected
d)	Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
e)	Encroachment to the waterway: Nil
f)	NH/SH/MDR along and/or within 5 km from the waterways: Nil
g)	Railway Line and Stations in the vicinity: Nil
h)	Land Use Pattern along Waterway on visual assessment: Nil
i)	Crops / Agriculture in the region on visual assessment: Rice cultivation
j)	Availability of Bulk / Construction Material: Nil
k)	Existing Industries along Waterway with their types and details: Nil
l)	Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
m)	Existing Cargo Movement: Nil
n)	Prominent City / Town / Places of Worship / Historical places for Tourism: Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-VI

STRETCH- 6 (50 TO 60)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M³)**
I	50	60	0.5	11.3	6300	152840.6
II	50	60	0.5	11.3	6900	299717.95
III	50	60	0.5	11.3	7435	566852.34
IV	50	60	0.5	11.3	7435	738462.84
V	50	60	0.5	11.3	10000	1409495.19
VI	50	60	0.5	11.3	10000	2179002.62
VII	50	60	0.5	11.3	10000	2916573.49

2.5.7. Stretch VII

Stretch is from Dmodarpur to Khandagan. At ch 65.820 there is aroad bridge Near Jamuna Nagar. River becomes wider after the bridge Both the banks are cultivated area.

Figure 2.8: Google image of the stretch

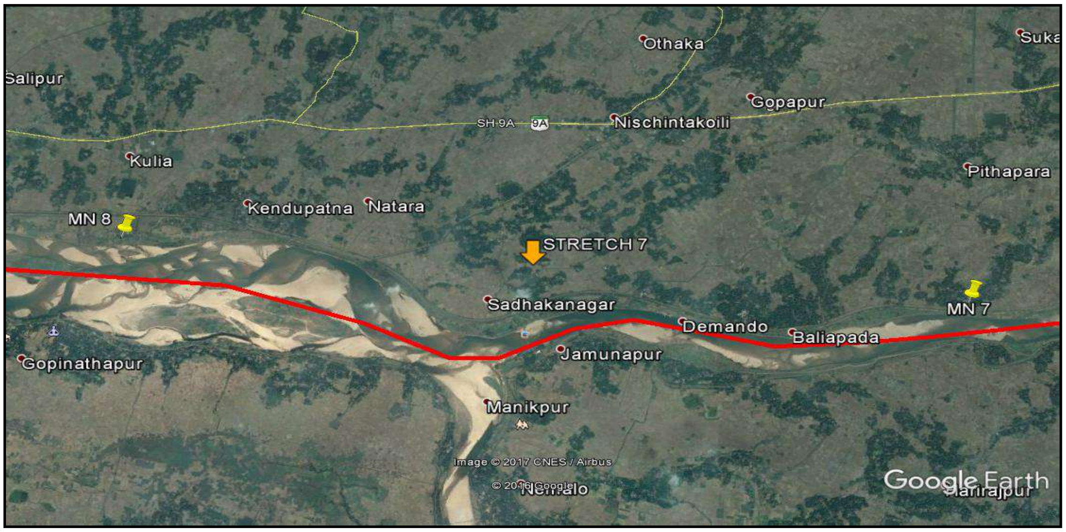


Table 2-24: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
60 to 61	0.8	3.0
61 to 62	0.8	2.5
62 to 63	0.8	2.6
63 to 64	1.0	3.1
64 to 65	1.2	4.4
65 to 66	0.8	1.9
66 to 67	0.8	2.3
67 to 68	0.8	1.3
68 to 69	0.9	2.7
69 to 70	0.8	3.4

Table 2-25: Features along the stretch

a)	Prominent Dams / Barrage: No Dam and Barrage in this stretch
b)	Tidal stretch: Full stretch is Non – tidal
c)	Conditions of banks (protected, un-protected): Full stretch is unprotected
d)	Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
e)	Encroachment to the waterway: Nil
f)	NH/SH/MDR along and/or within 5 km from the waterways: Nil.
g)	Railway Line and Stations in the vicinity: Nil
h)	Land Use Pattern along Waterway on visual assessment: Nil
i)	Crops / Agriculture in the region on visual assessment: Rice cultivation
j)	Availability of Bulk / Construction Material: Nil
k)	Existing Industries along Waterway with their types and details: Nil
l)	Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
m)	Existing Cargo Movement: Nil
n)	Prominent City / Town / Places of Worship / Historical places for Tourism: Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-VII

STRETCH – 7 (60 TO 70)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M^3)**
I	60	70	1.3	4.5	2700	58239.56
II	60	70	1.3	5.3	2700	156147.57
III	60	70	1.3	5.3	3200	370436.84
IV	60	70	1.3	5.3	3320	527899.85
V	60	70	1.3	5.3	9400	1118834.88
VI	60	70	1.3	5.3	10,000	1872804.72
VII	60	70	1.3	5.3	10,000	2559232.66

2.5.8. Stretch VIII

Stretch is from Khandagan to Tentol. Both sides are cultivated area. BM 9 is there at ch 80.000. There is a road bridge at ch 78.000.

Figure 2.9: Google image of the stretch

Table 2-26: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
70 to 71	0.8	2.3
71 to 72	0.8	1.9
72 to 73	0.8	1.3
73 to 74	0.8	1.7
74 to 75	0.8	1.8
75 to 76	0.8	2.7
76 to 77	0.8	2.2
77 to 78	0.8	2.0
78 to 79	0.8	4.5
79 to 80	0.8	11.5

Table 2-27: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: Full stretch is Non - tidal stretch
c) Conditions of banks (protected, un-protected): Full stretch is unprotected
d) Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
e) Encroachment to the waterway: Nil
f) NH/SH/MDR along and/or within 5 km from the waterways: Nil.
g) Railway Line and Stations in the vicinity: Nil
h) Land Use Pattern along Waterway on visual assessment: Nil
i) Crops / Agriculture in the region on visual assessment: Rice cultivation
j) Availability of Bulk / Construction Material: Nil
k) Existing Industries along Waterway with their types and details: Nil
l) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
m) Existing Cargo Movement: Nil
n) Prominent City / Town / Places of Worship / Historical places for Tourism: Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-VIII.

STRETCH – 8 (70 TO 80)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	70	80	1.3	4.6	5100	46094.37
II	70	80	1.3	4.6	4900	118661.19
III	70	80	1.3	4.6	5505	280809.09
IV	70	80	1.3	4.6	5505	402728.11
V	70	80	1.3	4.6	10,000	845852.37
VI	70	80	1.3	4.6	10,000	1482899.98
VII	70	80	1.3	4.6	10,000	2026044.39

2.5.9. Stretch IX

Stretch becomes wider from here. Also, from here Mahanadi divides into branches. BM 9 is at ch 80.000. BM 10 is at Ch 90.000 near Purbakacha village.

Figure 2.10: Google image of the stretch

Table 2-28: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
80 to 81	0.8	1.6
81 to82	0.8	4.6
82 to 83	1.0	2.0
83 to84	0.8	2.3
84 to85	0.8	1.3
85 to 86	0.9	3.2
86 to 87	0.8	1.7
87 to 88	0.8	2.1
88 to 89	0.8	2.2
89 to 90	0.8	2.3

Table 2-29: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: Full stretch is Non - tidal stretch
a) Conditions of banks (protected, un-protected): Full stretch is unprotected
b) Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
c) Encroachment to the waterway: Nil
d) NH/SH/MDR along and/or within 5 km from the waterways: Nil.
e) Railway Line and Stations in the vicinity: Nil
f) Land Use Pattern along Waterway on visual assessment: Nil
g) Crops / Agriculture in the region on visual assessment: Rice cultivation
h) Availability of Bulk / Construction Material: Nil
i) Existing Industries along Waterway with their types and details: Nil
j) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
k) Existing Cargo Movement: Nil
l) Prominent City / Town / Places of Worship / Historical places for Tourism: Nil

SHOAL AND DREDGING INFORMATION TABLE STRETCH-IX

STRETCH - 9 (80 TO 90)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	80	90	0.8	14.2	2300	142494.04
II	80	90	0.8	14.2	2300	277298.45
III	80	90	0.8	14.2	3180	523967.43
IV	80	90	0.8	14.2	3320	784079.93
V	80	90	0.8	14.2	10,000	1285787.13
VI	80	90	0.8	14.2	10,000	2033383.4
VII	80	90	0.8	14.2	10,000	2657918.98

2.5.10. Stretch X

Stretch is very wide and dangerous for bathing. Fatal Incidents are always happening in this area while bathing on the Ghats. BM 11 is at Ch 98.000 near Jobraanikut. Three lane rail and road bridges are there before Anikut.

Figure 2.11: Google image of the stretch

Table 2-30: Minimum and maximum available depth

Range (from – to)Km	Min. Observed Depth(m)	Max. Observed depth(m)
90 to 91	0.8	2.3
91 to 92	0.8	1.3
92 to 93	1.0	2.7
93 to 94	0.8	2.3
94 to 95	0.8	2.0
95 to 96	0.8	2.1
96 to 97	0.9	3.0
97 to 98	0.9	2.7

Table 2-31: Features along the stretch

a) Prominent Dams / Barrage: No Dam and Barrage in this stretch
b) Tidal stretch: Full stretch is Non - tidal stretch
a) Conditions of banks (protected, un-protected): Partially Protected
b) Hindrances - Hyacinth, rocks, rapid waterfalls, steep gradient, forest, wild-life sanctuary, security issues. Obstruction (if any) for navigation, e.g. fishing stakes: Nil
c) Encroachment to the waterway: Nil
d) NH/SH/MDR along and/or within 5 km from the waterways: NH-5 Crossing the river near Cuttack.
e) Railway Line and Stations in the vicinity: East-Coast Rail Line Crossing the river near Cuttack.
f) Land Use Pattern along Waterway on visual assessment: Nil
g) Crops / Agriculture in the region on visual assessment: Rice cultivation
h) Availability of Bulk / Construction Material: Nil
i) Existing Industries along Waterway with their types and details: Nil
j) Existing Ghats, Jetties and Terminals (with conditions and facilities). Existing navigation facilities (if any): Nil
k) Existing Cargo Movement: Nil
l) Prominent City / Town / Places of Worship / Historical places for Tourism: Cuttack

SHOAL AND DREDGING INFORMATION TABLE STRETCH-X.

STRETCH – 10 (90 TO 98.0 Km)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M³)**
I	90	98	0.8	3.9	6500	97584.29
II	90	98	0.8	3.9	6500	195685.62
III	90	98	0.8	3.9	6595	376568.2
IV	90	98	0.8	3.9	6655	496712.27
V	90	98	0.8	7.9	11000	969395.39
VI	90	98	0.8	8.1	9,600	1562066.33
VII	90	98	0.8	8.1	10,200	18460751.65

STRETCH - I (0 TO 10)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	0	10	3.2	12.5	0	0
II	0	10	3.1	12.5	0	0
III	0	10	3.1	12.5	0	0
IV	0	10	3.1	12.5	0	0
V	0	10	2.5	12.5	0	0
VI	0	10	2.5	12.5	0	300.94
VII	0	10	2.5	12.5	0	509.02

STRETCH- 2 (10 TO 20)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	10	20	0	10.9	2200	103391.79
II	10	20	0	11	2400	160817.61
III	10	20	0	11	2750	253629.18
IV	10	20	0	11	2750	319385.91
V	10	20	0	11	4,000	512619.3
VI	10	20	0	11	5800	869442.4
VII	10	20	0	11	6200	1121003.54

STRETCH - 3(20 TO 30)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	20	30	0	12.3	2000	119299.71
II	20	30	0	14.3	3050	190423.9
III	20	30	0	14.3	3660	312924.28
IV	20	30	0	14.3	3660	404175.54
V	20	30	0	14.3	8200	653029.96
VI	20	30	0	14.3	9200	1087049.23
VII	20	30	0	14.3	9800	1417473.48

STRETCH- 4 (30 TO 43)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	30	43	0	6.8	10250	1010650.67
II	30	43	0	8.7	10400	1507936.92
III	30	43	0	8.7	10630	2208534.59
IV	30	43	0	8.7	10630	2539698.38
V	30	43	0	8.7	12000	4203614.28
VI	30	43	0	8.7	13,000	5466335.47
VII	30	43	0	8.7	13,000	6972749.69

STRETCH – 5 (43 TO 50)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	43	50	0	8.7	5700	207715
II	43	50	0	14	5850	341680.2
III	43	50	0	14	5870	569392.38
IV	43	50	0	14	6405	704655.43
V	43	50	0	14	7,000	1307156.66
VI	43	50	0	14	7,000	1907466.26
VII	43	50	0	14	7,000	2573047.97

STRETCH- 6 (50 TO 60)						
Dredging calculation						
Class	FROM CH (KM)	TO CH (KM)	MIN DEPTH (m)	MAX DEPTH (m)	Shoal length (m)	Dredging quantity (M^3)
I	50	60	0.5	11.3	6300	152840.6
II	50	60	0.5	11.3	6900	299717.95
III	50	60	0.5	11.3	7435	566852.34
IV	50	60	0.5	11.3	7435	738462.84
V	50	60	0.5	11.3	10000	1409495.19
VI	50	60	0.5	11.3	10000	2179002.62
VII	50	60	0.5	11.3	10000	2916573.49

STRETCH – 7 (60 TO 70)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M^3)**
I	60	70	1.3	4.5	2700	58239.56
II	60	70	1.3	5.3	2700	156147.57
III	60	70	1.3	5.3	3200	370436.84
IV	60	70	1.3	5.3	3320	527899.85
V	60	70	1.3	5.3	9400	1118834.88
VI	60	70	1.3	5.3	10,000	1872804.72
VII	60	70	1.3	5.3	10,000	2559232.66

STRETCH – 8 (70 TO 80)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M^3)**
I	70	80	1.3	4.6	5100	46094.37
II	70	80	1.3	4.6	4900	118661.19
III	70	80	1.3	4.6	5505	280809.09
IV	70	80	1.3	4.6	5505	402728.11
V	70	80	1.3	4.6	10,000	845852.37
VI	70	80	1.3	4.6	10,000	1482899.98
VII	70	80	1.3	4.6	10,000	2026044.39

STRETCH - 9 (80 TO 90)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M^3)**
I	80	90	0.8	14.2	2300	142494.04
II	80	90	0.8	14.2	2300	277298.45
III	80	90	0.8	14.2	3180	523967.43
IV	80	90	0.8	14.2	3320	784079.93
V	80	90	0.8	14.2	10,000	1285787.13
VI	80	90	0.8	14.2	10,000	2033383.4
VII	80	90	0.8	14.2	10,000	2657918.98

STRETCH – 10 (90 TO 98.0 Km)						
Dredging calculation						
Class	**FROM CH (KM)**	**TO CH (KM)**	**MIN DEPTH (m)**	**MAX DEPTH (m)**	**Shoal length (m)**	**Dredging quantity (M^3)**
I	90	98	0.8	3.9	6500	97584.29
II	90	98	0.8	3.9	6500	195685.62
III	90	98	0.8	3.9	6595	376568.2
IV	90	98	0.8	3.9	6655	496712.27
V	90	98	0.8	7.9	11000	969395.39
VI	90	98	0.8	8.1	9,600	1562066.33
VII	90	98	0.8	8.1	10,200	18460751.65

Table 2-32: Average bed slope

Area		River / Canal Bed Level (cm)	Distance (km)	Slope (cm/km)
From	**To**			
00	10.00	0.369	10	0.0369
10.00	20.00	0.460	10	0.0460
20.00	30.00	0.469	10	0.0469
30.00	40.00	0.190	10	0.0190
40.00	50.00	2.100	10	0.2100
50.00	60.00	1.776	10	0.1776
60.00	70.00	5.200	10	0.5200
70.00	80.00	2.247	10	0.2247
80.00	90.00	4.668	10	0.4668
90.00	98	1.935	10.8	0.1792

Average Slope= 0.1927

2.6. Water and Soil Samples analysis and Results

Water and bottom soil sample are collected from the deepest route at every 10km interval and are tested.

Table 2-33: Analysis results of bottom samples taken at 10km interval

SL.NO.	EASTING(m)	NORTHING(m)	LATITUDE	LONGITUDE	RAW DEPTH (m)
01	465729.06	2247805.22	20° 19' 40.5608" N	086° 40' 18.1001"	4.8
02	457334.17	2252042.46	20 °21' 57.7879" N	086° 35' 28.2284"	8.2
03	451825.39	2257470.3	20 °24' 53.8795" N	086° 32' 17.6799"	4.3
04	443518.33	2258834.98	20° 25' 37.4461" N	086° 27' 30.8889"	2.8
05	435489.3	2261157.93	20° 26' 52.0857' N	086 °22' 53.5265"	3.2
06	428759.18	2262591.63	20° 27' 37.8525" N	086° 19' 1.0539 "E	2.2
07	419486.52	2262030.76	20 °27' 18.2701" N	086° 13' 41.1107"	2.0
08	410609.32	2262852.58	20° 27' 43.5667" N	086° 08' 34.594" E	1.1
09	401561.57	2262966.08	20° 27' 45.6415 "N	086° 03' 22.31" E	0.7
10	394436.95	2262344.5	20 °27' 24.0415" N	085° 59' 16.5577"	1.3
11	386589.9	2266461.53	20° 29'36.3112'"N	085° 54' 44.8137"	2.4

Table 2-34: Water characteristics

MAHANADI_ LUNA RIVER								
Sl.no	Chainage		LATITUDE	LONGITUDE	Depth	Parameter	Units	Sediment concentration (MID Depth)
WS 1	0	10	20 19 40.5608 N	086 40 18.1001 E	4.8	Soil Content	mg/1	21
WS 2	10	20	20 21 57.7879 N	086 35 28.2284 E	8.2	Soil Content	mg/1	23
WS 3	20	30	20 24 53.8795 N	086 32 17.6799 E	4.3	Soil Content	mg/1	20
WS 4	30	40	20 25 37.4461 N	086 27 30.8889 E	2.8	Soil Content	mg/1	18
WS 5	40	50	20 26 52.0857 N	086 22 53.5265 E	3.2	Soil Content	mg/1	13
WS 6	50	60	20 27 37.8525 N	086 19 1.0539 E	2.2	Soil Content	mg/1	16
WS 7	60	70	20 27 18.2701 N	086 13 41.1107 E	2	Soil Content	mg/1	19
WS 8	70	98	20 27 43.5667 N	086 08 34.594 E	1.1	Soil Content	mg/1	24

2.7. Comments for Hydrographic Survey

River Mahanadi having a length of 98 km stretches from Mahanadi River Mouth to Cuttack. Presently there is no traffic present in the waterway, whereas huge potential for cargo traffic is foreseen considering the length and connectivity with the industrial hub. The waterway from the Mahanadi mouth to DIhanalaram Pur is tidal affected for a length of 43.0 km and from Dihabalarampur to Cuttack having a length of 57.8 km is non - tidal area. From the Hydrographic survey report, it is noted that for stretch 1 (Ch 0-10Km), the tidal variation is 2.30m, for Ch 10-20 km it is 2.00 m, for Ch 20-30 km it is 1.80 m and for Ch 30-43 km it is 1.2m.

The geometry of the waterway generally satisfies as a Class III waterway. The Benchmarks taken in the path are 11 numbers and the tide gauges are aloud erected to take the data. There are many existing bridges and crossing over waterways along the project way. Mainly two syphons are identified on the waterway at Ch 80.7 km and Ch 69.6 km. The average bed slope of the river varies from 1:0.0000369to 1:0.0001935 from Mahanadi mouth to Cuttack.

The river bed samples from first 20 kms from Mahanadi mouth are found to be coarse sand at a raw depth of 4.8 m to 8.2 m. the water characteristics of the river is characterized from salt water to salt and muddy water from Ch 0 to 40 km, Mild salt water for Ch 40 – 50 km and Fresh water in Ch 50 – 98.0 km.

3. FAIRWAY DEVELOPMENT

3.1. Proposed Class / Type of Waterway

The type of water way to which the considered stretch is to be developed is ascertained based on the traffic potential and present hydrographic features of the river. The traffic to be handled through the waterway should justify the development of the waterway. 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 up to 2000 dead weight tonnage(DWT) and tug-barge formation in push-two units of carrying capacity up to 8000tonnes. The classification of waterways for rivers is discussed below (based on IWAI notification dated 7th November 2016):

Table 3.1: Classification of inland waterways for rivers

Sl. No.	Class of waterway	Minimum depth (m)	Bottom width (m)	Bend radius (m)	Vertical clearance (m)	Horizontal clrearance (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	6	50
4	Class IV	2.0	50	800	8	50
5	Class V	2.0	80	800	8	80
6	Class VI	2.75	80	900	8	80
7	Class VII	2.75	100	900	8	100

In case of Mahanadi-Luna river system, from the traffic study, it is observed that Cuttack region has an industrial cluster with a goof amount of both import and export cargo moved between Paradip port region and Cuttack. Also, an IFFCO fertilizer plant located at Musadia along the Mahanadi riverbanks has an annual production of around 1.75MMTPA of different chemicals and many raw materials for which are imported. Considering the possible divertible traffic of IFFCO, the state government has sponsored a terminal near IFFCO plant so that a good connection can be established between the IFFCO plant region to the NW5. Thus, it is proposed to develop the stretch as Class III with bottom width of 50m and limiting bend radius of 700m.

The river has assured water only during fair weather seasons, so the waterway can be proposed to be used between June and October only and in which during 2 to 3 weeks falling to the end of July and start of August, the waterway cannot be used to severe flood.

3.2. Details of Shoals

Shoal is a natural submerged ridge, bank, or bar that consists of sand or other unconsolidated material and rises from the bed of a body of water to near the surface. Often, they are submerged ridges, banks or bars that rise near enough to the surface of a water body as to constitute a danger to navigation. Shoals include relatively shallow place in a water body, rocky area on the waterbed within area mapped for navigation, etc. The type of material is seen to be sandy with fine and silt contents, maintenance dredging at intervals may be required to maintain the depth for navigation. For the present river system, presence of shoal for various Classes are as given in table 3.2 below.

Table 3.2: Shoal length with chainage for different classes

Chainage from (km)	Chainage to (km)	Shoal length (m) (Class III)
0	1	0
1	2	0
2	3	0
3	4	0
4	5	0
5	6	0
6	7	0

7	8	0
8	9	0
9	10	0
10	11	0
11	12	700
12	13	1000
13	14	600
14	15	0
15	16	300
16	17	0
17	18	0
18	19	800
19	20	900
20	21	500
21	22	200
22	23	100
23	24	1000
24	25	1000
25	26	300
26	27	0
27	28	900
28	29	800
29	30	1000
30	31	1000

31	32	1000
32	33	1000
33	34	1000
34	35	1000
35	36	1000
36	37	1000
37	38	1000
38	39	1000
39	40	1000
40	41	1000
41	42	1000
42	43	1000
43	44	1000
44	45	1000
45	46	1000
46	47	1000
47	48	1000
48	49	1000
49	50	1000
50	51	1000
51	52	1000
52	53	1000
53	54	1000
54	55	1000

55	56	1000
56	57	1000
57	58	1000
58	59	1000
59	60	600
60	61	1000
61	62	1000
62	63	1000
63	64	500
64	65	900
65	66	1000
66	67	1000
67	68	1000
68	69	1000
69	70	1000
70	71	1000
71	72	1000
72	73	1000
73	74	1000
74	75	1000
75	76	1000
76	77	700
77	78	1000
78	79	700

79	80	600
80	81	1000
81	82	1000
82	83	1000
83	84	1000
84	85	1000
85	86	800
86	87	1000
87	88	1000
88	89	1000
89	90	1000
90	91	1000
91	92	1000
92	93	1000
93	94	1000
94	95	1000
95	96	1000
96	97	1000
97	98	800

3.3. Proposed Conservancy Activities

3.3.1. Low Cost structures

The conservancy works aim at preserving the course of the channel, making it navigable year long. The dredged channel may be conserved using low cost structures as bamboo bundling, sub-merged vanes, etc. But owing to the severe flood expected in the region, bamboo bundling may not help as this will get washed out during rainy season. Since the proposal here to develop the waterway with minimum depth of 1.7m with comparatively limited dredging, no conservancy works are proposed. In future, when the Class of waterway is upgraded, conservancy works to reduce the secondary flow and thereby bank erosion in curves may be considered.

3.3.2. Dredging

Dredging is the removal of sediments and debris from the bottom of lakes, rivers, harbors, and other water bodies. It is a routine necessity in waterways around the world because of sedimentation, the natural process of sand and silt washing downstream gradually fills channels and harbors. It is often focused on maintaining the depth of the waterway to ensure the safe passage of vessels by preventing the vessels from grounding. In case of rivers with alluvial banks and sandy sediment loads, maintenance dredging may be required.

As can be seen from the table 3.3 below, the amount of dredging required for developing the waterway as Mentioned Class VII (CH 0 to CH 7) Class III (CH 7 to CH 98) are around **5463623.35** cum. As per the survey report, the bed material is mostly sandy in nature. Hence closed grab dredger is recommended for dredging the channel. The dredge material can be used for embankment strengthening and maintenance.

The dredged materials can be dumped on the riverbanks itself. The maximum depth of the deposition is limited to 0.75 m. the calculation for finding the height of the dumping can be formulated as follows:

Height = Dredging quantity (in Volumetric dredging quantity for each km)/ (Proposed length of deposition * Width)

Eg: - For Ch 10 – 11: (0.14/(2000*5)) = 0.0 m (2 km upstream from 10 km chainage)

For Ch 12 – 13: (11261.07/ (2000*5) = 1.13 m (2 km upstream from 12 km chainage)

For Ch 13 – 14: (149069.83/ (3000*5) = 5.51 m (5 km upstream from 12 km chainage)

Most of the drudged quantity shall be dumped in the same kilometer stretch all along the embankment on both sides of the river forming a trapezoidal section. Some of the dredged shall be dumped in the low-lying areas nearby all along the stretch.

Figure 3.1: Dredging a river

Table 3.3: Dredging quantity for class III

Chainage from (km)	Chainage to (km)	per km. dredging qty	Accumulated dredging quantity for Class III (cub. m.)
0	1	0	0
1	2	0	0
2	3	0	0
3	4	0	0
4	5	0	0
5	6	0	0

6	7	0	0
7	8	0	0
8	9	0	0
9	10	0	0
10	11	0	0
11	12	89942.91	89942.91
12	13	97622.47	187565.38
13	14	9610.34	197175.72
14	15	0	197175.72
15	16	32276.24	229451.96
16	17	0	229451.96
17	18	0	229451.96
18	19	22469.67	251921.63
19	20	1707.55	253629.18
20	21	24808.72	278437.9
21	22	0.51	278438.41
22	23	710.22	279148.63
23	24	29551.71	308700.34
24	25	95533.45	404233.79
25	26	911.56	405145.35
26	27	0	405145.35
27	28	83873.73	489019.08
28	29	7606.51	496625.59
29	30	69927.87	566553.46

30	31	40532.09	607085.55
31	32	140106.52	747192.07
32	33	148799.22	895991.29
33	34	154108.31	1050099.6
34	35	176398.04	1226497.64
35	36	165466.17	1391963.81
36	37	203004.81	1594968.62
37	38	186958.17	1781926.79
38	39	219982.67	2001909.46
39	40	187435.8	2189345.26
40	41	230179.4	2419524.66
41	42	216248.18	2635772.84
42	43	139315.21	2775088.05
43	44	212596.27	2987684.32
44	45	121739.95	3109424.27
45	46	22980.37	3132404.64
46	47	42047.43	3174452.07
47	48	51348.46	3225800.53
48	49	32663.48	3258464.01
49	50	86016.42	3344480.43
50	51	106244.83	3450725.26
51	52	52943.12	3503668.38
52	53	12632.62	3516301
53	54	88816.37	3605117.37

54	55	73883.06	3679000.43
55	56	60567.96	3739568.39
56	57	42554.66	3782123.05
57	58	47031.93	3829154.98
58	59	70310.6	3899465.58
59	60	11867.19	3911332.77
60	61	16149.88	3927482.65
61	62	23073.3	3950555.95
62	63	46686.98	3997242.93
63	64	18858.04	4016100.97
64	65	27771.3	4043872.27
65	66	46209.15	4090081.42
66	67	35907.12	4125988.54
67	68	47759.07	4173747.61
68	69	57586.33	4231333.94
69	70	50435.67	4281769.61
70	71	61284.21	4343053.82
71	72	28164.75	4371218.57
72	73	52032.74	4423251.31
73	74	20404.76	4443656.07
74	75	40583.93	4484240
75	76	50818.37	4535058.37
76	77	7050.44	4542108.81
77	78	11021.16	4553129.97

78	79	5441.39	4558571.36
79	80	4007.34	4562578.7
80	81	63051	4625629.7
81	82	69102.19	4694731.89
82	83	9807.5	4704539.39
83	84	24748.35	4729287.74
84	85	38745.06	4768032.8
85	86	29318.11	4797350.91
86	87	73972.51	4871323.42
87	88	79138.17	4950461.59
88	89	68503.62	5018965.21
89	90	67580.92	5086546.13
90	91	73744.45	5160290.58
91	92	86076.36	5246366.94
92	93	56871.06	5303238
93	94	80546.14	5383784.14
94	95	33363.87	5417148.01
95	96	11663.59	5428811.6
96	97	19807.11	5448618.71
97	**98**	14495.62	5463114.33
Total quantity			

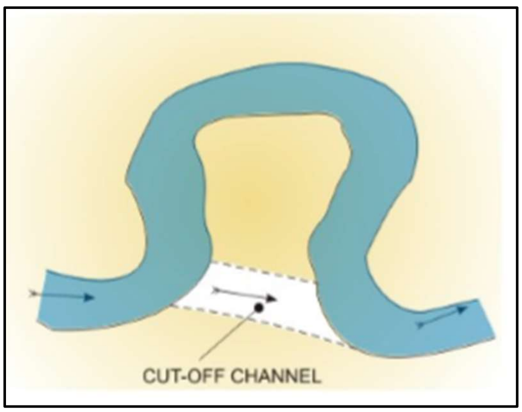
3.3.3. River Training

River training is the stabilization of the channel to maintain the desired cross section and alignment. Training structures are then necessary to protect the channel against the changes that occur due to this disturbance. In general, the objectives of river training may be summarized as:

- To increase the safety against flooding by accommodating the flood flow.
- To improve the efficiency of the sediment transport.
- To minimize bank erosion by stabilizing the course of flow.
- To direct the flow to a desired river, stretch.
- To reduce the probability of meandering.
- And in most of the cases the primary objective of river training is to improve navigation by maintaining channel depth.

In the present case, river training is required to attain the minimum bend radius at regions of meandering.

Figure 3.2: Cut-off



The techniques proposed for river training includes, cut-offs, at regions where the minimum bend radius criteria are not attained. The cut off length comes around 14.66km for the entire stretch of the river. The proposed locations of cut offs are shown in the table 3.3 below.

Table 3.4: Locations of cut offs

LOCATION	PRESENT BEND RADIUS/ LOOP LENGTH	BEND RADIUS AFTER TRAINING/ CUT OFF LENGTH
CH 1.4 km to CH 2.4 km	355m (Radius)	1100m
CH 23.3 km to CH 24.7 km	415m (Radius)	988m
CH 39 km to CH 43 km	3714 m (loop length)	1975m
CH 44 km to CH 51 km	6800m (loop length)	4700m
CH 68.3 km to CH 69.75 km	280m (Radius)	800m
CH 73.18 km to CH 73.85 km	330m (Radius)	1000m
CH 84 km to CH 85.61 km	480m (Radius)	1900m
CH 86 km to CH 87.7 km	530m (Radius)	1400m
CH 89 km to CH 90 km	400m (Radius)	920m

3.4. Bank Protection / Embankment Strengthening

During the monsoon season the floods in the region are very common, so for this reason some short and as well as long temporary embankments are needed in the both banks of the river especially in the region of terminal. Soft and locally approved practices may be given priority site specifically. Bank protection works are to be taken up to protect land and property on canal sides from flooding. Bank erosion problem due to turbulence would be more severe in the narrow stretches than in wider stretches. In addition to the traditional canal bank protection measures, many alternative methods of bank protection, which are acceptable visually and functionally, are in use, which includes:

- Rip - Rap (large boulders)
- Concrete blocks or large pre-cast units
- Metal sheet piling

- Gabions (wire mesh cage with tightly packed stones)
- Concrete pile – slab method
- Geotextiles combined with vegetative cover

Figure 3.3: A typical protected bank using rip-rap and vegetation

The banks close to the terminal location are affected by the wakes of the vessels, thus, these locations are proposed to be protected using riprap combined with vegetation. It is proposed to protect a minimum of 50m up and down stream beyond the extreme of the jetty structure and the region between the two jetties of different levels. A total length of 200m is required to be protected. The extend of location is marked in the drawing enclosed as Annexure I.

3.5. Navigation Markings / Navigation Aids

Navigation markings are mandatory for safe movement of vessels. Proper markings may be provided demarcating the dredged and maintained channel of the waterway.

Channel markings for day navigation need to be erected and maintained in entire waterway. As of now, night navigation is not proposed, which may be considered in future if found required. It is proposed to have buoys to demarcate the channel boundaries and range to guide the ships through the center line of the channels. Apart from this, it is proposed to have at least monthly thalweg surveys to ensure the navigability of the channel. As a general guide, as per IALA recommendation, red buoys mark the terminal side of the channel.

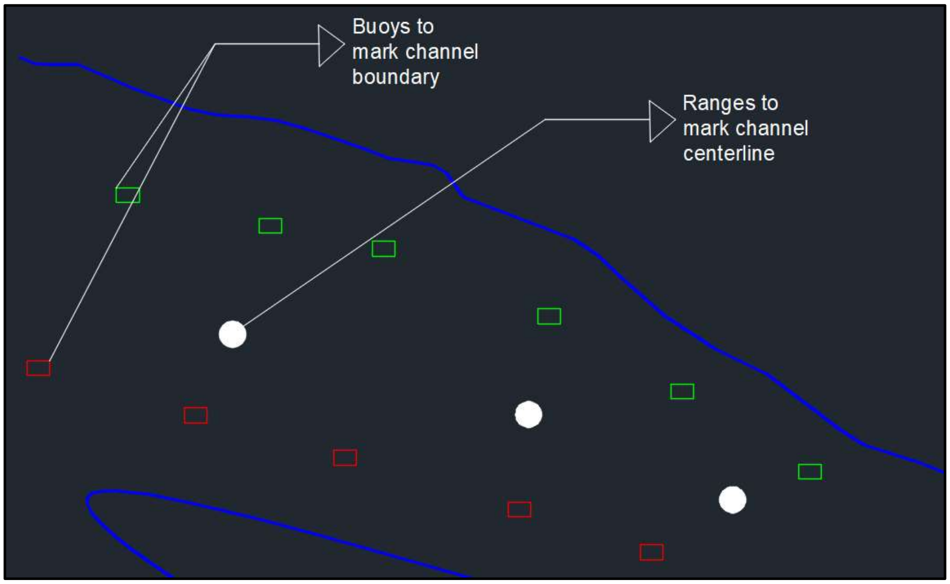
Table 3.5: Locations of Navigational Aids

Chainage in kms	Number of buoys
1 – 2	2
2-3	2
3-4	2
4-5	2
5-6	0
6-7	2
7-8	2
8-9	2
9-10	2
10-11	2
11-12	0
12-13	2
13-14	2
14-15	2
15-16	2
16-17	0
17-18	2
18-19	2
19-20	2
20-21	2
21-22	0
22-23	2
23-24	2
24-25	2
25-26	0
26-27	2
27-28	2
28-29	2
29-30	2
30-31	2
31-32	0
32-33	2
33-34	2
34-35	2
35-36	2

36-37	2
37-38	2
38-39	2
39-40	0
40-41	2
41-42	0
42-43	2
43-44	0
44-45	2
45-46	2
46-47	1
47-48	1
48-49	0
49-50	2
50-51	2
51-52	2
52-53	2
53-54	0
54-55	2
55-56	2
56-57	2
57-58	2
58-59	2
59-60	0
60-61	2
61-62	2
62-63	2
63-64	2
64-65	2
65-66	2
66-67	2
67-68	0
68-69	2
69-70	2
70-71	2
71-72	2
72-73	0
73-74	2
74-75	2

75-76	2
76-77	2
77-78	2
78-79	2
79-80	0
80-81	2
81-82	2
82-83	2
83-84	2
84-85	0
85-86	2
86-87	2
87-88	2
88-89	2
89-90	0
90-91	2
91-92	2
92-93	2
93-94	2
94-95	2
95-96	2
96-97	2
97-98	0

Figure 3.4: Proposed aids to navigations



3.6. Modification Requirement in existing Bridges / Cables / Dams / Barrages / Locks / Weirs / Anicuts / Aqueducts

The vertical clearance as required by the IWAI Act 1985 and IWAI notification dated 7TH Nov 2016, for Class III water way is 6m and horizontal clearance required is 50m. From the hydrographic survey report, it is clear that all the bridges and other cross in structures are located beyond CH 20km. The cross structures which violate the specifications of Class III and proposed modifications are as shown in the table below.

Table 3.6: Modifications to crossing structures

Type of structure	Location (Chainage km)	Deviating parameter	Available value (m)	Proposed modifications
Road bridge	Marsaghai (25.20)	VC	5.9 from HFL	To have warning boards to caution the restriction on heights permitted
Road bridge	Marsaghai (025.4)	VC	5.9 from HFL	To have warning boards to caution the restriction on heights permitted

Road bridge	Mehindinagar (34.80)	HC, VC	40, 4.1	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Karilopatna (43.80)	HC, VC	40, 3.4	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Artamul (52.70)	HC, VC	40, 4.2	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Jamunapur (57.70)	HC, VC	40, 2.9	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Bhagabanpur (67.20)	HC, VC	30, 3.6	Demolishing existing structure and rearranging the spans to attain vertical clearance
Road bridge	Murkundi (Syphon bridge) (78.00)	HC, VC	20, 4.6	Demolishing existing structure and rearranging the spans to attain vertical clearance

It can be observed from the above table that the deviation from vertical and horizontal clearance criteria is observed for few bridges. The traffic in the waterway is also not too high. Thus, it is proposed to keep the bridges as it is w.r.t. the horizontal clearance and to have restriction on the height of the waterway wherever possible. Sufficient warning boards and signs shall be placed near the bridge location and on the side face of the bridge. For the bridges which do not meet the horizontal clearance criteria, it is proposed to have one-way traffic in adjacent spans with the vessels going in opposite direction through two consecutive spans. As can be seen from the table above, there exists horizontal clearance of minimum 30m in one span and the horizontal clearance required for Class III waterway is 50m, thus it is safe to move in one direction using one span. For the bridges where vertical clearance criteria are deviated with large margin, modifying the pier height and span arrangement utilizing maximum of existing structure is proposed. In future, once a justifiable traffic generates, after analyzing the age, structural and functional conditions of the bridge, reconstructing the bridges may be considered. For the syphon cum bridge at around CH 78km, from site investigation, it is observed that, the underwater structure is not obstructing the navigation as the minimum water depth during summer as per the survey report is around 1.6m. The bridge super structure lacks required horizontal and vertical clearance, so it is proposed to have replacement of the central piers with improved horizontal and vertical clearances with the pile foundation bridging across the siphon on either end. A central span of 50 clear span can be provided with the subsequent spans sloping down to the existing piers. For the siphon at Paika too, the vessel movement is observed to be possible during fair-weather season and here since no elevated superstructure is available, restriction due to clearance is not reported.

3.7. Proposed Dams / Barrages / Locks / Weirs to improve depth

Based on the hydrographic survey report, the river dries out during summer rendering the channel not navigable. However, in the present situation no barrages are proposed. It is proposed to have vessel services during the fair season only and temporary shutdown during lean season; in lieu of the immense investment required for the construction of barrage and associated weirs. But once justifiable traffic is generated, construction of a barrage can be considered to ensure all weather traffic movement. The location and height of barrage shall be arrived at based on inundation studies and numerical modelling. As an approximation based on the available data, it is suggested to have a barrage at around CH 44km with a height of around 19m from existing bed level and associated lock system along with three weirs are required, one at CH50km, 4m height; at CH68km of 7.4m height and at CH85km of 9.5m height in the future, when the traffic generated revenue can compensate for the capex for the barrage system.

At the site of Chitroptala siphon cum bridge, if an artificial canal and lock system is considered to cross the canal leading to the siphon on the left bank, the additional capex is noted to be around 100 crores approximately apart from the huge operational and maintenance expenditure likely to incur. Hence this option seems quite unfeasible.

3.8. Land Acquisition

The land required for the terminal infrastructure in Jagatpur village near Cuttack is around 2.32 hectares. It is understood from the site investigation that around 23 acres of government owned land is available in the proposed location. Once barrages are required, inundated land must be acquired.

For the fairway alignment proposed targeting to achieve the bend radius, land acquisition of around 34,67,914.677 sqm. is required, details of which are presented in the table below.

Table 3.7: Land acquisition required for fairway development

Chainage from (km)	Chainage to (km)	Area (sqm.)
1.4	2.4	27795.8
23.3	24.7	100211.96
39	43	1534012.9
44	51	1153735.88
68.3	69.75	123785.9
73.18	73.85	45607.557
84	85.61	214577.45
86	87.7	176513.67
89	90	91673.56
Total		**3467914.677**

3.9. Fairway Costing

3.9.1. Capital Cost

Table 3.5: Capital cost for fairway

Sl. No.	Description	Amount
1	River training	₹ 42,51,40,000.00
2	Land acquisition	₹ 10,28,29,197.24
3	Dredging	₹ 1,09,27,24,670.00
4	Embankment protection	₹ 1,34,00,000.00
5	Aids to navigation	₹ 30,00,000.00
6	Modifications to 5 bridges to meets VC criteria	₹ 50,00,00,000.00
7	Modification to the bridge at Chitroptala	₹ 25,00,00,000.00
	Total	₹ 2,38,70,93,867.24

3.9.2. O&M Cost

The operation and maintenance cost are as shown in the table below.

Table 3.6: Operation and Maintenance Cost

Sl. No.	Description	Percentage of Capex	Amount
1	Dredging	5	₹ 5,46,36,233.50
2	Embankment protection repair	1	₹ 1,34,000.00
3	Aids to navigation	2	₹ 60,000.00
4	River training	5	₹ 5,48,25,143.3

4. TRAFFIC STUDY

This chapters analyzes the subject ~98 km stretches of Mahanadi River (from Paradip to Cuttack Bridge) form the traffic perspective. The traffic analysis has been conducted using the following approach:

- **Identification of Hinterland / Influence Area** – Identification of area likely to contribute to traffic onto the waterway based upon the location of waterways, presence of nearby industries, competition from nearby waterway (NW-5) and characteristics of the hinterland (population, industries, tourism avenues, infrastructure etc.)
- **Commodity Composition**: Identification and analysis of various commodity categories in the influence area including agricultural products, industrial cargo.
- **Originating / Terminating Commodities**: Directional analysis of cargo movement, shortlisting of cargo movement in the hinterland as **potential traffic** for waterway movement, identification of traffic movement along the general direction of waterway (with origin and / or destination points along the waterway) as **relevant traffic** which can be targeted for modal shift from road / railways
- **Passenger Traffic**: Analysis of current / potential waterway passenger movement arising from tourist activities, leisure, local transport or cross-river movements
- **Ro-Ro Traffic**: Analysis of Ro-Ro (roll on – roll off) traffic movement on the waterway either for cargo transport or passenger movement or both
- **Growth Trend**: Analysis of historical trends, traffic influencers in the region, upcoming / expected future development to understand viability for waterway transport and basis for traffic forecasting
- **Forecasting and Potential IWT Assumptions**: Definition of forecasting assumptions, formulation of scenarios and traffic projections based upon the assumptions
- **Terminal wise IWT Analysis**: Analysis of terminal-wise traffic for identification of terminal locations, terminal design and planning and vessel design

4.1. Influence Area / Hinterland

The study area for the project includes sections of the Mahanadi river and its anabranch Luna also called National Waterways (NW) 64. The proposed waterway originates from Paradip port and extends till Cuttack for a total distance of ~98 km.

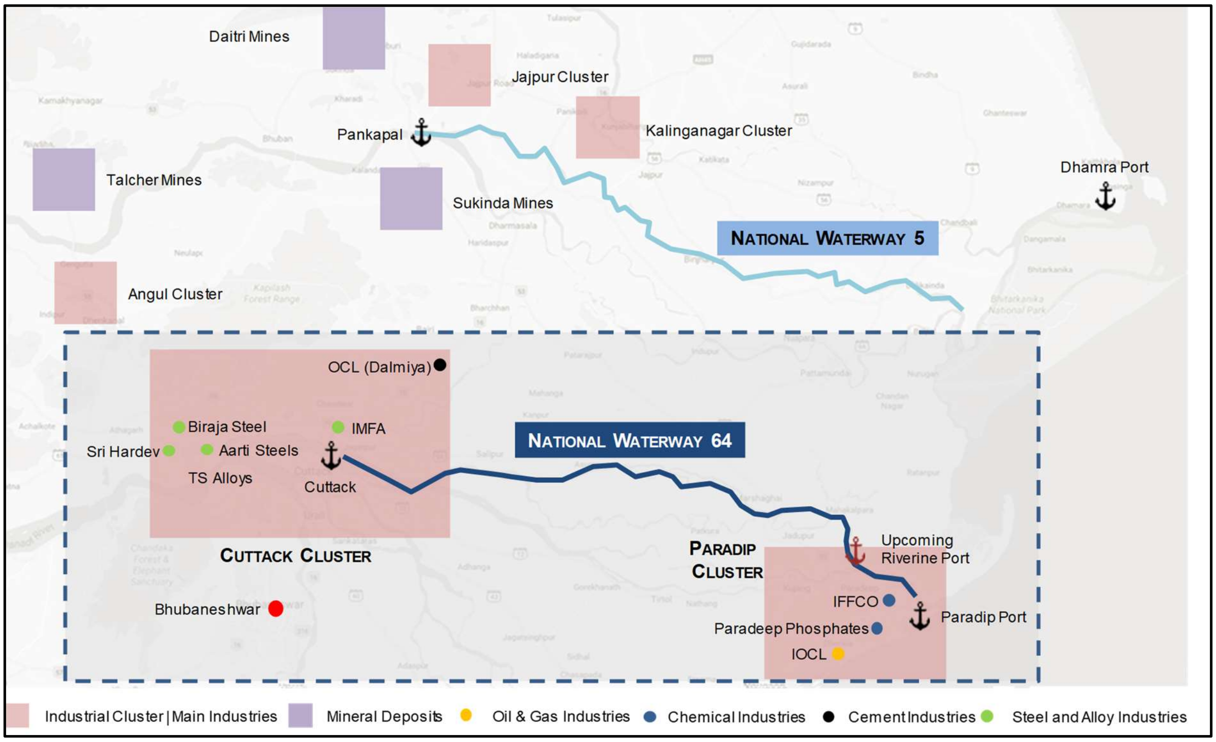
Cuttack and Paradip are the main industrial centres in proximity of the waterway. Paradip hosts several large-scale industrial units in petrochemical, fertilizer, chemicals sector. Paradip port is one of the major ports of India and handled ~90 million tonnes[1] of cargo in 2016-17. Cuttack houses medium scale iron & steel, cement units besides several small / micro scale industrial units. Hence the waterways' hinterland has been defined to comprise of Paradip and Cuttack clusters.

In addition to the above, there are several major industrial clusters in the region such as Angul,Dhenkanal, Jajpur, Kalinganagar etc. However, National Waterway 5 (along the Brahmani river) is better suited to service these clusters. Moreover, NW-5 provides connectivity to both Dhamra and Paradip ports and is currently being developed with a capacity of ~25 MTPA. Hence, these clusters have been excluded from the catchment of NW 64

The following map shows the catchment area for the project.

[1]http://www.business-standard.com/article/economy-policy/paradip-port-cargo-traffic-up-16-per-cent-in-2016-17117040300400_1.html

Figure 4-1:Catchment Area



Riverine Port

In addition, the Department of Commerce and Transport (DoCT), Govt. of Odisha is developing a **riverine port at Akhadashili village in Mahakalpada block, Kendrapada**. In June 2018, the State Government Cabinet had approved financial bidding process for the port. Four major port developing agencies (**Essar, Adani Ports and Hindustan Ports (DP World), Navyuga Engineering Company**) who qualified the technical bid have now been ordered to submit the financial bid. The Riverine port intends to capitalize on the vast mineral wealth in its hinterland and the wide array of major industrial development in its vicinity. The major highlights of the project are as below –

- **Site Location and Area** - The Proposed Port site is located at Akhadasali village in Kendrapa district, Odisha. The site is very close to Paradip Port. It is situated ~12km upstream from Paradip sea mouth. The riverine port is proposed to be developed over 300 hectares (175 hectares in Phase 1 and balance 125 hectare in Phase 2)

- **Connectivity** – The port site would have a 6-lane access from NH-53. Rail connectivity would be through a direct branch from the upcoming Haridaspur-Paradip rail line.
- **Traffic** - Major commodities the port is expected to handle are Iron ore, coal, pellets, crude Oil and steel. The port would also cater to minor regional and coastal traffic. As per the WAPCOS report for the port, it is projected to handle ~40 MTPA to ~58 MTPA traffic. Iron Ore, Coal and Fertilizer make up the bulk of cargo traffic
- **Vessel Sizes** – The port is expected to cater to Panamax vessels (65,000 DMT). The port would also cater to ~25,000 DWT general cargo vessels and ~10,000 TEU Container vessels.
- **Infrastructure** – 3 berths would be established – 500 m in Phase-I, and additional 1,000 m in Phase-2. The planned berth capacity would be ~18 MTPA in Phase-I, increasing to ~45 MTPA in Phase-2.
- **Dredging** - The depth of Inner channel proposed to be 14.2 m and outer channel is proposed to be 16.2 m. Thus, the port development would require dredging of 12 to 14 m of the river-bed. Total quantity of dredging works out **30 Million m3** for phase I development.

4.1.1. Infrastructure Overview

The catchment area (**Paradip – Cuttack**) for the subject waterway stretch enjoys good connectivity through both road and railways. The development of transport infrastructure has been precipitated by increasing traffic at Paradip Port and major urban centers of Cuttack and capital city Bhubaneshwar. An analysis of both rail and road transport is as given below.

4.1.1.1. Road Network

Cuttack serves as a major transit point in East Odisha owing to presence of three national highways viz. NH-16, NH-55 and NH-316, passing through it.

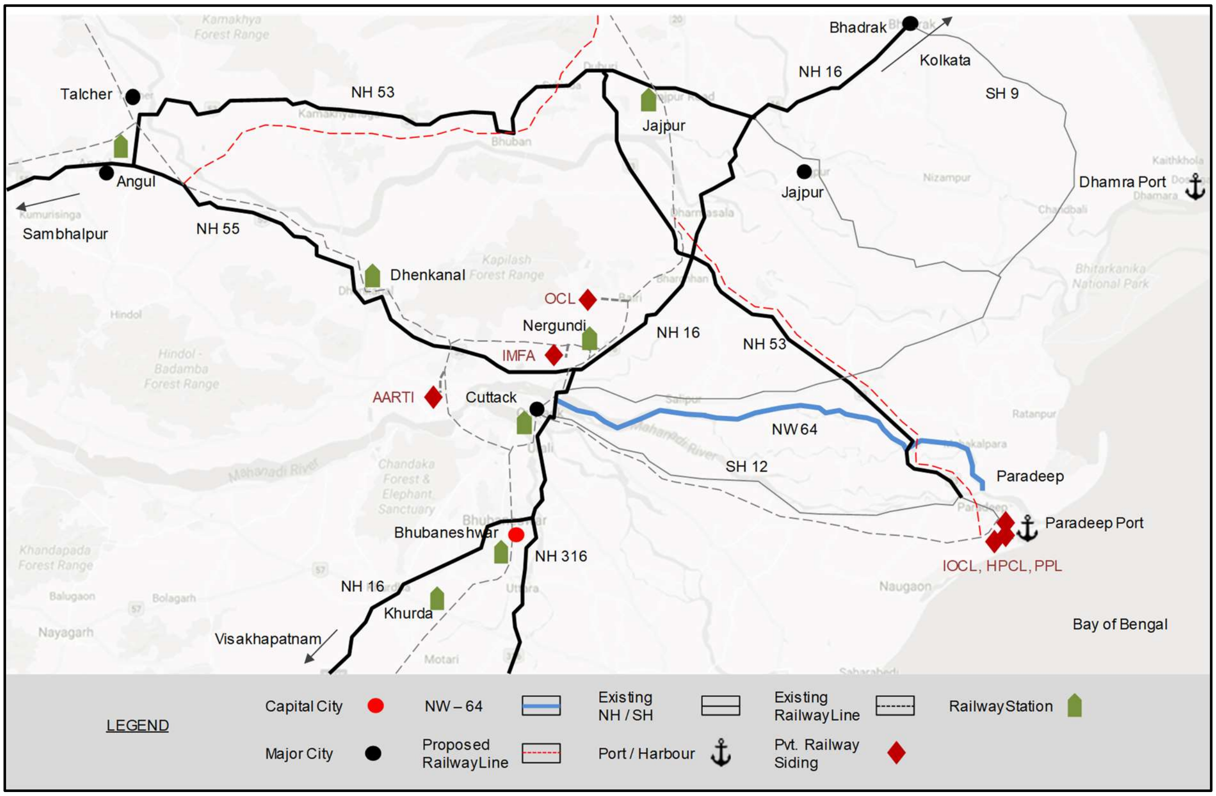
- **NH-55**: It (previously NH-110) primarily connects Sambalpur to Cuttack. It services major industrial and mining traffic originating from Sambalpur, Jharsuguda, Angul areas and connects it to Cuttack. The highway also connects to NH-53 near Angul / Talcher and diverts significant traffic onto NH-53 as well.

- **NH-16**: It forms part of the Golden Quadrilateral project and primarily connects Kolkata to Chennai. In the process, it traverses along India's east coast through states of West Bengal, Orrisa, Andhra Pradesh and Tamil Nadu. The 6 lane highway directly connects Cuttack and Bhubaneswar. With regards to catchment area, the highway connects Cuttack and Sunguda (near Chandikhol).
- **NH-316**: Itprimarily connects Bhubaneshwar to Puri and majorly services urban and tourist passenger traffic plying towards Puri / Satpada.

The road connectivity between Cuttack and Paradip is as follows:

1. **SH-12** (Total distance – 92 km) - This highway directly connects Cuttack and Paradip Port. The highway has been recently redeveloped and upgraded to 4 lanes. While this is the shortest road between Paradip and Cuttack, movement of dirty cargo is not allowed on this highway as it passes through several populated towns along the way. Thus, its services limited traffic between Cuttack and Paradip.
2. **NH-16 + NH-53** (Total distance – 122 km) - This route is the preferred by trucks due to uninterrupted movement and good condition of the roads. The route has two tolls along the way – Manguli Toll Plaza and Srirampur Toll Plaza. The toll for single journey (3-axle vehicle) is INR 510 and INR 405 respectively. The trucks however take SH-12 for return journey if they are empty, due to absence of tolls.
3. **SH-9A + NH-53** (Total distance – 104 km) - SH-9A, also known as Cuttack – Chandabali road, diverts from NH-16 near Jagatpur (Cuttack) and meets NH-53 at Pandiri.

Figure 4-2: Transport Infrastructure – Hinterland



The major road projects coming in the region include four laning of NH-53 from Angul to Cuttack. There is also a proposal for connecting Bhubaneswar to Paradip. However, despite an extensive road network, the following issues exists in road transport:

Congestion: Currently, logistic operators primarily use NH-16 via NH-53 owing to the following reasons:

- SH-12 allows very restricted opportunities for transport of freight traffic as movement of dirty cargo is not allowed on this highway. Further, SH-12 passes through several population centres which act as bottlenecks for heavy traffic and lead to congestion. SH-12 is primarily used as a return route from Paradip to Cuttack,
- SH-9A does not have significant ROW to be usable for freight traffic. Further, civil works on the route lead to congestion and longer travel times.

- NH-16 and NH-53 are 6 lanes and 4 lanes respectively providing for uninterrupted movement. However, in time, the traffic is bound to increase on these routes owing to unavailability of alternate routes.

Freight rates: The road transport in the catchment area is managed by local Truck Owner Associations. Subsequently, freight rates vary from region to region. The impact is acute at Paradip due to monopolistic market environment and high demand driving up logistic rates by 40%-60% as compared to market norm in the region. Presence of two toll plaza on NH-16 and NH-53 route further increases the transportation costs. However, lack of alternate solutions abets the existing rates.

4.1.1.2. Rail Network

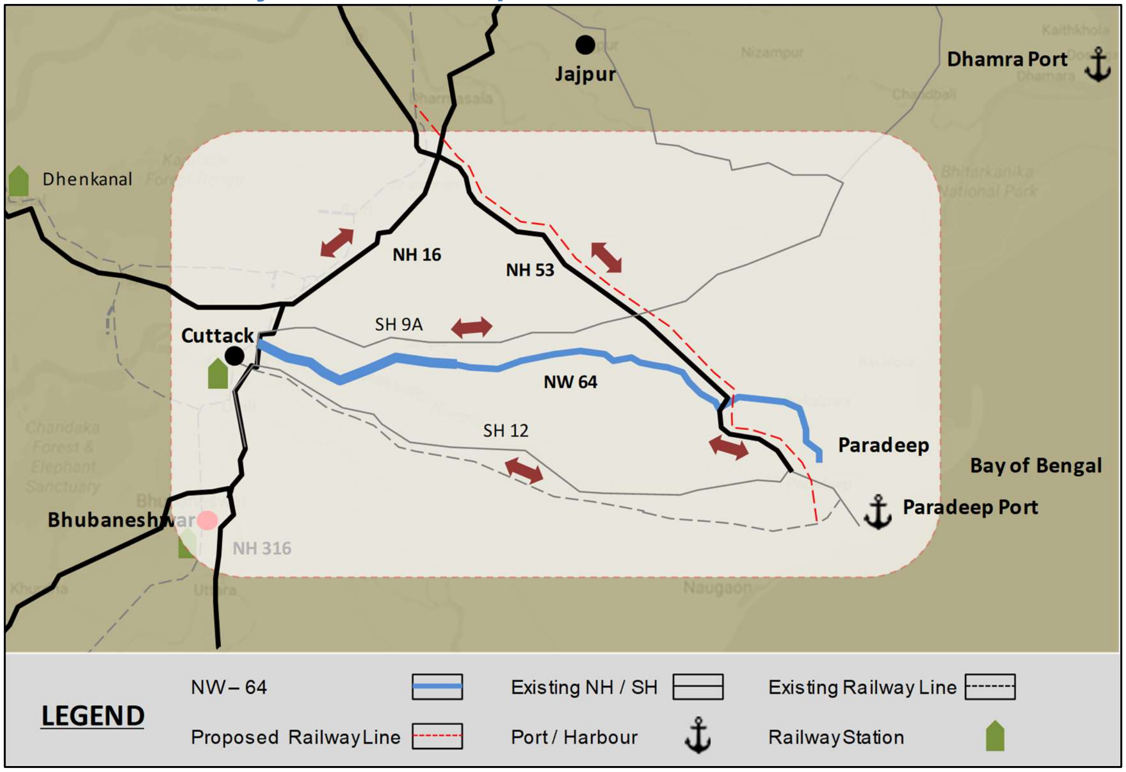
The rail network in the hinterland falls under Khurda division of East Coast Railway Zone (ECoR). The region enjoys a well-developed railway network due to presence of the Paradip Port and important cities of Cuttack and Bhubaneswar. Cuttack and Paradip are connected by a double electrified line. Cuttack serves as the main transit node for ECoR. Several important railway sections emanate from Cuttack including Talcher/Angul, Paradip, Bhadrak and Khurda. Major stations include Talcher, Angul, Sukinda, Dhenkanal, Bhadrak, Paradip, Bhubaneswar and Khurda. Along with double line Rail networks, the catchment also has several private sidings as listed below with their Siding codes:

- Cuttack
  - Aarti Steels (Aarti) – ASNG
  - Indian Charge Chrome / Indian Metals & Ferro Alloys (IMFA) – ICCC
  - Orissa Cements Limited (OCL) – MOIB
- Paradip
  - Paradip Port Trust – PPSM, PPTG, PPTP
  - Indian Oil Corporation (IOCL) - IOSP
  - Hindustan Petroleum Corporation Limited (HPCL) - HPPK
  - Paradip Phosphates Limited (PPL) – PRPL & PPGP (for gypsum)

Majority of the large industrial players are serviced by their private railway sidings for transport of raw materials and finished products. The rail network in the region is integral to transportation of raw materials (coal, iron ore, minerals, limestone) to major industrial areas (Jajpur, Dhenkanal, Angul, Paradip). Additionally, the rail network connects import/export traffic at Paradip port to the neighbouring states and rest of India. In view of increasing cargo traffic, a new 82 km line connecting Paradip to Haridaspur is under construction with expected completion in 2018.

However, despite an extensive rail network, the current system is bottlenecked at Cuttack. The Cuttack junction serves as a transit point, with negligible loading and unloading operation, for rest of Odisha and neighboring states witnessing significant freight and passenger traffic. All import and finished product traffic flowing inland from Paradip passes through Cuttack to reach all over India. Similarly, export products such as coal, iron ore from mines are being exported from Paradip Port moving via the Cuttack junction. This has created a congestion in the network with the Cuttack junction witnessing movement of 25-30 rakes per day as compared to the estimated demand of 45-50 rakes per day.

Figure 4-3: Connectivity between Paradip and Cuttack



4.1.2. Population of Hinterland area

The subject stretch of waterway passes through three districts of Odisha – Cuttack, Kendrapada and Jagatsinghpur. The combined population of these districts is 26 lakhs (as per 2011 Census) as shown below:

Table 4.4-1: Hinterland Population

Head	Population (2001 Census)	Population (2011 Census)
Cuttack	13,02,005	14,40,361
Kendrapada	10,57,629	11,36,971
Jagatsinghpur	47,00,728	52,01,802
Total	**23,41,094**	**26,24,470**

The waterway connects important cities of Cuttack and Paradip. While Cuttack city has a population of ~6 lakh, Paradip municipality has only ~70,000 residents. As evident from its population, Paradip lacks any major urban development and mainly serves the purpose of an industrial / port centric town.

Apart from these cities, the waterway lacks any other major settlement en-route. There are some villages located along the subject stretch with the major ones being Salipur, Asureswar, Danpur, Karilopatana, Jamapara, Mehendinagar, Athabatia, Gaudabadpur and Sathiabati. However, all these villages have population of less than 3,000 each.

4.1.3. Existing and proposed Industries

As mentioned above, the primary industrial clusters in catchment area include the Cuttack Industrial cluster as well as the Paradip industrial cluster.

The region has a presence of ancillary and downstream metal industries as well as cement manufacturing. Captive power plants are also associated with many large-scale industries. The relevant industrial clusters have been described in detail in the following sections.

4.1.3.1. Cuttack Industrial Cluster

The Cuttack industrial cluster is spread over the areas of Athagarh, Chaudhwar, Jagatpur, Nuasasan and Nidhipur. There are more than ~13,000 industrial units in the region with 16 active large and medium scale registered units. Following are the major industries in this cluster.

- Iron & Steel
  - **Sponge Iron**- Aarti Steel
  - **Ferro Alloys**- Indian Metals & Ferro Alloys Ltd., T.S Alloys
  - **Steel**- Sri Hardev Steel, Biraja Steel & Power
- Others
  - **Cement**- OCL India
  - **Glass & glass products**- Orissa Industries
  - **Bottling plant**- Tripti Drinks
  - **Paper**- COS Board
  - **Sugar & spirit**- Badama Sugar India

- **Refractories**- Manisree Refractories
- **Oxygen gas**- Paradip Oxygen
- **Project Material**- RBS Transmissions

Out of the commodities produced, major exportable items include Steel, Ferro Chrome whereas the rest are used for domestic consumption and distribution.

Also, there are 8 industrial areas in Cuttack – Cuttack, Jagatpur (Old and New), Choudwar, Athagarh-Radha Damodarpur, Atahgarh-Ankula, Nuasasan and Nidhipur.Major commodities produced by them include Spices, Readymade Garments, Pharmaceuticals, Electronics (UPS and Inverters), Engineering products (Gates, grills, shutters), and Fly ash bricks among others. These areas are characterized by small / micro industrial units only. **Such industries predominantly cater to domestic markets with no significant potential for export or import. Hence, this category of industries is not considered as a relevant contributor to waterway traffic.**

4.1.3.2. Paradip Industrial Cluster

The Paradip industrial cluster falls under Jagatsinghpur district. It has 7 active large-scale industrial units:

- **Fertilizers**- IFFCO, Paradip Phosphates
- **Steel**- Essar Steels
- **Coke oven products**- Paradip Carbons
- **Marine products**- Falcon Marines
- **Structural metal products**- Kalinga Engineering
- **Food Products**- Surya Foods

Majority of the products are exported including fertilizers, edible oil, calcined petroleum coke and marine products. Some by-products such as Gypsum, etc. are utilized as raw materials in cement industries, brick kilns and are sent to nearby industries in Cuttack.

In addition, there are 3 industrial areas in Paradip, Udayabhat and Bhitargarh focused on marine and craft products. **Majority of the produce is exported and hence, hasn't been considered as relevant for waterway traffic.**

4.2. Commodity Composition / Categorization

4.2.1. Agricultural Commodities

Agricultural production in Cuttack, Jagatsinghpur and p district is given below:

Table 4.4-2: Agricultural Production in the catchment area ('000 tonnes/annum)

District	Rice	Pulses	Other Grains	Food	Oilseeds	Total agricultural output
Cuttack	**249**	52	3		24	**328**
Jagatsinghpur	**139**	23	0		19	**182**
Kendrapara	**170**	30	1		18	**218**

The catchment area is characterized by rich fertile soil being part of river basin. As a result, large part of catchment is covered by agricultural fields. Rice is the main cultivated crop in the region and contributes over 80% of the total agricultural output. Majority of the rice production in the area is procured at Cuttack and nearby towns / villages of Choudwar, Jagatpur, Athagarh, Salipur, Mahanga etc at Odisha State Civil Supplier Corporation Ltd. Godowns. Significant quantity of procurement is used for local consumption on account of large catchment population (15 - 20 lakhs). Transport of agricultural produce via waterway is not viable on account of the following reasons:

- **Distributed Production**: The area is characterized by presence of large number of small farmers (small farmlands). Hence the production is spread across the entire area nearby the waterway.
- **Cost Savings:** Considering low cargo volume and small transport distances, the waterway savings reduce significantly and even become negative. The farmer would prefer to directly take the produce to the procurement centres opposed to

doing multiple handlings on waterway transport. Well-developed transport network enables quick and effective transport of grains from farms to go downs.

Hence, there is no potential of organized transportation of food produce through the subject waterway. No waterway intervention is recommended towards provision / upgradation of any such facilities and infrastructure.

4.2.2. Industrial Commodities

For the purpose of estimating the potential traffic on the waterway**, only large and medium scale industries with EXIM potential have been considered as contributors to waterway traffic** due to following reasons

- **EXIM Potential:** As the proposed waterway links the proposed river terminal at Cuttack to Paradip port, the primary traffic on the waterway will comprise of raw material imports and finished product exports. Cuttack in itself is not a major consumption centre. Hence commodities with EXIM movement have been considered.
- **Scale of operations:** Small and micro industries are primarily focussed on catering to domestic markets. Individual commodity flow in these facilities is negligible and hence have not been considered under potential traffic for waterway.

4.2.2.1. Cuttack Industrial Cluster

Post preliminary assessment, Cuttack cluster comprise of the following relevant industries.

Table 4.4-3: Relevant Industries – Cuttack Cluster

S.No.	Industrial Unit	Commodity Produced	Actual Production (MMTPA)	Raw Materials (MMTPA)
1	OCL India	Cement	1.20	Slag - 0.7 Gypsum – 0.06 Cement Clinker – 0.5
2	Aarti Steels	Sponge Iron	0.24	Coal – 0.1 Iron Ore – 0.4 Dolomite – 0.012
3	Sri Hardev Steel	Sponge Iron	0.04	Coal – 0.05 Iron Ore – 0.1 Dolomite – 0.002
4	Biraja steel and power	Sponge Iron	0.02	Coal – 0.02 Iron Ore – 0.03 Dolomite – 0.001
5	T.S. Alloys Limited	Ferro Chrome	0.05	Chrome Ore – 0.5 Coal – 0.1 Coke – 0.1
6	IMFA, Choudwar	Ferro Chrome	0.20	Chrome Ore – 0.5 Coal – 0.1 Coke – 0.1

Following section gives the information regarding the raw material and finished products in the Cuttack cluster.

Raw Materials

- **Slag –** Slag is a by-product of Steel industry and is used as a raw material for Portland cement production.
- **Coal / Coke** – Coal and Coke find multiple uses as raw material in metal industries as well as Thermal power plants.
- **Iron Ore –** Primarily used as a raw material in metal industries

- **Dolomite / Quartzite** – Primary raw material in metal industries, Dolomite is used as flux for the smelting of iron and steel and is generally preferred over Quartzite as a more economical alternative
- **Gypsum –** By-product in fertilizer manufacturing, Gypsum is used as raw material in cement manufacturing
- **Cement Clinker–** Intermediate product in cement manufacturing, cement grinding plants source clinkers from cement manufacturing plants.
- **Chrome Ore –** Primarily used as a raw material in ferro alloy / steel production

Finished Goods

- **Cement –** Cement is produced by OCL in the catchment.
- **Ferro Alloys –** Ferro Alloys (primarily Ferro Chrome) is an intermediate product and is used in production of stainless steels
- **Sponge Iron** – Sponge Iron is an intermediate product and is primarily used in the production of wrought iron as well as steel

A summary of volumes of various commodities in the Cuttack industrial cluster is as given in the following table.

Table 4.4-4: Commodity Profile – Cuttack

S.No.	Commodity	Quantity in MMTPA
Raw Materials		
1	Slag	0.7
2	Coal / Coke	0.4
3	Iron Ore	0.5
4	Dolomite / Quartzite	0.02

S.No.	Commodity	Quantity in MMTPA
5	Gypsum	0.13[2]
6	Cement Clinker	0.5
7	Chrome Ore	0.5
Finished Goods		
1	Cement	1.20
3	Ferro Chrome	0.25
2	Sponge Iron	0.30

4.2.2.2. Paradip Industrial Cluster

Post preliminary assessment, Paradip cluster comprise of the following relevant industries.

Table 4.4-5: Relevant Industries – Paradip Cluster

S.No.	Industrial Unit	Commodity Produced	Actual Production (MMTPA)	Raw Materials (MMTPA)
1	IFFCO Fertilizers	Fertilizers	DAP – 0.9 A. Phosphate – 0.6 Gypsum – 0.05 NPKF – 0.2	Rock Phosphate – 2.5 Sulphur – 0.5 Ammonia– 0.35 MOP – 0.06 Urea – 0.03
2	Paradip Carbons	Sponge Iron	C P Coke – 0.1	P. Coke – 0.15

[2]Gypsum movement consists of 0.06 MTPA (required for OCL India plant) + 0.07 MTPA (for various brick kilns and small industries located near Cuttack).

S.No.	Industrial Unit	Commodity Produced	Actual Production (MMTPA)	Raw Materials (MMTPA)
3	Paradip Phosphates	Fertilizers	DAP – 0.7 S. Acid – 0.66 P. Acid – 0.2 Gypsum – 0.01	Rock Phosphate – 2.0 Sulphur – 0.37 Ammonia– 0.3 MOP – 0.03 Urea – 0.01
4	Essar Steels	Steel Pellets	Steel pellets – 6 (Capacity)	Iron Ore Slurry – 6 P. Coe – 0.05

Following section gives the information regarding the raw material and finished products in the Paradip cluster.

Raw Materials

- **Fertilizer related raw material –** Rock Phosphate, Sulphur, Ammonia, MOP and Urea
- **Coke** – Coke is primarily used as raw material for production of Calcined Petroleum Coke
- **Iron Ore Slurry –** Iron Ore Slurry is primarily used as raw material in Steel palletization plants

Finished Goods

- **Fertilizer and Fertilizer related products-** Primarily used in agricultural industry.
- **Gypsum –** Created as a by-product of fertilizer industry, Gypsum is primarily used as a raw material in cement industry. Gypsum also finds use in manufacture of fly-ash bricks among other uses.
- **Calcined Petroleum Coke**– Primarily used in Steel industries

A summary of volumes of various commodities in the Paradip industrial cluster is as given in the following table

Table 4.4-6: Commodity Profile – Paradip

S.No.	Commodity	Quantity in MMTPA
Raw Materials		
1	Iron Ore Slurry	6.0
2	Rock Phosphate	4.5
3	Sulphur	0.4
4	Ammonia	0.65
5	MOP	0.1
6	Urea	0.04
7	P. Coke	0.2
Finished Goods		
1	Steel Pellets	6.0
2	DAP	1.6
3	Ammonium Phosphate	0.6
4	Sulphuric Acid	0.6
5	Gypsum	0.25
6	NPKF	0.2
7	Phosphoric Acid	0.2
8	C. P Coke	0.1

IFFCO Plant - Paradipo

IFFCO plant at Paradip Port, is located on the banks of waterway. With support from promotion to inland waterway in India (under Sagarmala Project), IFFCO plant is desirous of using coastal shipping and waterway transport for domestic movement of fertilizers.

The fertilizer is currently transported majorly via rakes. However, due to easy access to coastal shipping (direct frontage of Mahanadi / Bay of Bengal Confluence) and issues in rake availability, the plant was desirous of constructing a captive jetty at their Paradip plant. IFFCO had maintenance plans for constructing captive jetty at their Paradip plant as far back as 2012. Driven by government support to promote waterway / coastal transport, IFFCO may also be able to achieve cost savings w.r.t. rail transport. However, detailed cost analysis has not been done as this cargo would use <10km of waterways, which falls under tidal influence. Hence, this cargo is not relevant as it would neither generate meaningful revenues nor require any IWAI investment for operationalization.

IFFCO plant can potentially move up to 1.5 – 2MTPA of fertilizers using waterway[34]. IFFCO would develop their own captive waterway terminal at their plant location and ply 1,500 – 2,000 DWT barges for coastal shipping followed by waterway transport.

4.3. Origination / Terminating Commodities

The flow of raw materials and primary manufactured products has been studied for the relevant industrial clusters, as described below. The flow is used to determine the relevant cargo traffic in the catchment for waterways.

Raw Materials

- **Slag –** OCL India is the primary consumer of Slag in the Cuttack Industrial area requiring ~0.7 mn tons of Slag annually. The slag is sourced from iron and steel plants in Jajpur, Kalinganagar tec.
- **Coal / Coke** – While majority of coal requirement in the catchment is met through coal mining in Talcher Valley and Ib Valley mines, the coal quality is not appropriate

[3]Traffic would traverse <10km on waterway (near Paradip mouth of the river)

[4]The plant has a production capacity of ~3 MTPA (mainly DAP/NPK, Sulphuric Acid, Phosphoric Acid). While ~50% of produce is transported to smaller nearby catchment (Odisha, Chhattisgarh etc.) via road and rakes, rest is transported via rakes to states of Bihar, UP, West Bengal, Karnataka, Andhra Pradesh and Jharkhand. The later quantity is considered as relevant for transport through coastal shipping and is estimated as 1.5 – 2 MTPA based on FOIS railway data. For servicing UP, Bihar and Jharkhand use of coastal shipping followed by transport of NW-1 has already been proposed.

and requires mixing with higher quality imported coal /coke for use in industries. The coal is imported at Paradip Port.

- **Iron Ore –** Industries in the Cuttack region source iron ore from Daitari mines situated in Harichandanpur tehsil of Keonjhar district and Dangadi tehsil of Jajpur district, ~120 km from Cuttack.
- **Dolomite / Quartzite** – Sundargarh district is the only source of Dolomite in the State situated ~350 km from Cuttack.
- **Gypsum –** Cuttack-based cement industries and brick kilns source Gypsum primarily from Fertilizers plants such as IFFCO etc. located in Paradip. Gypsum depots in Cuttack witness transactions in the range of 1.5-2 lakh tons of Gypsum annually. The same has been considered as relevant traffic for waterways.
- **Cement Clinker–** Cement grinding plants of Cuttack primarily source clinkers from cement manufacturing plants located in Rajganpur near limestone mines.
- **Chrome Ore –** Odisha houses 98% of India's total chromite deposits. Cuttack-based industries source Chromite ore from Sukinda Mines in Kaliapani Odisha, located ~120 km from Cuttack.
- **Fertilizer related raw material –** Rock Phosphate, Sulphur, Ammonia, MOP and Ureaamong other are predominantly imported via Paradip Port from South Africa, Australia and other locations.
- **Iron Ore Slurry –** Iron Ore Slurry is sourced via pipeline from Steel industries in Dabuna, Odisha.

Finished Goods

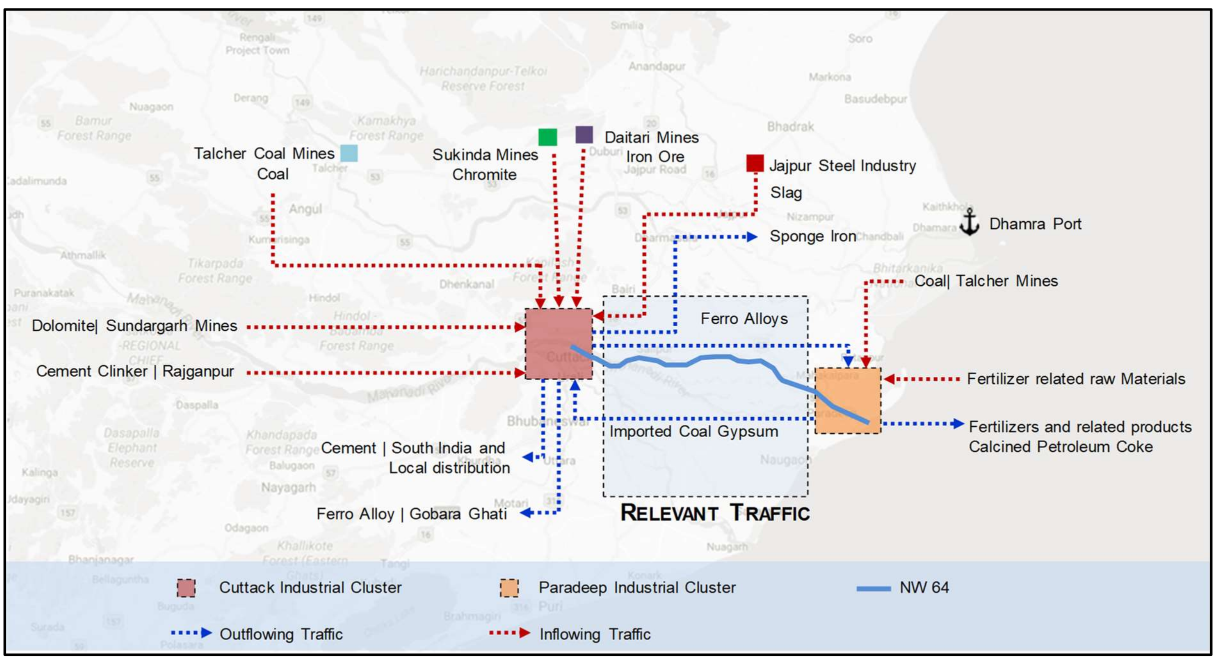
- **Cement -** Cement produced at Cuttack is entirely used for domestic consumption and distribution in Southern Odisha and nearby states.
- **Ferro Alloys –** Ferro Alloys manufactured in Cuttack is sent to Stainless steel manufacturing plants in GobaraGhati, Odisha (~80 km) as well as exported via Paradip port
- **Sponge Iron** – Sponge Iron produced from the Cuttack cluster is primarily sent to Steel and Iron Industries located in Jajpur, Odisha and other parts of Northern India

- **Fertilizer and Fertilizer related products –** Fertilizer produced at Paradip based plants is primarily sent via rakes to 16 states of India. The same has not been considered as relevant traffic as offload of fertilizers at Cuttack is insignificant in the range of 15 - 20,000 tons per annum
- **Calcined Petroleum Coke** – Primarily used in Steel industries located in Angul or exported via Paradip Port

4.3.1. Relevant Traffic

The commodity flow for the relevant industrial clusters i.e. Cuttack and Paradip cluster is as shown in the following map.

Figure 4-4: Commodity Flow in Hinterland



As mentioned earlier, Inland waterways is economically suited to carry large volumes of bulk commodities over long distances. The bulk commodities moving in the direction of the proposed waterway i.e. Between Cuttack and Paradip have been considered as relevant traffic and is as summarised in the table below.

Table 4.4-7: Commodity Details

S.No.	Commodity	Quantity in MMTPA
	Finished Goods	
1	Gypsum	0.13
2	Ferro Chrome	0.10
	Raw Materials	
1	Coal / Coke	0.39
	Total	**0.62**

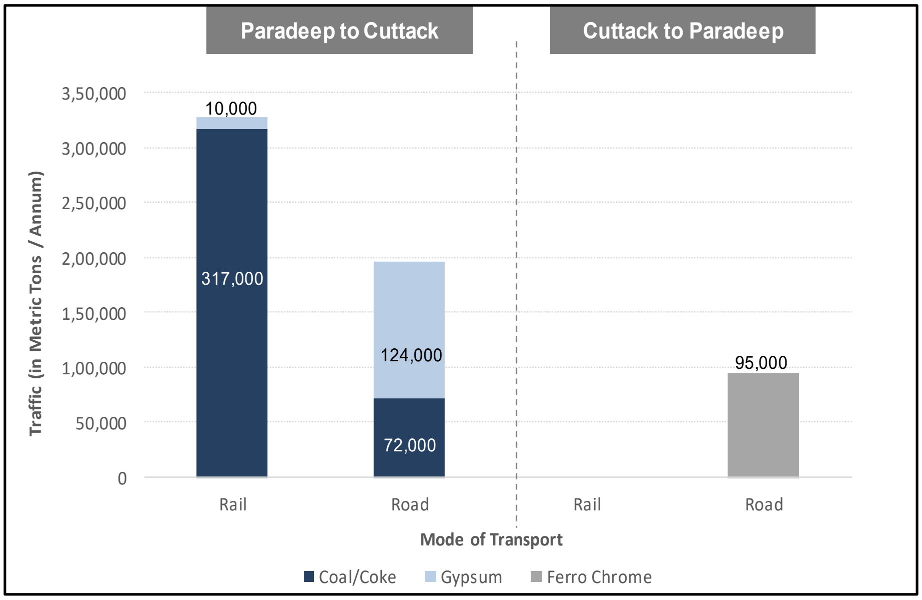
Please note the following points:

- **Gypsum**: As highlighted in Cuttack Commodity Profile section, Gypsum movement into Cuttack (**0.13 MTPA**) comprise of raw material demand of OCL India Plant (0.06 MTPA) and various brick kilns and small industries (0.07 MTPA) located nearby Cuttack.
- **Ferro Chrome**: As highlighted above, total 0.25 MTPA of ferro chrome is produced in Cuttack (IMFA and TS Alloys Ltd). However, 0.15 MTPA of the above output is exported from Vishakhapatnam Port due to long term contracts between manufacturers and the port. Remaining **0.10 MTPA** of output is exported via Paradip Port.
- **Coal / coke**: As highlighted above, total movement of imported coal/coke between Cuttack and Paradip Port is **~0.4 MTPA**. This is mainly contributed by demand of major sponge iron and ferro chrome plants which rely on imported coal.

In addition to above, 1.5 – 2 MTPA of fertilizer traffic (IFFCO plant at Paradip) can also be captured onto the waterway for a small stretch at the Paradip end.

Following figure shows the model split for the above-mentioned traffic.

Figure 4-5: Modal Split of Relevant Traffic



Based on the above figure, the following observations can be made:

- **Ferro Chrome** is exclusively transported through road from industries in Cuttack (TS Alloys, IMFA) to Paradip. Due to low quantities of ferro chrome, the rate of production is less. As a result, transport through rails is not feasible.
- **Coal/ Coke** is majorly transported through rail. This trend is dominated by large industries (including Aarti Steels, IMFA, OCL) which possess private railway sidings and hence prefer to use railways over trucks. Only smaller players (Hardev Steel, Biraja Steels) use trucks to transport coal due to lower quantities. Usually, coal traders import shiploads of coal, store it at their depots/sheds and transport it downstream to small industries via trucks.
- **Gypsum** is primarily transported through road only. It is imported at the Paradip port along with some production as by-products from fertilizer plants at Paradip (IFFCO, PPL). Several inland cement plans (Ultratech, Ambuja, Melcon etc.) transport gypsum from Paradip using rakes. However, in the catchment area gypsum is used by OCL and several small fly ash brick units. Due to highly segregated demand and lack of any major players, gypsum is transported by traders / fertilizer companies using trucks only.

In summary, the major players in the catchment area use their private railway sidings for transporting bulk materials (mainly coal) and the small players usually rely on trucks due to short distances and low demand. In addition to above, some petroleum products (transported by tankers) and negligible quantities of iron files (by-product of steel/iron industries) are also transported along this route.

4.4. Passenger Traffic

Mahanadi river and its tributaries (including Luna) are navigable for less than third of a year due to lack of sufficient water (significant water being diverted for consumption & irrigation, heavy siltation). Hence the waterway is usable for only small country boats in limited stretches and during limited time period only.

Due to well-developed road infrastructure and absence of any large villages along the river stretch, **cross-ferry passenger movement on the river is negligible** and limited to some downstream stretches where river has sufficient water. Fishing activity in the region is limited to Mahanadi estuaries near the Paradip port. Fishermen use the NehurBangala Service Harbour at Paradip (right at the confluence of Mahanadi with Bay of Bengal). Hence, it does not contribute to any boat movement along the waterway. In addition, some local unorganized fishing activities are conducted along the subject waterway using make-shift small boats.

Currently there is no meaningful passenger traffic plying on the subject stretch of the waterway. Hence, no waterway interventions are recommended towards provision of such infrastructure and facilities.

4.4.1. Tourism Traffic

The waterway currently has negligible tourism activities. Some boat ply to Dhabaleswar temple (located on a river island near Cuttack). Minor water sports (scuba diving, wind surfing) activities have been established upstream of Jobra barrage. River cruise services were started by Seashore Group but were shut down later. **Hence, the tourism activities currently contribute negligible traffic onto the waterway.**

The waterway, however, has significant tourism potential on account of following factors:

- **Serene Surroundings**: The river traverses through lush green surroundings and adjoining agricultural farms which serve as a scenic backdrop
- **Pleasant Weather**: The river enjoys pleasant weather throughout the year, even during summer evenings. Thus, it can become a popular family outing destination during summer months.
- **Large Tourist inflow**: Large number of tourists already visit the ecosystem comprising of Puri, Konark, Bhubaneswar, Bhitarkanika National Park etc. These tourists can be targeted for marketing of tourist facilities on the waterway.
- **Large Catchment Population**: 14 lakhs plus population of Cuttack and Bhubaneswar provide ready base for promotion of tourism activities

Hence development and marketing of hospitality (resorts, restaurants, leisure points, treks, boat / cruise rides), water sport activities, riverfront development etc. should be explored on the waterway. Both short and long leisure trips can be organized on the waterway. Entire waterway subject stretch (in addition to waterway stretch upstream of Jobra barrage) should be included in the tourist experience as the waterway would be operational (and navigable) post development for industrial cargo movement. As the tourist activities pick up on the waterway, night tourism / night boat rides and overnight cruise services can also be explored. Tourism activities on the waterway would not only promote the region, but also supplant the local economy, create economic opportunities and provide employment to local populace.

Hence it is recommended to explore waterway related tourism potential in the region and promote such activities through concerted government efforts and involvement of private players. Private players can be invited for development of infrastructure & facilities, procurement of boats and operation of tourist services on PPP or lease model.

4.5. Ro-Ro Traffic

Due to presence of well-developed road and railway infrastructure, the **waterway currently has no Ro-Ro traffic.**

Operation of Ro-Ro barges for transport of industrial cargo between Cuttack and Paradip is economically unviable due to the following factors:

- **Lower utilization of Ro-Ro Barge**: A 1,500 DWT barge can carry only 36 trucks (~750 tons) as opposed to ~1400 tons in bulk transport. Hence barge utilization is only **50% for Ro-Ro barges**. This is due to only 1-2 decks for Ro-Ro (due to height restriction), inefficient truck packing and additional weight of trucks themselves.
- **Higher per unit transport costs**: Due to 50% utilization, unit transport cost of **Ro-Ro barge increases to ~INR 2 / ton / km** (compared to ~INR 1 / ton / km for bulk barges[5]). In comparison, the **road transport costs are ~INR 2.5 / ton / km** which is only 25% higher than Ro-Ro transport costs.
- **Addition Truck costs in Ro-Ro Barge**: Truck driver costs, maintenance costs and truck hiring charges are still incurred in case of Ro-Ro barges

The above factors result in negligible difference between direct trucking and Ro-Ro barge transport costs. Hence Ro-Ro barge transport case has not been considered.

4.6. Growth Trend

Paradip Industrial Expansion - As mentioned earlier, a Petroleum, Chemical and Petrochemical Investment Region (PCPIR) is being developed at Paradip. The development of Smart Industrial Port City (SIPC) has also been proposed for Paradip. These mega projects would significantly increase the industrial output of Paradip cluster. The investment region is proposed to spread over 284 sq. km. The IR would have IOCL as the anchor tenant which has already set up a 15 MMTPA oil refinery at Paradip. PCPIR would have frontage of ~20km along NW-64, extending from confluence with Bay of Bengal till Kuanarpal village (nearby NH-53 river bridge crossing).

[5] Based on RITES Report of 2014 on “Integrated National Waterways Transportation Grid (INWTG)” - http://pib.nic.in/newsite/PrintRelease.aspx?relid=159571. This represents the haulage cost of waterway transport (barge transport) only and excludes any terminal charges / handling charges / last mile transport costs that might also apply.

However, it is expected that majority of the cluster outputs (chemicals, plastics, petrochemicals) would be transported directly through road / rail domestically all over India or exported directly from Paradip Port. Similarly, the demand of raw materials would be majorly met through imports at Paradip port only (as majority of industries would be import based industries). **Hence, any potential for relevant traffic which is originating / destined to Cuttack or nearby areas is not expected from the upcoming developments at Paradip.**

Industrial Growth - The catchment area currently has limited number of large / medium industrial units comprised of iron & steel and cement plants. Relocation of coal mines and iron ore mining scam have led to the closure of few large-scale industries in the area. Currently, there are **limited industrial expansion plans** in the catchment. Based on industry interactions, only Aarti steels (steel and ferro chrome) and Hardev Steels (sponge iron capacity) have plans to expand their current capacities production capacity. However, the expected addition in total capacity is less than 50,000 tons over the next 3 years. Overall, industries in the region are conservative in expansion due to lack of clarity on macro parameters (mining permissions, development / upgradation of trunk infrastructure, market demand etc.). Restoration of mining operations with time would however boost the industrial sector in the region.

Container Traffic - Paradip International Cargo Terminal (PICT) is also expected to be fully operational in 2018 itself. The terminal with a draft of 17m (450m berth length) and capacity of 5 MMTPA would handle clean cargo (iron and steel products, aluminum ingots, pig iron, finished fertilizer, food grains and sugar) including containers. The terminal plan includes ~12 acres container yard. While minority of container traffic would be transported to Cuttack and nearby areas, waterway transportation of Containers is not recommended due to high handling and storage costs. For reference, container handling charges at Vishakhapatnam Container Terminal are INR 4,200 per TEU (foreign) for composite handling[6]. Hence, waterway transport would incur additional ~INR 8,400 handling cost in comparison to road transport as explained below:

- Ship to Container Yard: Common for both road and waterway
- Container Yard to Barge (Origin): Additional 4,200 for waterway transport
- Barge to Container Yard (Destination): Additional 4,200 for waterway transport
- Container Yard to Truck: Common for both road and waterway
- Truck to Factor Premises / Warehouse: Common for both road and waterway

In comparison, end to end Cuttack to Paradip container transport rates for trucks are expected to be INR 10,00 - 12,000 per TEU. **Hence, waterway transport of containers is not recommended on account of usually high container handling charges.**

Coastal Shipping – The government, through its ambitious Sagarmala project aims to promote inland waterways and coastal shipping for cargo movement. The subject waterway has large scale industries in Paradip, including PSUs which can be desirous of using the coastal shipping route. IFFCO, as mentioned above, has proposed to set up a captive jetty at its Paradip plant. Similarly, other large-scale industries may employ coastal shipping for domestic distribution of their products. It should be noted however, that **movement of such cargo on subject waterway is not expected as** (a) Cuttack in not a consumption centre, but a transit point (b) Transport of cargo from Paradip to Cuttack on waterway would require mode change at Cuttack thereby further increasing congestion at Cuttack. Only IFFCO plant, because of its location on the waterway is expected to use a small stretch of waterway (6-7 km) for accessing the sea.

4.7. Forecasting and Potential IWT Assumptions

Note – As highlighted in the report, the waterway currently benefits from leakage in Cuttack barrage. As per information provided by state government officials, the leakage is being corrected. This would leave negligible water in the subject stretch from Cuttack Barrage to Paradip River Mouth. In such a scenario, the waterway navigability would be

[6] Including handling by quay crane, lashing / unlashing, transport between container yard and quayside, lift on / off at container yard. Scale of Rates issued by Visakha Container Terminal Private Limited for 2015, "*http://www.vctpl.com/vctpl-terminal-tariff.pdf*"

severely restricted. The navigation would only be possible in the monsoon season and couple of subsequent months.

Hence, while the waterway stretches for 98 km, there is merit in analysing traffic for 43 km waterway length (**from Paradip sea mouth to Chainage 43 km is under tidal influence**). Such stretch would allow better navigability throughout the year. However, **the traffic analysis of this 43 km stretches yields minimal traffic**, and also suffers from other major challenges such as trucker resistance, poor road access etc. Hence, Feedback has explained the **detailed viability of 43 km stretch in the last sub-section of this chapter (Section 4.7.6)**. Rest of this chapter focuses on the traffic analysis of the 98 km stretch only.

4.7.1. Waterway Opportunities

The waterways offer significant **advantages** over other transport modes viz. road and railways:

- **Ready right of way**: Since waterways already have a natural right of way, it does not suffer from land acquisition, land compensation, resettlement and rehabilitation issues and variety of legal issues associated with construction of new road and railways projects.
- **Cheapest Transport Mode**: Waterways have the lowest freight cost (INR / ton / km) of road and railways. One litre of fuel can transport ~200 tons of load for 1 km through waterways as compared to 95 tons on rail and only 24 tons by road[7].
- **Environmentally Efficient**: Due to lower fuel consumption in waterways for the same quantity and distance of cargo transported, they have lower CO2 emissions

At the same time, waterways suffer from following **disadvantages** compared to road and railways:

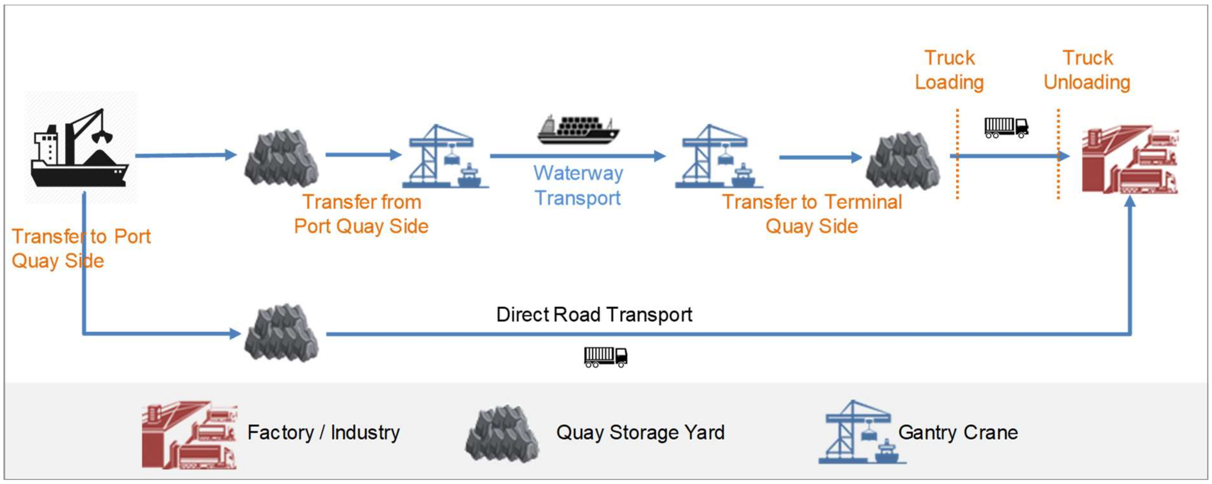
- **Last mile connectivity**: Due to physical RoW constraints of waterways, often first mile or last mile or both are required for waterway transport. Origin or destination

[77]Inland Water Transport to Reduce Overall Logistics Cost, Press Information Bureau; "*http://pib.nic.in/newsite/PrintRelease.aspx?relid=159571*"

points are rarely located right on the waterway itself. Hence additional costs are incurred during such transport.

- **Multiple Cargo Handling**: Due to first mile and last miles, multiple handlings are required as illustrated in the figure below. Multiple handling leads to significant additional handling costs and time.

Figure 4-6: Multiple Handling in Waterways



- **Longer transport times**: Waterway barges (10-12 km/hr) are much slower as compared to road or rail transport. Hence a ~4 hours door to door journey from Cuttack to Paradip (~100km) on road / rail would require ~15 hours on waterway (waterway transport, handing, first / last mile). Without night navigation, the journey can extend to 2 days.
- **High maintenance costs**: Channel dredging and maintenance dredging incur high capital costs. The costs are higher for rivers like Mahanadi which have high siltation.
- **Seasonality**: Waterway suffer from navigability challenges during summer (no water) and rainy seasons (unsafe operations). The subject waterway is not navigable during summer months. Industries would have to seek alternative transport modes during these time period.

Hence, waterway transport is considered viable for (a) longer waterway stretches where freight cost savings over long lengths compensates for additional first / last mile and handling costs on waterways (b) perennial rivers which are navigable during long summer months (c) rivers with traffic centres (industrial, passenger) in close proximity of the river so that first / last mile costs are minimized.

The subject waterway benefits from proximity of Paradip port. It is recommended to use the port's berth by payment of relevant port charges. The port is capable to handle barges. The road freight charges in the region are high which provides the opportunity for diverting traffic onto the waterways. The cost comparison of the three modes is as follows:

- Road costs
    - Transport Cost – comprising mainly of fuel and sustenance cost
    - Handling charges – Loading and unloading charges charged based on the type of commodity
    - Detention Charges – Occurring due to unforeseen events such as landslides, etc. Such charges would be **not applicable** for the subject stretch as the route is within the same state and totals ~100 km only.
    - Toll charges – Charges of ~INR 900 for two toll plazas between Cuttack and Paradip. These charges are **not applicable** as these are temporary charges and would be removed in the future.
- Rail costs
    - Handling charges – Loading and unloading charges determined based on the type of commodity
    - Freight Charges – slab-wise rates as defined by Indian railways; commodity dependent
    - Last Mile Connectivity – **Not applicable** as the major players have private railway sidings
- Waterway costs
    - Waterway Usage Charges – Charges towards construction and maintenance of navigable waterway; also, called fairway charges
    - Various Terminal Charges – Includes Vessel Related Charges (berth hire, pilotage, towage etc.) and cargo related charges (wharf age, cargo handling – either manual or through hired equipment such as Cranes, forklift, etc.)

- Last Mile Connectivity – Charges for freight transport through trucks from river terminal (at Cuttack) to the industries' locations

Freight charges are derived for **coal** under the following considerations.

- Rail (~INR 2.3 / ton / km) – Calculated based on rates declared by Indian Railways
- Road (~INR 6 / ton / km) – Based on interactions with Truck Owners Associations
- Waterway (~INR 2.2 / ton / km) – comprised of operations. costs (INR 1.06 / ton / km)[8] and barge operator margins (INR 1.14 / ton / km)

Note – Based on experience in waterway sector, a 100% margin is typical in barge operations. The margin is high due to significant market / traffic risk, large depreciation costs, contingencies associated with waterway operations. Hence, we have also assumed Barge Haulage Charge as INR 2.2/ton/km, which includes INR 1.1/ton/km as operating costs and margin of INR 1.1/ton/km. This translates to barge operator margin of ~INR 100/ton on the waterway stretch (~100 km). For revised waterway stretch of ~43km, the barge operator margin would be ~INR 50/ton. Further, we proposed that IWAI can reasonably charge 20% of this margin / 10% of end-user charges, in lieu of provision of waterway infrastructure and associated facilities. This would still leave sufficient margins for the barge operator to ensure waterway's financial attractiveness.

Haulage time has been calculated based on following considerations:

- Road: 300 - 400 km / day
- Rail: 300 – 400 km / day
- Waterways: 200 km / day
  - Average Speed (upstream and downstream) – 7 knots
  - Discharge rate: 200 to 300 tons / hr
  - Cargo Handling time: 8 - 10 hrs

Handling charges has been calculated based on following considerations:

- Handling Rate (for coal)

[8]As per estimates of transport costs http://pib.nic.in/newsite/PrintRelease.aspx?relid=117695

- Truck Loading[9]– INR 30 / ton
- Truck Unloading – INR 20 / ton
- Crane Handling (loading / unloading) – INR 35 / ton[10]

- Common Costs –following charges are common to all 3 modes and hence need not considered –
  - Port Wharf age
  - Ship to Port Storage Yard (Stevedoring and shore handling)
- Rail
  - Common costs as indicated above
  - + 1 handling from port storage yard to rake (INR 30 / ton)
  - + captive handling at plant (not considered due to very low costs)
- Road
  - Common costs as indicated above
  - + Truck loading at port storage yard (INR 30 / ton)
  - + Truck unloading at factory (INR 20 / ton)
- Waterways (Refer Figure 4.6 above)
  - Common costs as indicated above
  - + Crane transfer from port storage yard to barge (INR 35 / ton)
  - + Crane transfer from barge to waterway terminal storage yard (INR 35 / ton)
  - + Truck loading at waterway terminal storage yard (INR 30 / ton)
  - + Truck unloading at factory (INR 20 / ton)

[9]Based on primary interactions, loading a truck of coal cost INR 400-450 and unloading costs INR 300-350. Thus considering 15 tonne truck, coal loading rate is INR 30 / ton and unloading rate is INR 20 / ton.
[10]Based on published Scale of Rates (2017) of Paradip Port Trust – charges for hire of Harbour Mobile Crane (HMC)

Table 4.4-8: Transport Cost Comparison between Road, Rail and Waterway[11]

Transport Mode	Route Length (km)	Handling Charges (INR/ton)[12]	Freight Charges (INR/ton)	Last Mile (INR/ton)	Total Cost (INR/ton)	Transport Time
Rail	91	30	209	-	**239**	**~0.5 day**
Road	105[13]	50	650		**700**	**~0.5 day**
Waterway	110	120 + 21[14]	242	100 (by truck)	**483**	**~1 day**

Following observations can be drawn based on the above figures:

- Road and waterways costs are evenly matched.
- Rail is, by a significant margin, the cheapest transport mode. A major factor for such low costs is provision of private sidings which prevents issues of last mile connectivity.

4.7.2. Traffic Estimation Methodology

The following methodology has been used for estimation of waterway traffic:

- **Estimation of Market Size**: As mentioned previously, Cuttack and Paradip industries have been considered in the catchment. The catchment comprises of iron & steel (sponge iron, ferro chrome, slag as by-product), cement, fertilizer and petrochemical industries. Raw materials (from mines, for industries) including coal, dolomite, gypsum, chrome ore, fertilizer raw materials are also handled in the catchment.
- **Estimation of Relevant Traffic**: As analysed previously, relevant traffic has been derived based on commodity movement along the waterway (traffic between Cuttack and Paradip). Relevant commodities include the following

[11]It should be noted that charges have been calculated after the cargo has been transferred (from ship) to Paradip's storage yard and storage charges have been paid. As these charges would be common to all 3 modes of transport, these have been left out of consideration.
[12] Handling charges considered from / to storage shed at Paradip. Charges for shifting cargo from ship to Paradip's storage yard and storage charges thereafter would be common to all 3 modes of transport, these have been left out of consideration.
[13]Average of to and fro distances have been taken between Paradip and Cuttack due to different routes taken
[14]Additional Port Charges (for Barge handling at Paradip Port) considered as follows – (i) Pilotage and Towage – INR 12.5/GRT (ii) Berth Hire – INR 0.45/GRT (for 8 hours berth hire) (iii) Port Dues – INR 5.95/GRT. Considering 1 GRT = 0.9 DWT, total portscharges – INR 21.0/ton. It should be noted that these port charges are applicable for sea going vessels, and charges for barges are expected to be significantly lower than the above charges.

- **Gypsum** - By product of Paradip Fertilizer industries used as raw material for cement plants and brick kilns in Cuttack
- **Ferro Chrome** – Produced by IMFA and TS Alloys Ltd in Cuttack and exported via Paradip Port
- **Coal /** coke – Imported at Paradip port and transported to iron & steel plants at Cuttack

- **Estimation of Waterway Divertible Traffic:** Relative comparison of transport modes (rail, road, waterways) on various parameters (transport cost, handling, mode convenience, product type and travel time) to arrive at generalized cost of each transport mode and derive modal share of traffic

4.7.3. Divertible Traffic Estimation

Digestibility for waterways is ultimately a competition with rail and road transport over the multiple factors, the most important being the transport costs. Other factors like reliability, transport time, type of cargo etc. also affect the preference of one transport mode over another.

While various models exist for calculating Digestibility, Binary Logit Model is the most widely used. Binary logit model[15] is the simplest form of mode choice, where the travel choice between two modes is made based on assigned costs for the modes. Mode costs are calculated using the generalized cost method. If overall cost for one mode is lower, it is preferred for transport and captures majority of traffic share. The modal share between OD pairs i and j is determined by the following equation:

$$\text{Modal Share} = \frac{e^{-\beta c1_{ij}}}{e^{-\beta c1_{ij}} + e^{-\beta c2_{ij}}}$$

where,

- $C_{ij}$is the generalised cost for travel between i to j
- C_1 is the generalised cost of waterways and,
- C_2 is the generalised cost of the competing mode

[15]Mathew T., Rao K.V.; Introduction to Transportation Engineering, NPTEL; (2007)

- β is the relative weight assigned for each cost item in generalized cost

The generalized cost calculation is based on the following **Influencing Factors**:

- **Logistics Cost** – Actual transport cost for each OD pair including freight, handling, storage and detention costs
- **Mode Convenience** – Mode preference based on distance, administrative overheads, current mode preference and distance slabs (based on Planning Commission Study)
- **Handling** – Considers the type of handling (mechanical, manual), number of handlings, infrastructure availability and handling time
- **Product Type** – Mode preference of a commodity shifts based on life of products, value, volume, susceptibility to pilferage, handling / transfer losses etc.
- **Reliability** – Considers availability of transport mode, both in short-term and long-term. Short-term availability is relevant to cater to instant / spontaneous demand. Long-term availability is relevant to cater to bulk, assured demand.
- **Speed** – Considers time of travel including waiting time / detention time

In this study, the potential for inland navigation was determined from the perspective of the demand side of freight flows. The limiting factors (β / relative weight) can have a substantial impact on the shares of the transport modes and are as shown in the following table. The numeric values to the limiting factors have been derived from the study based on calculating Digestibility on European Waterways – Modal Shift Target for Freight Transport above 300 Km: An Assessment; (2011) by Tavasszy L. The variables considered here have been derived from the European study as follows –

- 'Mode Convenience' has been modelled based on 'Accessibility of Transport Models' variable of the European study, as both concern the ease of using the transport mode from perspectives including nearest terminal / rail station, number of 3PL's involved and general market inertia.
- 'Handling' has been modelled based on 'Transport Distance', as 'Transport Distance' variable in the study, as both variables focus on need for larger transport distances to offset higher handlings cost associated with a transport mode.

- 'Product Type' has been modelled based on 'Product Characteristics'.
- 'Reliability' has been modelled based on 'Size of Shipment' variable of the European study, as both the variables concern the ease of availability of the model for the specific cargo. For example, rail shipments are usually preferred for high volume shipments. Or in other words, rail is more reliable for high volume shipments, as availability is relatively easier for such shipment size.
- 'Speed' has been modelled based on 'Speed' variable of the European study.

Table 4.4-9: Influencing Factors for transportation potential

Limiting Factors	Relative Weights
Logistics costs	1
Mode Convenience	0.87
Handling (Quantum and Infra)	0.61
Product Type	0.5
Reliability	0.35
Mode Speed	0.34

4.7.3.1. Calculation of Generalized Costs

In order to calculate generalized costs, limiting factors for road, rail, waterway have been assigned for the Influencing Factors (higher limiting factor signifies higher generalized costs) **for Moderate Scenario**as described below:

- **Logistics costs –** Considering the comparison of freight transport costs, loading/unloading costs, last mile connectivity costs for all the three modes, the rail is the most preferred option. Hence, limiting factor for rail is 1, and for road and waterway is derived based on the ratio of logistics cost w.r.t rail as derived in table 4.8.
- **Mode Convenience –** Modal convenience is based on the distance to nearest transport hub, number of 3PL contract required. Road provides end to end connectivity from factory to port. Also, industrial plants also have the option of extracting a private siding. In terms of convenience, higher preference has been

assigned to roads and rail, with limiting factor of 1. Conversely, waterways have been assigned a higher limiting factor (of 2) as accessing waterway terminal requires first mile road transport, and there are multiple players involved in the logistics chain (first mile trucker, waterway terminal, barge operator, port).

- **Handling –** In this factor, number of handlings has been considered. Road and rail have one set of handling (one loading and unloading), and hence, assigned limiting factor of 1. Waterways has 2 sets of handling (one crane loading/unloading set, one truck loading / unloading set), and hence, assigned limiting factor of 2
- **Product Type –** The relevant traffic would comprise majorly of bulk commodity only (coal, gypsum, ferro chrome etc.), In this case, waterway and rail would have an upper hand as they both lower spillage and higher safety for bulk cargo. Hence, rail and waterways have been assigned limiting factor of 1, while road has been assigned limiting factor of 2.
- **Reliability**–Reliability is based on ease of availability of transport mode for both short and long-term cargo movement. Only rail has availability issues and has been assigned limiting factor of 2. Both road and waterways have been assigned limiting factor of 1.
- **Mode Speed –** Mode speed is based on the time taken for commodity to reach the destination excluding waiting period. Limiting factor has been assigned based on ratio of travel times as derived in table 4.8.

4.7.3.2. Traffic Scenarios

The traffic divortiality of waterways from both rail and road have been calculated for two scenarios - **Moderate scenario and Aggressive scenario**. Higher Digestibility and higher traffic growth rates have been assumed in the Aggressive scenario. The table below provides the Generalized cost for both scenarios.

Table 4.4-10: Generalized Costs - Moderate Scenario

Influencing Factors	Relative Weight	Waterways	Roadways	Railways
Logistics costs	1	2.0[16]	2.9	1
Mode Convenience	0.87	2	1	1
Handling (Quantum and Infra)	0.61	2	1	1
Product Type	0.5	1	2	1
Reliability	0.35	1	1	2
Mode Speed	0.34	2	1	1
Generalized Costs		**6.52**	**6.10**	**4.03**

The following assumptions have been changed for the Aggressive Scenario –

- **Logistics costs** – Waterway transport subsidy of INR 2/ton/km (total INR 220/ton) has been considered. The **'Scheme for Incentivizing Modal Shift of Cargo'**, while pending Cabinet approval, provides for subsidizing waterway/coastal shipping transport, in order to increase their share in overall cargo movement. Two other factors would further tilt the scale in favour of waterway – large barge sizes (and consequently lower cost), and future industrial development in vicinity of the waterway.
- **Mode Convenience** – Convenience of waterway use would improve once the waterways become operational. This would not only overcome the intertia associated with waterways, but consolidation is also expected in the sector. The focus would be on end-to-end delivery, with the same logistic player taking care of first mile transport, terminal handing, barge transport, port handling or combination of such steps. Such consolidation with help to achieve efficiency, improve margins on 3PL side and improve convenience on customer side.
- **Handling –** no change
- **Product Type** – no change

[16]Based on cost comparison between road, rail and waterways as derived in Table 4-8

- **Reliability** – Road availability is considered to suffer in this scenartioon account of potential congestion / restriction of road movement of bulk cargo. Hence its limiting factor has been increased from 1 to 2.
- **Mode Speed** – no change

Table 4.4-11: Generalized Costs - Aggressive Scenario

Influencing Factors	Relative Weight	Waterways	Roadways	Railways
Logistics costs	1	1.1[17]	2.9	1
Mode Convenience	0.87	1.5	1	1
Handling (Quantum and Infra)	0.61	2	1	1
Product Type	0.5	1	2	1
Reliability	0.35	1	2	2
Mode Speed	0.34	2	1	1
Generalized Costs		**5.17**	**6.47**	**4.03**

4.7.3.3. Divertible Traffic

Based on the Binary Logit Model and the generalized costs calculated for the competing modes, the traffic Divertibility of waterways from both rail and road have been calculated separately for moderate and aggressive scenario. The results are as follows:

Moderate Scenario

$$\text{Modal Share (with respect to road)} = \frac{e^{-6.52}}{e^{-6.52} + e^{-6.12}} = 0.40$$

$$\text{Modal Share (with respect to rail)} = \frac{e^{-6.52}}{e^{-6.52} + e^{-4.03}} = 0.08$$

- **Road:40%** traffic divertible onto waterway
- **Rail:8%** traffic divertible onto waterway

[17]Contingent upon favorable market for waterway operations – (i) Larger barge sizes (ii) Industrial development in the vicinity (iii) implementation of government subsidies for waterway transport

Aggressive Scenario

Modal Share (with respect to road) = $\frac{e^{-5.17}}{e^{-5.17} + e^{-6.47}}$ = 0.79

Modal Share (with respect to rail) = $\frac{e^{-5.17}}{e^{-5.17} + e^{-4.03}}$ = 0.24

- **Road:79%** trafficdivertible onto waterway
- **Rail:24%** trafficdivertible onto waterway

The divertibility of current freight traffic (in catchment area) calculated for above two scenarios is shown below:

Table 4.4-12: Waterway Divertible Traffic - Moderate & Aggressive Scenarios

S.No.	Commodity	Relevant Traffic (MMTPA)	Divertible Traffic (MMTPA)	
			Moderate	Aggressive
	Finished Goods			
1	Gypsum	0.13	0.05	0.10
2	Ferro Chrome	0.10	0.04	0.07
	Raw Materials			
1	Coal / Coke	0.39	0.05	0.13
	Total	**0.62**	**0.14**	**0.31**

For the above commodities, the basis divertibility onto waterways can be described as follows –

a) Gypsum, Ferro Chrome – due to their small volumes, securing rake availability for these commodities is a challenge. Hence road is preferred mode for transporting these commodities to the Port due to better availability and convenience. However, since waterway would provide logistic costs savings, reliability and other benefits, these commodities can shift from road to waterway.

b) Coal – Coal is currently transported via rail (for larger players) and road (for smaller players). Feedback already assumes a smaller divertiblity from rail. This is justified as even larger players sometimes rely on alternate modes due to rake availability issues.

The primary target for coal would be smaller players who currently use road transport. Waterway provides logistic costs savings, reliability and other benefits w.r.t road and hence can be expected to capture market from road for this traffic.

Futher following points should be noted for diversion of cargo to waterways –

- Rail – The traffic is already aggregated and meant exclusively to service captive industrial demand. Hence, diversion to waterway should not present a challenge in terms of shipment size.
- Road –This traffic is also primarily meant for larger industries. During the import leg, the traffic is already aggreged as it comes via bulk carrier. Hence, aggregation for barge transport shouldn't be an issue. On export leg, the only commodity transported is ferro chrome. Its production is limited exclusively to T.S. Alloys Limited and IMFA, Choudwar. Hence, aggregation should not be an issue on the export leg also.

4.7.4. Future Traffic Projections

4.7.4.1. Infrastructure Upgradation

- **Road –** As mentioned previously, the road network currently suffers from congestion due to reliance on NH-16 + NH-53 for majority of cargo movement. SH-9A does not have significant ROW for cargo transport and movement of dirty cargo is now allowed on SH-12.
- **Rail –** As mentioned previously, the rail network is severely bottlenecked at Cuttack terminal as it the main transit point for all Paradip traffic as well as handles significant transit passenger traffic in the region.

However, it is expected that with increase in industrial activity (especially upcoming developments in Paradip), the road and rail infrastructure will be upgraded. Paradip – Haridaspur railway line is already under construction and would handle traffic from Paradip port, industrial clusters of Jajpur, Dhenkanal, Kalinganagar and nearby iron ore, chromite mines. Hence waterway traffic is not expected to receive traction from current infrastructure constraints in the region in the long term.

4.7.4.2. Future Traffic Growth

As mentioned previously, the industrial growth in the region is muted with lack of clarity on macro-parameters and limited pipeline capacity (<50,000 tons for Aarti and Hardev steels). Hence an initial growth rate of (till 2025) of 4% p.a. has been considered based on the market primary interactions, and subsequent lack of any substantial development plans of existing industries in the region.

However, the industrial activity is expected to increase in the long run with restored mining operations and industrial development at Paradip. Waterways would also benefit from government promotion, evolution of technology and establishment of waterway transportation concept.

For long term, following growth rates have been take for the two scenarios:

- Moderate scenario: Growth rate of **5% p.a.**[18]
- Aggressive scenario: Growth rate of **8% p.a.**[19]

8% growth has been considered in the aggressive scenario considering favorably manufacturing climate – with restored mining operations, industrial development driven by PCPIR, improved connectivity etc. Note that while PCPIR may spur nearby industrial development, however, timelines of PCPIR development cannot be ascertained; hence the impact of PCPIR has been factored only in the aggressive scenario through higher growth rates. It should be noted that the growth rates considered for divertible traffic is based industries growth / expansion rather than growth of individual commodities.

In addition to the above considerations, following additional factors have been accounted in traffic projections:

[18]Based on growth in Odisha's manufacturing GSVA (INR 52,000 Cr in 2013-14, INR 62,000 Cr in 2017-18, CAGR of 4.7%) - http://pc.odisha.gov.in/Download/Economic_Survey_2017-18.pdf
[19]Considering favorable manufacturing climate – with restored mining operations, industrial development driven by PCPIR, improved connectivity etc.

- **Traffic build-up**: Waterway traffic would increase in a phased manner. Hence it has been assumed that the waterway would actually capture only 80% of its potential traffic in initial years.
- **Seasonality factor**: The waterway currently suffers from low water levels, especially during the pre-summer and summer months, making it unnavigable. Further due to high capital costs involved in ensuring summer navigability (cost of barrages, dredging costs etc as explained later in the report), it has not been considered for the waterway. Hence factor of 50% has been assumed to account for seasonal barge navigation.

Based on these considerations, the waterway traffic for subject stretch is projected as follows:

Table 4.4-13: Projected Barge Traffic (trips/annum)

Waterway Divertible Traffic (MMTPA)	2019	2020	2030	2040	2050
Moderate	0.03	0.06	0.11	0.19	0.30
Aggressive	0.06	0.13	0.29	0.62	1.34

Barge size of 500 DWT is recommended for the waterway based on divertible traffic. The barges would require multiple compartments as the same barge would carry all thee commodities – coal/coke, gypsum, ferro chrome. As the traffic increases over the years, a greater number of barge would be required on the waterway. Considering vessel size of 500 DWT (based on waterway class), following operational considerations are observed:

- Size of Vessel: 500 DWT
- Average Utilization: 80%
- Seasonality Factor: 50% (without summer navigability – 6 non-navigable months in a year)
- Round Trip Travel Time: 48 hours
    - River travel Time (upstream + downstream): 16 hours[20]

[20]Consdiering Average Barge speed of 12 km /hr and waterway length of 100km

- Loading + Unloading time: 4 hours
- Lashing, Mooring, Waiting Time: 4 hours
- Terminal Operations / Navigation time: 12 hours / day (without night navigation)

- Annual trip / barge: 91 trips per annum (365 days x 50% seasonality / 48 hours per barge round trip)
- **Annual barge capacity: 36,400 tons per annum**

Based on these considerations, the waterway traffic for subject stretch is projected as follows:

Table 4.4-14: Projected Barge Traffic (trips/annum)

Scenario	2019	2020	2030	2040	2050
Moderate	71	147	286	466	759
Aggressive	154	321	717	1,547	3,340

As one barge can conduct ~90 trips per annum, the barge requirement would increase from 1 initially to 2 barges (by 2030) for moderate scenario and 2 initially to 4 barges (by 2030) for aggressive scenario.

It is evident, the waterway has severely restricted traffic potential. Lack of industrial development and small stretch (~100 km) are the main reasons. Other cargo categories like fly-ash, containers can be transported on waterway, but very small distances and multiple handling operations renders the waterway impractical for such commodities. Commodities like agricultural produce, food grains, brick kilns are distributed along the waterway. This increases the distance for last mile connectivity (from inland waterway terminal at Cuttack) and makes it more convenient to use trucks for end-to-end transport.

4.7.5. Projected Tourist Traffic

While no tourism traffic exists on the waterway, it has significant waterway related tourism potential. Multiple factors including pleasant weather, picturesque surroundings, large tourist inflow (Puri, Konark, Bhubaneswar, Bhitarkanika etc.), large population base (~14 lakh population of Cuttack, Bhubaneswar) support development of waterway tourism. This can include, riverfront development, water sport activities, river cruises etc. Cuttack itself has some nearby attractions, which are amenable for waterway access. These are shown in the map below.

Figure 4-7: Multiple Handling in Waterways

The annual footfall of these attractions, totals ~10 lakh tourists / visitors as shown below–

- Dhabaleswara Temple – 7,40,000
- Naraj (Peakcock Valley, Viewpoints) – 68,000
- Anshupa Lake – 66,000
- Barabati Fort, Deer Park, Cuttack Maritime Museum

Thus, on a conservative estimate **5% of the tourists** can be considered to use the waterway leisure rides for accessing these sites. This translates to **~50,000 annual tourist** footfall on the waterway.

However, majority of tourist traffic for NW-64 is expected to be realized from local populace only, who might take leisure boat rides to either view the picturesque surroundings or enjoy the pleasant weather. As the trips would be located upstream of jobra barrage, sufficient water is expected to be available for small boats. Considering an immediate catchment population of ~8 lakhs (Cuttack) and nearby catchment population of ~10 lakhs (Bhubaneswar), and conservative estimate of population using waterway once a year as 2% and 1% respectively, total **~25,000 local population** can be expected to use the waterway for tourism purposes. Considering, the tourist traffic at closest waterway (Bhitarkanika National Park / Baitarani River) is ~1.1 lakh tourists (2015), the projected traffic for NW-64 is only ~70% of it. Considering the size of catchment and multiple local attractions, the arrived traffic is reasonable. A moderate traffic growth of 6% has been considered based on industry standards. In comparison, tourist footfalls in Odisha have been growing at 9% annually for past couple of years. Buildup of tourist inflows has been phased over initial 5 years[21]. **Further capturing of tourist traffic has been considered in the Aggressive Scenario only.** Projected traffic is as below:

Table 4.4-15: Projected Tourist Footfalls (in '000s) - Aggressive Scenario

	2019	2020	2030	2040	2050
Tourist Footfalls[22]	17	30	107	191	343

4.7.6. Viability of 43 km Waterway Stretch (Paradip to Karilopatana)

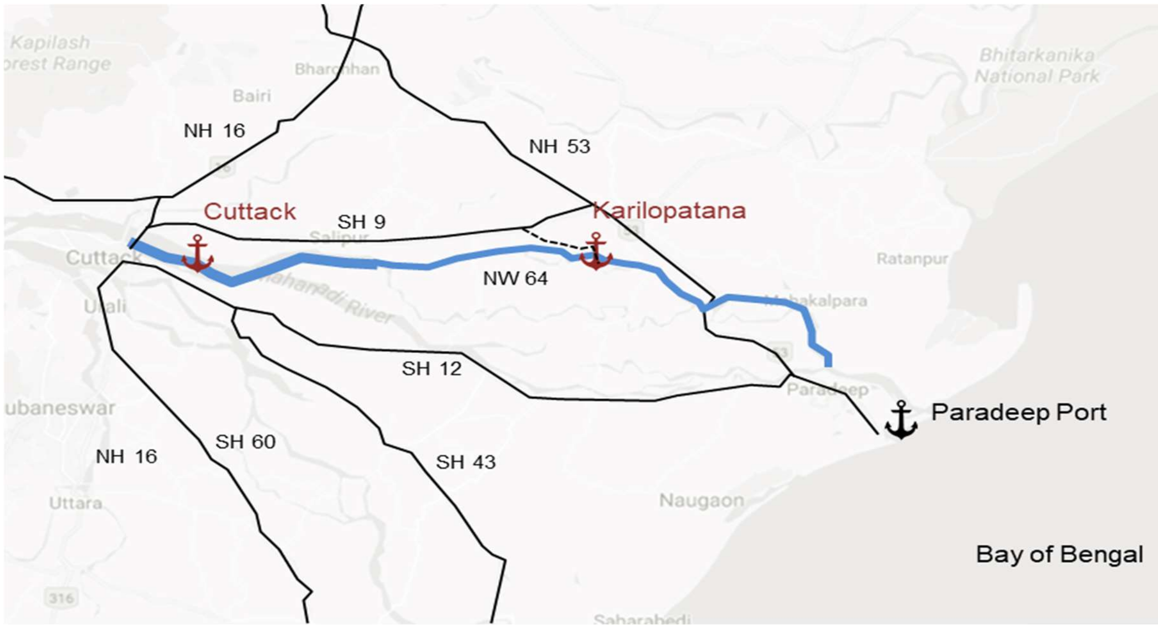
4.7.6.1. Navigational Viability of 43 km

The present waterflow downstream of Cuttack barrage is mainly due to leakage in the structure. As per the information provided by the state government officials, the leakage in barrage would be corrected, thereby leaving negligible water in the subject stretch from Cuttack Barrage to Paradip River Mouth. In such a scenario, the navigation would only be possible in the monsoon season and nearby months.

As an alternate, Feedback has considered to use the tidal portion of waterway (43 km) for navigation. Thus, the waterway could be developed till 43 km in Phase 1, leaving development of the rest of the portion to a later stage. Given the location of road bridge

[21] Tourist footfalls in initial years are ramped up year on year as 10%, 30%, 50%, 85% and 100% of tourist potential in initial years
[22] Base traffic of 75,000 tourist in Y1 has been assumed at 6% growth that. Further tourist build-up factor of 10% (Y1), 30% (Y2), 50% (Y3), 85% (Y4) and 100% (Y5) has been considererd in initial years.

at Karilopatna village (~43 km chainage), the same is the most suitable location for setting up the terminal. Following map, highlights the location of this terminal –



4.7.6.2. Traffic Viability

As highlighted in the previous sections, the industrial catchment of the waterway is concentrated at Cuttack and Paradip. Cuttack has presence of some major iron, steel, ferro chrome and cement industries. Paradip being a port has large fertilizer, petrochemical plants. It is to be noted that **there is no intermediate industrial economy along the waterway**.

In such a scenario, establishing the terminal at 43 km, reduces the travel length of waterway freight. This in turn reduces the competitiveness of waterway as the main USP of waterways is cheapest freight movement. Waterways still inherently suffer from additional costs of first / last mile connectivity and multiple cargo handlings. The fact is clearly highlighted in the two tables below. The table shows the case of Terminal at Cuttack, whereby the cargo travels ~100 km on waterway. The second table shows the case of Terminal at Karilopatana, whereby the cargo travels ~43 km on waterway.

Table 4-16: Cost comparison for 98 km length Waterway (Terminal at Cuttack)

Transport Mode	Route Length (km)	Handling Charges (INR/ton)	Freight Charges (INR/ton)	Last Mile (INR/ton)	Total Cost (INR/ton)
Rail	91	30	209	-	**239**
Direct Road	105	50	650	-	**700**
Waterway	~100	120 + 21	242	100 (by truck)	**483**

Table 4-17: Cost comparison for 43 km length Waterway (Terminal at Karilopatana)

Transport Mode	Route Length (km)	Handling Charges (INR/ton)	Freight Charges (INR/ton)	Last Mile (INR/ton)	Total Cost (INR/ton)
Direct Road	105	50	650		**700**
Waterway	~100	120 + 21	95	480*	**716**

* 80km from Cuttack to Karilopatana @ INR 6 / ton / km.

Lack of local traffic – The Karilopatana terminal has no major villages / towns nearby to provide for any substantial local passenger traffic. Moreover, the terminal is located close-by to a road bridge, thus removing the need for any cross-river ferry services.

4.7.6.3. Implementation Viability

- **Competition from Tuckers** – A trucker earns ~INR 650 for carrying cargo from Cuttack to Paradip. The same trucker would get ~INR 480 from Cuttack to Karilopatana, which is ~INR 170 less than direct route. Hence, there is no incentive for truckers to lose out on its revenues and transport cargo to Karilopatana terminal instead. Given, the strong trucking association in the region, convincing truckers to transport from factory to the IWT terminal at Karilopatana would be a major challenge.

- **Road Access Quality to Karilopatana** – Access to Karilopatana terminal would require travel via SH-9 followed by village roads. While SH-9 is 2-laned metaled highway, the terminal would need **expansion and strengthening of ~12 km of village roads**. For providing seamless flow of traffic, this would require additional ~INR 20 crore of expenses

4.7.6.4. Financial Viability

While development of waterway till 43 km reduces the development cost significantly as compared to development of entire 98 km stretch, it would still cost ~INR 100 Cr as shown in the table below. Please note that this estimate of ~INR 100 Cr is not a detailed estimate and has been roughly calculated for illustrating the said point. Feedback has considered revised cost for smaller terminal, lower dredging requirement, fewer cross-structure modifications in the revised costing. Feedback has also included ~INR 20 Cr for village road widening & strengthening of 12 kms.

Sl. No.	Description	CAPEX - INR Cr (Terminal at 43 km)	CAPEX – INR Cr (Terminal at 98 Km) ORIGINAL CAPEX
1	Terminal, Storage, Berthing Structures	~3	~9
2	Utility shifting, Auxiliary Items, Mechanical Equipment, Landscaping	~3	~5
3	Fairway Development	~61	~164
4	Navigation and communication	~3	~3
5	Modification to existing crossing bridges	~10	~75
6	Village Road Widening & Strengthening	~20	-
	TOTAL	**~100**	**~256**

4.7.6.5. Overall Recommendation for 43 km Stretch

Based on above observations, Feedback recommends that development of 43 km of waterway, while navigationally viable, is not viable from traffic, financial and implementation perspective. The development would still require ~INR 100 Cr of investment, without providing for any meaningful traffic to justify the same. Moreover, heavy resistance would be expected from truckers for transporting cargo till Karilopatana Terminal, as they would earn ~INR 480 / ton as compared to ~INR 650/ton for transporting cargo directly to Paradip.

Hence, in Feedback's opinion, **the stretch development and operations should extend to entire ~98 km, while accounting for seasonal navigation of the waterway and associated development costs.** While this option suffers from high CAPEX and low navigability, it still **provides cost savings** with respect to competing rail and road modes, and thus would be able to divert portion of catchment's traffic.

If development of waterway till 43 km is to be considered as Phase 1 of waterway development, it would require heavy government subsidies. Moreover, this option would fail to achieve the desired outcome of multi-modal traffic shift as it is not sustainable, and the operations would eventually shift to 98 km terminal with development of Phase-2.

4.8. Terminal-wise IWT Traffic Analysis

The waterway cargo traffic would be handled at Cuttack and Paradip only. While it is proposed to develop terminal facility at Cuttack, existing berths at Paradip port can be utilized for cargo handling upon payment of relevant port fees. Analysis of Paradip port facilities is provided in the annexure.

4.9. End Note

NW-64 stretches from Paradip to Cuttack bridge. **Catchment area** of the waterway is characterised by presence of industrial development at Paradip and Cuttack. Nearby industrial area of Jajpur, Kalinganagar, Angul are better serviced by NW-5 (Bhahmani River). The catchment has well developed road and rail infrastructure although issues of congestion and higher road freight charges exist. Cuttack being the main transit point for Paradip traffic remains a bottleneck.

Industries - Cuttack has presence of some iron and steel (Aarti, Hardev, Biraja, IFCA, T.S. Alloys) and a cement industrial units (OCL India). Paradip has several large-scale fertilizer, steel, chemicals, petrochemicals and marine industries (IFFCO, Paradip Carbons, Essar Steel, Paradip Phosphates).

Relevant Traffic - The relevant industrial traffic in the region comprises of Gypsum (produced as by-product of fertilizer plants at Paradip and used as raw material by cement plant and brick kilns in Cuttack), Coal / Coke (high quality coal imported at Paradip and used by iron and steel plants in Cuttack) and Ferro Chromes (Produced by T.S. Alloys and IMFA and exported via Paradip Port). The quantity of relevant commodities is shown below:

Table 4.4-18: Quantity of commodities

S.No.	Commodity	Quantity in MMTPA
Finished Goods		
1	Gypsum	0.13
2	Ferro Chrome	0.10
Raw Materials		
1	Coal / Coke	0.39
	Total	**0.62**

Currently, traffic between Cuttack and Paradip is primarily being transported through Rail (53%) and Road (47%). Ferro chrome is transported by road exclusively. Coal and coke are transported primarily by rail and road respectively.

Agricultural, passenger and Ro-Ro movement hasn't been considered on the waterways due to negligible traffic and economic unviability.

Upcoming Developments - Major upcoming development in the area include Petroleum, Chemical and Petrochemical Investment Region (PCPIR). The development is not expected to provide relevant traffic to the waterway as majority of the industries would be import based and output cargo would be transported through rail / road to Indian hinterland. Paradip International Cargo Terminal (PICT) at Paradip Port is also expected to be operational in 2018 and would handle containers and other clean cargo. Capturing of container traffic on waterway is not recommended due to multiple container handlings in waterways and prohibitively high associated handling costs.

IFFCO is desirous of setting up a **captive jetty** at their Paradip plant for costal shipping of fertilizers. IFFCO is expecting to move 1.5-2 MTPA. The barges would be using small stretch of waterway towards the Paradip end. The state government also has given approval for setting up a **riverine port** at Akhadashili village in Mahakalpada block, Kendrapada.

Cost comparison of waterways with other modes establishes cost effectiveness of waterways as compared to road:

Table 4.4-19: Cost effectiveness of waterways as compared to roads

Transport Mode	Route Length (km)	Handling Charges (INR/ton)[23]	Freight Charges (INR/ton)	Last Mile (INR/ton)	Total Cost (INR/ton)	Transport Time
Rail	91	30	209	-	**239**	**~0.5 day**
Road	105[24]	50	650		**700**	**~0.5 day**
Waterway	110	120+21	242	100 (by truck)	**483**	**~1 day**

Divertible Traffic - Binary Logit Model has been used based on the generalized cost method. The method compares various influencing factors for mode preference - transport cost, handling, mode convenience, product type and travel time. 2 scenarios viz. **Moderate & Aggressive** have been considered. The waterway divertible traffic for the scenarios is shown below:

Table 4.4-20: Divertible Traffic Scenario

S.No.	Commodity	Relevant Traffic (MMTPA)	Divertible Traffic (MMTPA)	
			Moderate	Aggressive
	Finished Goods			
1	Gypsum	0.13	0.05	0.10
2	Ferro Chrome	0.10	0.04	0.07
	Raw Materials			
1	Coal / Coke	0.39	0.05	0.13
	Total	**0.62**	**0.14**	**0.31**

Due to muted industrial growth in the region, a 4% growth rate has been considered till 2025. A higher growth rate (5% for Moderate and 8% for Aggressive) has been

[23] Handling charges considered from / to storage shed at Paradip. Handling charges consist of both loading and unloading charges. While for rail and road, transport involves one loading and unloading, for waterways an additional loading/unloading operation is required at the river terminal.
[24] Average of to and from distances have been taken between Paradip and Cuttack due to different routes taken

considered in the long run on account of restored mining operations, industrial development at Paradip and evolution of waterway operations in India. The projected traffic is shown below:

Table 4.4-21: Divertible Traffic projections

Waterway Divertible Traffic (MMTPA)	2019	2020	2030	2040	2050
Moderate	0.04	0.09	0.17	0.28	0.46
Aggressive	0.09	0.19	0.43	0.93	2.00

While no tourism traffic exists on the waterway, it has significant waterway related tourism potential. Multiple factors including pleasant weather, picturesque surrounding, large tourist inflow (Puri, Konark, Bhubaneswar, Bhitarkanika etc.), large population base (~14 lakh population of Cuttack, Bhubaneswar) support development of waterway tourism. This can include, riverfront development, water sport activities, river cruises etc. Following tourist traffic has been projected on the waterway:

Table 4.4-22: Tourism traffic projections

	2019	2020	2030	2040	2050
Tourist Footfalls	17	30	107	191	343

5. TERMINALS

5.1. General Review

A terminal/inland port is an intermodal transportation and distribution centre. Its secondary activity is industrial production and processing. It is a port on an inland waterway, such as a river, lake, or canal, which may or may not be connected to the ocean. Terminals are the centers of receipt, export, storage, distribution of cargo and embarkation of passengers. Terminals form the hub of connection at transit through various means and modes of transportation. They are the shelters where vessel can berth and load or unload cargo and get its supplies.

To meet the need of rapid economic development in the country and to reduce the congestion faced in other modes of transport like road and railway, it seems imperative to look at other alternatives, the cheapest of them being the water transport system. India has a good network of inland waterways with canals, creeks, lakes and rivers, which can be well explored with technical and scientific interventions. Lack of terminal and handling facilities and infrastructure has limited the expansion of inland water transportation rate and full utilization of canals along the waterways and fleets operating thereat.

5.2. Identification of Site Location

The proposed site for the terminal is such that, it has good land and waterside facilities with the location having proximity to a developed or developing industrial cluster. The various aspects considered for the dentification of the site location includes:

5.2.1. Site Condition

The following are the requirements:

- ✓ Enough area available for the terminal and associated infrastructures with margin for future expansion.
- ✓ Proximity to origin or destination of the expected cargo.
- ✓ Availability of quayage for the design vessel.
- ✓ Less difficulty related to acquisition.
- ✓ Reasonable foundation condition to permit economic design.
- ✓ Availability of appropriate turning circle and vessel mooring yards.

5.2.2. Water area characteristics

The capacity of the water area was evaluated in terms of numbers, types and sizes of vessels which are required to be simultaneously anchored in the terminal area and at wharfs. The general water area requirements for the harbour basin includes:

- ✓ Berthing area: The area in front of the berthing structure required to accommodate the vessels. It is based on the dimensions of the largest design ship and number and type of ships attended. The minimum length of berthing area considered is around length of design vessel plus 10% subject to a minimum of 15m. The width of the berthing area is taken as not less than 1.15 times the beam of the design vessel.
- ✓ Manoeuvring area: The width required for manoeuvring is approximately 0.6 times the length of the vessel for berthing parallel to the fairway.
- ✓ Turning circle: The minimum diameter of the turning circle where vessels may be warped round turning dolphins, is 1.2 times the length of the design vessel. Where vessels turn by free interplay of the propeller and rudder assisted by tugs, the minimum diameter of the turning circle should be 1.7 to 2 times the length of the design vessel. Where no tug assistance is available, the diameter is taken as 4 times length of the design vessel.
- ✓ Sheltering from wind, currents: The berthing area is planned in such a way that wind disturbances are limited.

5.2.3. Berthing Aids

The berthing aids required for the present are:

- ✓ Fenders: To protect the berthing structure and vessel hull from the berthing force.
- ✓ Bollards: Arrangement to properly moor the vessel, so that safe loading/ unloading of cargo is possible.

5.2.4. Type of structure

The berthing structure was opted based on the site condition. The structure must accommodate the existing hydraulic variations in the site and the cargo to be handled. The minimum width of apron is taken as 3m. The deck elevation is normally at or above highest high-water plus a clearance of 1m.

5.2.5. Cargo handling system

As the cargo is mainly dry bulk, it is proposed to have crane with closed grab of capacity around 50 tonnes.

5.2.6. Land area provisions

The minimum land area behind the berth is related to the type of cargo to be handled, type of equipment envisaged, capacity of the stockyard, rail and road requirements, etc. In the present case, mainly dry bulk to be handled using grab cranes and evacuated using trucks. There are provisions like water supply for firefighting, fire alarm, etc.

Well-connected road networks are planned within the terminal premise. The road system in the terminals comprise arterial roads for through traffic and feeder and circulatory roads to the individual berths, depots, yards and other operational points. The arterial roads are set at the back of the berths and linked to the public road system through security gates. The width of the roads is arrived at based on the expected traffic with provision for future widening. Roads are preferred to be at least5.5m wide and preferably 7.5m wide. Proper lighting and drainage of roads are required. Even though railways lines are not planned immediately, they can be installed in future.

5.2.7. Connectivity to the terminal area

Good network of roads and rails in the region of terminal is essential. The location enjoys well-developed railway network falling under Khurda division of East Coast Railway Zone. The road traffic is served by NH-16, a part of Golden Quadrilateral; NH-53, connecting Hazira to Paradip port; NH-55, connecting Sambalpur to Cuttack; NH-316, connecting Bubaneshwar to Puri; SH-12, connects Cuttack and Paradip directly and SH-9A.

5.2.8. Truck park location, both full and empty

Demarcated areas are provided trucks. In berth, parking may be provided only for limited number of trucks

5.2.9. Place for arrival/departure

The arrival and departure locations are provided for the passenger traffic. The passenger amenities can be incorporated within the terminal building.

5.2.10. Yard area

For bulk cargo, the area for open storage, where required, are determined by considering the location of transport facilities as well as proximity to berth. The minimum open storage is taken as 75% of design shipload. The minimum clear height inside the transit shed may be taken as 6m. Doors may be planned both in front and back, opposite to each other. Additional doors may be provided at the gable ends and locks and bolts provided may be operable from inside. Minimum size of doors considered is 5m X 6m. The floors shall be provided with slope upwards for cleaning and drainage. The desirable slope shall be 1 in 100. The capacity desirable for covered storage is taken as 75% the largest vessel expected. There are provisions for ventilators, lightings, protective devices, windows, etc.

5.2.11. Proximity to the industrial clusters

The site selected is having good proximity to the industrial cluster with assured traffic. The industrial clusters are well connected to the terminal location.

5.2.12. Electricity

As far as possible underground cables are to be laid for power supply. An uninterrupted electric supply is to be ensured.

5.2.13. Water supply

Water supply to vessels need to be ensured. It is desirable to have a minimum capacity of around 600liter/ min and outlet pressure of 175kN/m2. It is proposed to make use of the river water for washing but must be treated before discharging back. A freshwater tank of 1 lakh litre capacity is proposed.

5.3. Terminal Layout / Master Planning Including Phases of Development

The present study stretch starts from river mouth to Cuttack Barrage of Mahanadi-Luna River System. The major industrial cluster in this area is in Cuttack region. To complete a circuit, there needs to be minimum two terminals to handle the cargos, one near Paradip and one at Cuttack. A green field terminal is proposed to be constructed at Cuttack. Site selection for the same has been carried out and a location is identified at Jagatpur village of Cuttack District. (Jagatpur is an industrial town located in the Cuttack district of Odisha, India.). The land area required for the terminal infrastructure in Jagatpur village is around

2.32 hectares and from the preliminary investigation it was observed as a government land. The proposed site is very near to NH-09. The location is shown in the figure 5.1.

The terminal for Paradip is to be arranged within the existing port premise with creation of a connecting channel from the Mahanadi river mouth to the harbour area. From preliminary study it is observed that there exist sand bars in the estuary and hence good quantity of dredging is likely to be incurred. A detailed study is required to propose a dedicated terminal for inland vessels within Paradip port, which is expected to be managed by IWAI regional office. Hence the details about the terminal in Paradip port premise is not considered in the present study.

Figure 5.1:Proposed terminal location and back up area

The facilities described in section 5.3.1 is arrived at based on the conclusions of hydrographic survey report and traffic study. Only the most important amenities that can be justified by the present requirements are proposed, hence it is recommended to install all the above said facilities in a single phase. The master plan for the greenfield terminal at Cuttack is attached with the drawings enclosed as Vol. II.

5.3.1. Terminal Layout/Master Plan

The terminal is proposed to have the following:

5.3.1.1. Waterfront facilities:

- ✓ Turning circle: Turning circle of around 120m diameter, almost twice the length of design vessel. The vessels can turn with the aid of dolphins.
- ✓ Berthing facilities: Berthing jetty to cater the design vessel for the projected cargo are proposed. Two jetties at different elevations are required due to the water level fluctuations during lean season and flood season. The vessel is tied to the berth using bollards to minimize any undesirable movements during loading/ unloading operations and to align the vessel in the required position. Fenders are to be provided to absorb the energy of the vessels during the time of berthing. The mooring points and anchor line arrangements depend on the design vessel dimensions.

5.3.1.2. Land side facilities

- ✓ Loading/ Unloading equipment: The gears required to load/ unload the dry bulk cargo targeted is proposed. Agrab crane may be employed for loading and unloading which may be overridden with sophisticated equipment for specific cargo in future. Trucks can be used for evacuation. As per the design vessel specification, it is required to unload a 500DWT vessel. Thus, it is proposed to have a 50 tones crane with a handling rate of around 300 tons per hour during peak hours and 60 percentage of it is assumed as the average rate.
- ✓ Storage Area: According to the traffic study, it is desirable to have storage for commodities as cement, ferro chrome, etc., as finished goods and raw materials like slag, ores, cement clinker, etc. Thus, it is proposed to have a closed and open storage area. Since the exact quantities of each commodity and annual through can't be ascertained at this stage, it is recommended to have a closed storage area and an open storage area for 75% of one design vessel capacity. The storage buildings have to be provided with color painting, to complement the prevailing amounts of natural and artificial light and by increasing the light reflectivity of the closely coordinated painted surfaces of the ceiling, walls, and floor, as well as by judicious use and combination of color, to eliminate dark corners and areas of extreme brightness and produce a soft diffused effect, restful to the eyes. Open transit storage can be used for cargo that won't be damaged by

rain, sun and open-air temperature variations as applicable and which is not subjected to pilferage. The lighting fixtures on the transit sheds should be protected well against damage by cargo handling equipment and the lower parts of masts should also be protected against structural damage.

Warehousing facilities are of advantage to consignees who may not wish to receive into their own premises any or all their consignments at the time the goods are discharged from the ships. Thus, warehousing of goods forms a large part of the ports business, which take charge of the stored cargo.

Figure 5.2: A typical dry bulk warehouse and a grab crane unloading dry bulk

- ✓ Parking area: The parking area for trucks to wait at a time are planned. The trucks can wait in the parking area and can move to the apron for getting loaded or unloaded on call, so that the congestions can be avoided.

Figure 5.3: Vehicles parked in a warehouse area ready to be loaded

- ✓ Terminal building: This building houses administration office having administration, accounts, inquires, telephone switchboard, etc.; operational office; security office, waiting area for passengers, etc.
- ✓ Water supply: Safeguarding the delivery of potable and raw water supply to the port or terminal area is important. Hydrants to be installed at intervals. Both fresh and wash water supply without interruption are to be ensured. A fresh water supply tank is proposed in the terminal premise.
- ✓ Apron: The area just behind the berth front for loading and unloading to and from the ship. It is proposed to have around 5m wide apron.
- ✓ STP: Sewage treatment plant to purify the waste and wash water to the desired limit before discharging offshore or back to river or public sewer as and how required.
- ✓ Electricity: Underground cables for low and high voltage supply systems to the port installations, crane installations, lighting etc. are proposed. The earth cover of the supply system is recommended to be approximately. 0.8 to 1m. The power connection points along the berth front are proposed be at intervals of approximately 50 to 200m depending on the type of berth activities.
- ✓ Internal connectivity: Parallel road system interconnecting all major facilities are proposed.

5.4. Land Details

The identified location is situated in the Jagatpurvillage in the Cuttack District. The location is at 1.5 km downstream of Cuttack barrage in the left side. This location is well connected by road network NH9. Cuttack is the judicial and commercial capital of Odisha with many trading and business houses in and around the city. The identified location is within a 23-acre government land (2.32 hectares area is proposed for the terminal) having good connectivity and sufficient waterfront area. Jagatpur area has many industrial establishments. The region is in the immediate down stream of Jobra barrage. Has close proximity to road and rail networks.

5.5. Geotechnical Investigation

5.5.1. Regional Geology

The project districts can broadly be divided into four distinct geomorphic units (1) Tidal flat (2) Coastal plain (3) Alluvial plain (4) Flood plain.

The fine sediments carried by the rivers get deposited along the coast because of tidal action, as tidal flat / mud flat. The width of this tidal flat varies from 2 to 5 km.

The coastal plain is a gently sloping plain occurring parallel to the coast and mainly formed by fluvio–marine action and is intersected by network of creeks, which are mainly saline due to tidal action. The area is marshy with shrubby vegetation. The width of this coastal plain varies from 5 to 25 km. The coastal plain encompasses a series of beach ridges characterized by sand dunes of varied relief and extends for some kilometers, almost parallel to the coast.

The gently sloping alluvial plain occurs to the west of the coastal plain and forms the most fertile part of the district. The alluvial plain can be further divided into two i.e. (i) Older alluvial plain (ii) Younger alluvial plain.

5.5.2. Physical Condition and Drainage

Based on the physical and chemical characteristics, mode of origin and occurrence, soils of the project region may be classified into three groups namely Alfisols, Aridisols and Entisols.

i. Alfisols: This includes deltaic alluvial soils and this type of soils occupies nearly 90% of the entire district area. The deltaic alluvial soils are generally deficient in phosphate (P2O5) and nitrogen (N). Both the total and available potassium are adequate, and PH varies between 7.38 and 8.16.

ii. Aridisols: These are saline and saline alkali soils and occur in small pockets in the north eastern and south-eastern corner of the district near coast. These are rich in calcium, magnesium and consist of half decomposed organic matter.

iii. Entisols: This includes coastal sandy soils and occurs as narrow elongated ridge along the coastline. The soils are deficient in nitrogen, phosphoric acid and humus, but not in potash and lime.

5.5.3. General Geology and Stratigraphy

The State of Odisha exposes rocks ranging in age from Meso archaeon to Recent. The geographic distributions of the major Precambrian litho-tectonic domains are:

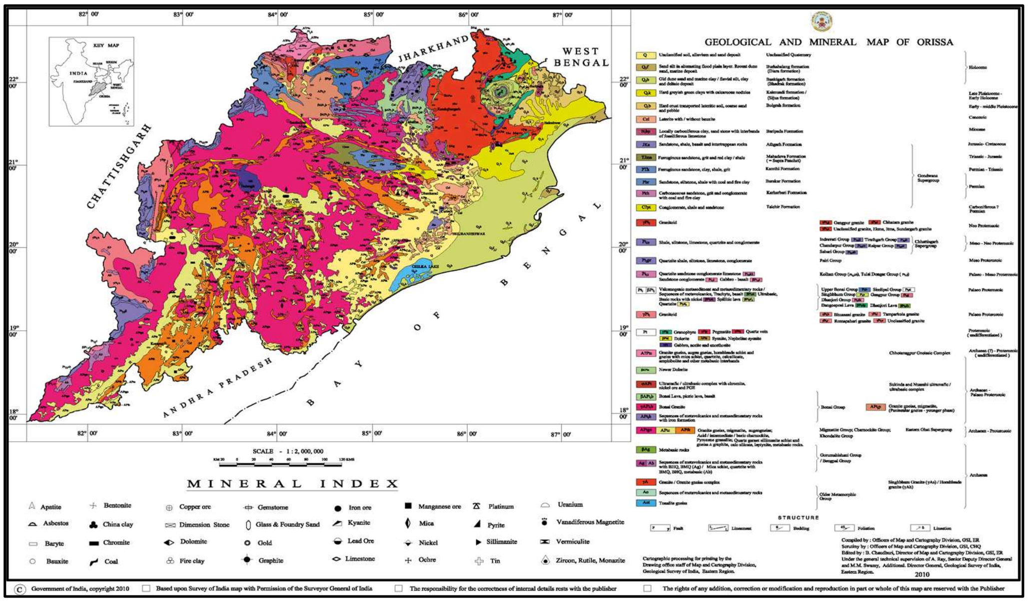
Table 5-1: Geographic distribution

Eastern Indian Craton (North Odisha Craton) and Singhbhum-Gangpur Odisha Mobile Belt, Mobile Belt	Northern and North-western
Part of Bastar Craton	Western Odisha
Part Eastern Ghats Mobile Belt (EGMB)	Central and Southern Odisha

Odisha, situated on the eastern seaboard of India is one of the gifted parts of the world, where a gamut of mineral resources exists in bounty. The state is endowed with large reserves of bauxite, china clay, chromite, coal, dolomite, fireclay, graphite, gemstones, iron ore, limestone, manganese ore, mineral sand, nickel ore, pyrophyllite and quartz. Recent discovery of diamond in the Dharambandha area of Nuapada district by the State Directorate of Geology has added a colored feather in the cap of the state. Other minerals of the state include copper ore, lead ore, titanium bearing veneniferous magnetite, talc/soap stone and high magnesia igneous rocks. Recent boom of the mineral industry has turned the state into a hotspot, with entrepreneurs from all over the world crowding for their share of fortune.

The rich mineral wealth of the state is attributed to its favorable geological set-up. Situated on the eastern fringe of the peninsular India, Odisha has about 72.5% of the area occupied by Precambrian metamorphic rocks (of Archaean and Proterozoic age) which host most of the minerals. The Gondwanas hosting the coal resources occur over about 8% of the land mass. The Tertiary and Quaternary formations, occupying rest of the area, provide avenues for aluminous / nickeliferous laterite and heavy minerals (in beach sand). Geological and Mineral map of Odisha is given below.

Figure 5.4: Geological Map of Odisha



Source: Geological Survey of India

Based on the two bore holes investigation and subsequent laboratory tests results the following sub soil stratification identified. The subsoil stratification of the site is given below.

Table 5-2: Stratification at the site from subsurface investigation

B.H No.	1st Layer	2nd Layer	3rd Layer
01	Filling materials are in medium dense condition found up to 2.80m.	Silty Sand in medium to dense condition found from 2.80m to 21.00m.	Poorly graded silty sand in dense condition found from 21.00m to 30.00m
02	Filling materials are in loose condition found up to 2.50m.	Silty Sand in medium to dense condition found from 2.50m to 27.00m.	Silty Clay in dense condition found from 27.00m to 30.00m

5.5.4. Sub-surface Investigations

5.5.4.1. Location of investigation

Two boreholes were taken at the below said locations during the month of May 2017. At each location, rotary type boring rig was shifted, assembled and erected.

Table 5-3: Bore hole locations

BH No.	Latitude	Longitude
BH 1	20^0 29’26.65”N	85^0 55’ 8.63”E
BH 2	20^0 29’29.47”N	85^0 55’ 14.82”E

5.5.4.2. Method of investigation

Boring was done in accordance with ***IS: 1892 -1979***. Standard rotary type drilling rig coupled with 8 H.P capacity diesel engines, which is fitted to a tripod frame and with all drilling accessories was used for boring. The rig deployed was generally suitable for all Geotechnical Investigation work and had an arrangement for driving and extraction of casing, boring and drilling by mud circulation method. Collecting D/S, UDS, conducting SPT test with this rig was possible.

Rotary method of boring was used for boring in soil. Boring was commenced by driving a SX casing. Boring was carried out in soil using 6” dia core barrel up to the top of the hard surface. Diameter of the borehole in soil was 150mm. SX casing was lowered in overburden as boring progressed. Advancement of borehole in soil was done by removing soil with help of water circulation under rotary action of the Core barrel. Boring in all types of soil was continued till the hard stratum was met with. Standard penetration tests were conducted at an interval of 1.50m.

During investigation In-situ tests were carried out. Standard penetration tests were conducted in overburden. Undisturbed and Disturbed soil samples were collected by split spoon sampler in SPT test for field observations and to determine the index properties from laboratory tests.

SPT’s were conducted as per IS 2131-1981.Disturbed Samples were collected through Split Spoon Sampler at 1.5m interval. A standard split spoon sampler was driven at the bottom of the hole. The penetration resistance in terms of blows for 300mm penetration of the split spoon sampler was measured as ‘N’ Value. The blows were impacted by a standard weight of 63.5 kg falling through a height of 750 mm. The resistance was measured for 150 mm, 300 mm and 450 mm penetrations. The resistance of first 150 mm was ignored and the resistance of next 300 mm was recorded as standard penetration value ‘N`. If the sampler was driven less than 450 mm (total) then the penetration resistance was given for the last 300 mm of penetration. If the penetration depth was less than 150 mm and the blow count was more than 50 then the ‘N’ value was considered as ‘Refusal’ or more than 100 blows for less than 30cms penetration.

Figure 5.5: Conduct of field test

5.5.4.3. Standards followed in investigation

Field Geotechnical investigation was executed in accordance with the Indian standard Codes listed below.

- IS: 1892: Code of practice for subsurface investigation of foundation
- IS: 1498: Classification and identification of soil for general engineering purpose.
- IS: 2131: Method for standard penetration test for soil
- IS: 6935: Method of Determination of water level in boreholes.

5.5.5. Laboratory tests of samples

The laboratory tests aim to obtain grain size distribution, liquid limit, plastic limit, specific gravity, moisture contents, bulk density, etc., of the soil samples of different layers. The below said standards were followed in the tests,

Table 5-4: Standards for laboratory tests

a)	Grain Size Distribution by Sieve Analysis	IS 2720(Part–IV)
b)	Consistency limits determination to obtain liquid limit plastic limit & Shrinkage limit	IS:2720 (Part– V)
c)	Specific Gravity determination	IS 2720(Part–III)
d)	Differential free swell index	IS 1122 (Part -40)
e)	Tri axial test (UU)	IS 2720 (Part -IX)
f)	Natural moisture and bulk density	IS 9143
g)	Engineering classification of soil	IS 1498

5.5.6. Geotechnical Results and Analysis

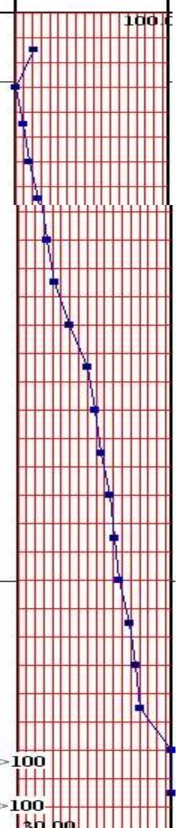
Table 5-5: Bore log data sheet for BH 1

Bore Log Data Sheet

Site :S.I.Work at River Mahanadi for Proposed Waterways to achieve navigation and to development water transport facilities across india.		Client : FEEDBACK INFRA PVT LTD New Delhi,India
Type of Boring	Rotary	Job No. :
Dia of Hole (mm):	150.00	Bore Hole No.: 01
Depth (M):	0.00-30.00	Co-ordinates : N:20°29'26.65" E:85°55' 8.63"
Commenced on : 2 May 2017	Completed on : 5 May 2017	Ground Bed RL:
Water Struc :	Ground Water : 3.80M.	Location of Bore Hole :

Description of Strata	Symbol	Thik. (M)	From (M)	To (M)	Sample Depth (M)	Sample Type	Sample Ref. No.	SPT Record 0-150	150-300	300-450	N
FILLING MATERIALS		0.00 1.00 2.00	0.00	2.80	1.50	P	SPT-1	6	10	13	23
SILTY SAND		3.00	2.80		3.00	P	SPT-2	4	6	6	12
		4.00 5.00			4.50	P	SPT-3	6	8	9	17
		6.00			6.00	P	SPT-4	7	9	11	20
		7.00 8.00			7.50	P	SPT-5	7	11	14	25
		9.00			9.00	P	SPT-6	9	11	18	29
		10.00 11.00			10.50	P	SPT-7	10	13	20	33
		12.00			12.00	P	SPT-8	14	19	23	42
		13.00 14.00			13.50	P	SPT-9	16	21	31	52
		15.00			15.00	P	SPT-10	18	23	33	56
		16.00 17.00			16.50	P	SPT-11	22	24	36	60
		18.00			18.00	P	SPT-12	23	26	39	65
		19.00 20.00		21.00	19.50	P	SPT-13	24	28	40	68
POORLY GRADED SILTY SAND		21.00	21.00		21.00	P	SPT-14	26	30	40	70
		22.00 23.00			22.50	P	SPT-15	31	36	40	76
		24.00			24.00	P	SPT-16	30	38	42	80
		25.00 26.00			25.50	P	SPT-17	35	40	42	82
		27.00			27.00	P	SPT-18	45	12cm in 100 blows,N>100		
		28.00 29.00 30.00		30.00	28.50	P	SPT-19	46	10cm in 100 blows,N>100		
Bore Hole Terminated at : 30.00											

SPT Curve



D-Disturbed Sample, U-Undisturbed Sample, P-Standerd Penetration Test,C-Core, W-Water Sample, V-

PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOIL

Work Reference : Soil Investigation work at Mahanadi River for Proposed Waterways.

Bore Hole NO :01

Sample Details			Natural Moisture content in %.	In Situ Bulk Density in gm/cc.	Shear Strength Parameter		Specific Gravity	Atterberg's Limit			Differentail Free Sweel Index.	Void Ratio	Mechanical Sieve Analysis					Hydrometer Analysis		Soil Classification As per IS:1498
Sl.No.of Sample	Type of Sample	Depth of Collection in mtr			Cohesion in kg/cm^2	Angle of Internal Friction in Degree.		Liqiid Limit in %	Plastic Limit in %	Plasticity Index in %			Fine Gravel in % mm to 4.75mm)	Coarse Sand in %(4.75mm to 2.00mm)	Medimum sand in % (2.00mm to 0.425mm)	Fine Sand in % mm to 0.075mm)	Silt & Clay in % (<0.075 mm)	Silt Size in % mm to 0.002mm)	Clay size in % (<0.002mm)	
1SPT1.5015.541.872 --2.69----0.666.9810.5628.9914.1239.35---																				
SPT3.0018.211.843 --2.6520.6-Np-0.703.125.1545.6238.997.12--SP-SM													(20			(0.425		(0.075		
SPT4.5017.361.851 --2.65--Np-0.684.585.9253.2129.287.01--SP-SM																				
SPT6.0016.581.868 --2.66--Np-0.663.206.3151.1332.816.55--SP-SM																				
SPT7.5016.321.875 --2.6620.3-Np-0.653.626.5352.0231.476.36--SP-SM																				
SPT9.0016.171.896 --2.66--Np-0.633.455.8850.0034.426.25--SP-SM																				

* Laboratory tests are Coundcted as per BIS Specifcation only.
* The Test Report refers only to the samples tested as above.

Technical Mannager

PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOIL

Work Reference : Soil Investigation work at Mahanadi River for Proposed Waterways.

Bore Hole NO :01

Sample Details			Natural Moisture content in %.	In Situ Bulk Density in gm/cc.	Shear Strength Parameter		Specific Gravity	Atterberg's Limit			Differentail Free Sweel Index.	Void Ratio	Mechanical Sieve Analysis					Hydrometer Analysis		Soil Classification As per IS:1498
Sl.No.of Sample	Type of Sample	Depth of Collection in mtr			Cohesion in kg/cm^2	Angle of Internal Friction in Degree.		Liqiid Limit in %	Plastic Limit in %	Plasticity Index in %			Fine Gravel in % (20 mm to 4.75mm)	Coarse Sand in %(4.75mm to 2.00mm)	Medium sand in % (2.00mm to 0.425mm)	Fine Sand in % (0.425mm to 0.075mm)	Silt & Clay in % (<0.075mm)	Silt Size in % (0.075mm to 0.002mm)	Clay size in % (<0.002mm)	
7	SPT	10.50	15.92	1.908	-	-	2.65	20.2	-	Np	-	0.61	3.12	5.92	48.65	36.21	6.10	-	-	SP-SM
8	SPT	12.00	15.37	1.935	-	-	2.65	-	-	Np	-	0.58	4.58	6.12	50.12	33.26	5.92	-	-	SP-SM
9	SPT	13.50	15.17	1.969	-	-	2.65	19.8	-	Np	-	0.55	4.92	6.30	55.20	28.00	5.58	-	-	SP-SM
10	SPT	15.00	15.01	2.000	-	-	2.66	-	-	Np	-	0.53	5.12	6.85	49.12	33.59	5.32	-	-	SP-SM
11	SPT	16.50	14.90	2.011	-	-	2.66	19.5	-	Np	-	0.52	5.22	7.12	47.44	35.00	5.22	-	-	SP-SM
12	SPT	18.00	14.53	2.023	-	-	2.65	-	-	Np	-	0.50	5.62	8.55	45.52	35.05	5.26	-	-	SP-SM
13	SPT	19.50	14.21	2.039	-	-	2.66	-	-	Np	-	0.49	4.11	7.16	46.31	37.28	5.14	-	-	SP-SM

*.Laboratory tests are Coundcted as per BIS Specifcation only.

*.The Test Report refers only to the samples tested as above.

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PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOIL

Work Reference : Soil Investigation work at Mahanadi River for Proposed Waterways.

Bore Hole NO :01

Sample Details			Natural Moisture content in %.	In Situ Bulk Density in gm/cc.	Shear Strength Parameter		Specific Gravity	Atterberg's Limit			Differentail Free Sweel Index.	Void Ratio	Mechanical Sieve Analysis					Hydrometer Analysis		Soil Classification As per IS:1498
Sl.No.of Sample	Type of Sample	Depth of Collection in mtr			Cohesion in kg/cm^2	Angle of Internal Friction in Degree.		Liqiid Limit in %	Plastic Limit in %	Plasticity Index in %			Fine Gravel in % (20 mm to 4.75mm)	Coarse Sand in %(4.75mm to 2.00mm)	Medium sand in % (2.00mm to 0.425mm)	Fine Sand in % (0.425mm to 0.075mm)	Silt & Clay in % (<0.075mm)	Silt Size in % (0.075mm to 0.002mm)	Clay size in % (<0.002mm)	
14	SPT	21.00	14.20	2.066	-	-	2.66	-	-	Np	-	0.47	2.36	5.12	52.20	35.23	5.07	-	-	SP-SM
15	SPT	22.50	13.78	2.095	-	-	2.67	18.6	-	Np	-	0.45	1.71	4.60	68.12	22.32	3.25	-	-	SP
16	SPT	24.00	13.50	2.119	-	-	2.67	-	-	Np	-	0.43	1.02	8.12	70.12	18.59	2.15	-	-	SP
17	SPT	25.50	13.23	2.129	-	-	2.67	18.3	-	Np	-	0.42	1.11	9.66	73.25	13.87	2.11	-	-	SP
18	SPT	27.00	13.12	2.149	-	-	2.66	-	-	Np	-	0.40	1.58	6.51	80.00	10.06	1.85	-	-	SP
19	SPT	28.50	13.02	2.171	-	-	2.67	-	-	Np	-	0.39	2.01	6.55	76.30	13.40	1.74	-	-	SP

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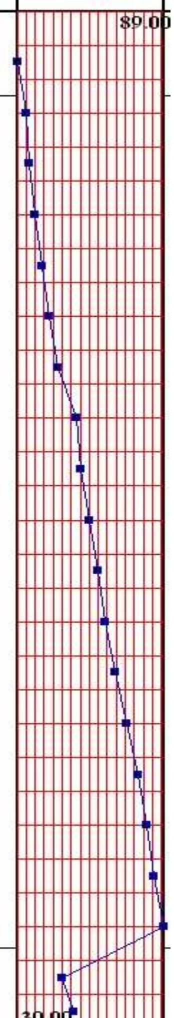
Table 5-6: Bore log data for BH2

Bore Log Data Sheet

Site : S.I.Work at River Mahanadi for Proposed Waterways to achieve navigation and to development water transport facilities across india.		Client : FEEDBACK INFRA PVT LTD New Delhi,India
Type of Boring	Rotary	Job No. :
Dia of Hole (mm):	150.00	Bore Hole No.: 02
Depth (M):	0.00-30.00	Co-ordinates : N:20^0 29' 29.47" E: 85^{0}55' 14.82"
Commenced on : 05 May 2017	Completed on : 07 May 2017	Ground Bed RL:
Water Struc :	Ground Water : 4.00m	Location of Bore Hole :

Description of Strata	Symbol	Thik. (M)	From (M)	To (M)	Sample Depth (M)	Sample Type	Sample Ref. No.	SPT Record 0-150	150-300	300-450	N	SPT Curve
FILLING MATERIALS		0.00 / 1.00 / 2.00	0.00	2.50	1.50	P	SPT-1	2	2	6	8	
SILTY SAND		3.00	2.50		3.00	P	SPT-2	4	6	7	13	
		4.00 / 5.00			4.50	P	SPT-3	5	7	8	15	
		6.00			6.00	P	SPT-4	7	8	10	18	
		7.00 / 8.00			7.50	P	SPT-5	9	10	12	22	
		9.00			9.00	P	SPT-6	9	11	15	26	
		10.00 / 11.00			10.50	P	SPT-7	11	13	18	31	
		12.00			12.00	P	SPT-8	13	20	21	41	
		13.00 / 14.00			13.50	P	SPT-9	16	20	23	43	
		15.00			15.00	P	SPT-10	18	23	25	48	
		16.00 / 17.00			16.50	P	SPT-11	20	25	28	53	
		18.00			18.00	P	SPT-12	22	27	30	57	
		19.00 / 20.00			19.50	P	SPT-13	23	30	32	62	
		21.00			21.00	P	SPT-14	25	33	36	69	
		22.00 / 23.00			22.50	P	SPT-15	28	35	40	75	
		24.00			24.00	P	SPT-16	31	38	42	80	
		25.00 / 26.00			25.50	P	SPT-17	32	40	44	84	
		27.00		27.60		P	SPT-18	35	43	46	89	
BLAKISH COLOURED SILTY CLAY		28.00 / 29.00	27.60		28.50	P	SPT-19	10	15	18	33	
		30.00		30.00		P	SPT-20	12	18	21	39	



Bore Hole Terminated at : 30.00

D-Disturbed Sample, U-Undisturbed Sample, P-Standerd Penetration Test,C-Core, W-Water Sample, V-V

PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOIL

Work Reference : Soil Investigation work at Mahanadi River for Proposed Waterways.

Bore Hole NO :02

Sample Details			Natural Moisture content in %.	In Situ Bulk Density in gm/cc.	Shear Strength Parameter		Specific Gravity	Atterberg's Limit			Differentail Free Sweel Index.	Void Ratio	Mechanical Sieve Analysis					Hydrometer Analysis		Soil Classification As per IS:1498
Sl.No.of Sample	Type of Sample	Depth of Collection in mtr			Cohesion in kg/cm²	Angle of Internal Friction in Degree.		Liqiid Limit in %	Plastic Limit in %	Plasticity Index in %			Fine Gravel in % (20 mm to 4.75mm)	Coarse Sand in %(4.75mm to 2.00mm)	Meadmum sand in % (2.00mm to 0.425mm)	Fine Sand in % (0.425mm to 0.075mm)	Silt & Clay in % (<0.075mm)	Silt Size in % (0.075mm to 0.002mm)	Clay size in % (<0.002mm)	
1	SPT	1.50	17.25	1.833	-	-	2.69	-	-	-	-	0.72	7.66	10.25	36.63	15.54	29.92	-	-	-
2	SPT	3.00	17.10	1.825	-	-	2.65	21.2	-	Np	-	0.70	2.21	5.90	35.12	50.19	6.58	-	-	SP-SM
3	SPT	4.50	16.50	1.838	-	-	2.65	-	-	Np	-	0.68	3.12	6.30	40.88	43.37	6.33	-	-	SP-SM
4	SPT	6.00	16.32	1.857	-	-	2.65	20.5	-	Np	-	0.66	3.22	6.50	43.26	40.90	6.12	-	-	SP-SM
5	SPT	7.50	16.21	1.873	-	-	2.66	-	-	Np	-	0.65	3.12	6.52	41.11	43.00	6.25	-	-	SP-SM
6	SPT	9.00	15.92	1.880	-	-	2.66	-	-	Np	-	0.64	3.17	5.93	40.58	44.40	5.92	-	-	SP-SM

*.Laboratory tests are Coundcted as per BIS Specifcation only.

*.The Test Report refers only to the samples tested as above.

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PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOIL

Work Reference : Soil Investigation work at Mahanadi River for Proposed Waterways.

Bore Hole NO :02

Sample Details			Natural Moisture content in %.	In Situ Bulk Density in gm/cc.	Shear Strength Parameter		Specific Gravity	Atterberg's Limit			Differentail Free Sweel Index.	Void Ratio	Mechanical Sieve Analysis					Hydrometer Analysis		Soil Classification As per IS:1498
Sl.No.of Sample	Type of Sample	Depth of Collection in mtr			Cohesion in kg/cm^2	Angle of Internal Friction in Degree.		Liqiid Limit in %	Plastic Limit in %	Plasticity Index in %			Fine Gravel in % (20 mm to 4.75mm)	Coarse Sand in %(4.75mm to 2.00mm)	Medium sand in % (2.00mm to 0.425mm)	Fine Sand in % (0.425mm to 0.075mm)	Silt & Clay in % (<0.075mm)	Silt Size in % (0.075mm to 0.002mm)	Clay size in % (<0.002mm)	
7	SPT	10.50	13.78	1.901	-	-	2.66	20.6	-	Np	-	0.62	2.69	6.17	44.97	40.97	5.20	-	-	SP-SM
8	SPT	12.00	15.55	1.928	-	-	2.67	-	-	Np	-	0.60	3.12	6.36	45.54	39.63	5.35	-	-	SP-SM
9	SPT	13.50	15.27	1.948	-	-	2.67	-	-	Np	-	0.58	3.58	5.52	42.28	43.61	5.01	-	-	SP-SM
10	SPT	15.00	15.00	1.974	-	-	2.66	20.3	-	Np	-	0.55	4.18	5.66	45.59	39.46	5.11	-	-	SP-SM
11	SPT	16.50	14.82	1.996	-	-	2.66	-	-	Np	-	0.53	4.62	5.92	50.12	33.98	5.36	-	-	SP-SM
12	SPT	18.00	14.53	2.004	-	-	2.66	-	-	Np	-	0.52	4.55	6.35	53.26	30.64	5.20	-	-	SP-SM
13	SPT	19.50	14.60	2.040	-	-	2.67	-	-	Np	-	0.50	4.10	7.02	51.77	32.01	5.10	-	-	SP-SM

*.Laboratory tests are Coundcted as per BIS Specifcation only.
*.The Test Report refers only to the samples tested as above.

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PHYSICAL AND GEOTECHNICAL PROPERTIES OF SOIL

Work Reference : Soil Investigation work at Mahanadi River for Proposed Waterways.

Bore Hole NO :02

Sample Details			Natural Moisture content in %.	In Situ Bulk Density in gm/cc.	Shear Strength Parameter		Specific Gravity	Atterberg's Limit			Differentail Free Sweel Index.	Void Ratio	Mechanical Sieve Analysis					Hydrometer Analysis		Soil Classification As per IS:1498
Sl.No.of Sample	Type of Sample	Depth of Collection in mtr			Cohesion in kg/cm^2	Angle of Internal Friction in Degree.		Liquid Limit in %	Plastic Limit in %	Plasticity Index in %			Fine Gravel in % (20 mm to 4.75mm)	Coarse Sand in %(4.75mm to 2.00mm)	Medimum sand in % (2.00mm to 0.425mm)	Fine Sand in % (0.425 mm to 0.075mm)	Silt & Clay in % (<0.075 mm)	Silt Size in % (0.075 mm to 0.002mm)	Clay size in % (<0.002mm)	
SPT21.0014.362.063 --2.67196-Np-0.484.206.2555.0029.435.12--SP-SM																				
SPT22.5013.802.059 --2.66--Np-0.473.685.9052.9032.19533--SP-SM																				
SPT24.0013.562.083 --2.66--Np-0.452.166.3253.6632.62524--SP-SM																				
SPT25.5013.252.107 --2.66193-Np-0.432.255.1555.7831.745.08--SP-SM																				
SPT27.0013.112.142 --2.67--Np-0.412.366.9956.1029.33522--SP-SM																				
SPT28.5018.531.981 --2.6434.01915-0.580.000.583.4513.1282.85--CL																				
SPT30.0017.651.991 --2.6433.01914-0.560.001.125.5612.3380.99--CL																				

* Laboratory tests are Coundcted as per BIS Specifcation only.
* The Test Report refers only to the samples tested as above.

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5.5.7. Recommendations for footing in the considered location

Table 5-7: Suggested footing types on land

Sl. No	Structure Type	Suggested Foundation Scheme
1	Structures without basement	Isolated Footings
2	Structures with one, two or three basements	Raft Footings
3	Structures having high height from ground surface.	Pile foundation

Table 5-8: Summary of depth of foundation and SBC

Borehole No.	Depth of Foundation in m.	Footing size BXL in m.	Allowable Bearing Capacity in Ton/m2.
01	3.00	3.00 X 3.00	16.4
	4.50	4.50 X 4.50	34.8
02	3.00	3.00 X 3.00	16.4
	4.50	4.50 X 4.50	34.7

The calculation of allowable bearing capacity for soil layers in BH 01 and BH 02 is as given below (taken from the geotechnical investigation report, enclosed as Volume IV.

FEEDBACK INFRA
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CALCULATION OF NET SAFE BEARING CAPACITY

REFERENCE : Soil Investigation work at Mahanadi River for Water way's at Jagatpur,Odisha.

Design Assumption

Bore Hole NO	=	0 1	
Shape of the Footing	=	SQUARE SHAPE	
Width of the Footing,B	=	4.50	m
Length of the Footing,L	=	4.50	m
Depth of Foundation,D	=	4.50	m
Factor of Safty	=	2.5	

Calculation of Net Safe Bearing Capacity

As per IS-6403:1981 cl.5.1.2, Point (a),pp.8 & Table-1 pp.8 "Net Ultimate Bearing Capacity" q_{net}

General Shear Failure, qnet : $c N_c s_c d_c i_c + q (N_q-1) s_q d_q i_q + 0.5 \gamma B N_\gamma s_\gamma d_\gamma i_\gamma W'$

Local Shear Failure, qnet : $c' N_c' s_c d_c i_c + q (N_q'-1) s_q d_q i_q + 0.5 \gamma B N_\gamma' s_\gamma d_\gamma i_\gamma W'$

where

c	: Cohesion for General Shear Failure	=	0	kgf/mtr^2
Φ	: Angle of Internal Friction for General Shear Failure	=	30.00	
c'	: Cohesion for Local Shear Failure = 2 / 3 c	=	0	kgf/mtr^2
Φ'	: Angle of Internal Friction for Local Shear Failure $\tan^{-1}(2/3 \tan\Phi)$	=	21.1	Deg.
γ_b	: Bulk Density of the Soil	=	1851	kg/mtr^3
γ	: Submerged Density of the Soil	=	982	kg/mtr^3
q	: Effective Surcharge at the base of the foundation		4420	kgf/mtr^2
e	: Void Ratio of the soil		0.68	
G	: Specific Gravity of the soil		2.65	
N_c, N_q & N_γ	: Bearing Capacity Factor for General Shear Failure			
N_c, N_q & N_γ	: Bearing Capacity Factor for Local Shear Failure			
S_c	: Shape Factor	=	1.30	
S_q	: Shape Factor	=	1.20	
S_γ	: Shape Factor	=	0.80	
d_c	: Depth Factor = $1+ 0.2D/B (N_\phi)^{1/2}$	=	1.35	
d_q	: Depth Factor = 1 for Φ<10 or $1+0.1(D/B)(N_\phi)^{1/2}$ for Φ >10	=	1.17	
d_γ	: Depth Factor = 1 for Φ<10 or $1+0.1(D/B)(N_\phi)^{1/2}$ for Φ >10	=	1.17	
i_c	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_q	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_γ	: Inclination Factor = $(1.0 - \alpha / \Phi)^2$	=	1.0	
W'	: Water Table Correction	=	0.5	
N_c	: $(N_q - 1) * \cot\Phi$	=	30.14	General Shear Failure
N_q	: $\exp(\pi * \tan(\Phi)) * \tan^2(45 + \Phi/2)$	=	18.40	
N_γ	: $2 * (N_q + 1) * \tan\Phi$	=	22.40	
N_c'	: $(N_q' - 1) * \cot\Phi'$	=	16.07	Local Shear Failure
N_q'	: $\exp(\pi * \tan(\Phi')) * \tan^2(45 + \Phi'/2)$	=	7.30	
N_γ'	: $2 * (N_q' + 1) * \tan\Phi'$	=	6.54	

Ultimate Net Bearing Capacity, q_{ns} :	152.1	T/m^2	**(For e < 0.55,Dense condition,General Shear Failure)**
Ultimate Net Bearing Capacity, q_{ns} :	52.0	T/m^2	**(For e > 0.75, Loose Condition,Local Shear Failure)**
Ultimate Net Bearing Capacity, q_{ns} :	87.0	T/m^2	**(For 0.55<e<0.75,Medium condition)**
Net Safe Bearing Capacity, $q_{nsf\text{-}safe}$:	34.8	T/m^2	**(For medium condition)**

Net Safe Bearing Capacity, q_{net} : 34.8 T/m^2

(B) SAFE BEARING PRESSURE

Taking the maximum permissible settlement of 50 mm for Isolated foundation in sand and hard clay as IS:1904. The compressible strata (Depth 4.50 to 11.3 mtr) consists of same type of layer.

P = Safe Bearing Pressure in ton/mtr^2; ΔP = Pressure Increment, IB x P; IB = Influence Value for Stress

Settlement of the layer (Depth 4.50 to 11.3 mtr.)

$$S_f = \frac{18}{10} \times \frac{1}{0.5} \times \Delta P$$

$$= \frac{18}{10} \times \frac{1}{0.5} \times 0.48\,P \quad = \quad 1.74\,P \text{ mm}$$

Total settlement after correction of depth factor (0.73)and rigidity factor(0.80)

$S_f = 0.73 \times 0.8 \times 1.74$ P mm

For P = 34.8 ton/mtr^2, S_f = 35 mm

Thus safe bearing pressure on the soil, P = **34.8** ton/mtr^2, ...(2)

(C) ALLOWABLE BEARING CAPACITY

The allowble bearing capacity shall be taken as either of the (1) and (2), whichever is less.

Allowable bearing capacity 34.8 ton/mtr^2,

CALCULATION OF NET SAFE BEARING CAPACITY

REFERENCE : Soil Investigation work at Mahanadi River for Water way's at Jagatpur,Odisha.

Design Assumption

Bore Hole NO	=	0 1	
Shape of the Footing	=	SQUARE SHAPE	
Width of the Footing,B	=	3.00	m
Length of the Footing,L	=	3.00	m
Depth of Foundation,D	=	3.00	m
Factor of Safty	=	2.5	

Calculation of Net Safe Bearing Capacity

As per IS-6403:1981 cl.5.1.2, Point (a),pp.8 & Table-1 pp.8 "**Net Ultimate Bearing Capacity**" q_{net}

General Shear Failure, $q_{net} : c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + 0.5\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$

Local Shear Failure, $q_{net} : c'N_c'\,s_c\,d_c\,i_c + q\,(N_q'-1)\,s_q\,d_q\,i_q + 0.5\,\gamma\,B\,N_\gamma'\,s_\gamma\,d_\gamma\,i_\gamma\,W'$

where

c	: Cohesion for General Shear Failure	=	0	kgf/mtr^2
Φ	: Angle of Internal Friction for General Shear Failure	=	28.00	
c'	: Cohesion for Local Shear Failure = 2 / 3 c	=	0	kgf/mtr^2
Φ'	: Angle of Internal Friction for Local Shear Failure $\tan^{-1}(2/3 \tan\Phi)$	=	19.5	Deg.
γ_b	: Bulk Density of the Soil	=	1843	kg/mtr^3
γ	: Submerged Density of the Soil	=	971	kg/mtr^3
q	: Effective Surcharge at the base of the foundation		2912	kgf/mtr^2
e	: Void Ratio of the soil		0.7	
G	: Specific Gravity of the soil		2.65	
N_c,N_q & N_γ	: Bearing Capacity Factor for General Shear Failure			
N_c,N_q & N_γ	: Bearing Capacity Factor for Local Shear Failure			
S_c	: Shape Factor	=	1.30	
S_q	: Shape Factor	=	1.20	
S_γ	: Shape Factor	=	0.80	
d_c	: Depth Factor = $1 + 0.2D/B\,(N_\phi)^{1/2}$	=	1.33	
d_q	: Depth Factor = 1 for $\Phi<10$ or $1+0.1(D/B)(N_\phi)^{1/2}$ for $\Phi>10$	=	1.17	
d_γ	: Depth Factor = 1 for $\Phi<10$ or $1+0.1(D/B)(N_\phi)^{1/2}$ for $\Phi>10$	=	1.17	
i_c	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_q	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_γ	: Inclination Factor = $(1.0 - \alpha / \Phi)^2$	=	1.0	
W'	: Water Table Correction	=	0.5	
N_c	: $(N_q - 1) * \cot\Phi$	=	26.37	General Shear Failure
N_q	: $\exp(\pi * \tan(\Phi)) * \tan^2(45 + \Phi/2)$	=	15.31	
N_γ	: $2 * (N_q + 1) * \tan\Phi$	=	17.79	
N_c'	: $(N_q' - 1) * \cot\Phi'$	=	14.46	Local Shear Failure
N_q'	: $\exp(\pi * \tan(\Phi')) * \tan^2(45 + \Phi'/2)$	=	6.16	
N_γ'	: $2 * (N_q' + 1) * \tan\Phi'$	=	5.12	

Ultimate Net Bearing Capacity, q_{nu} :	81.3	T/m^2	**(For e < 0.55,Dense condition,General Shear Failure)**
Ultimate Net Bearing Capacity, q_{nu} :	27.6	T/m^2	**(For e > 0.75, Loose Condition,Local Shear Failure)**
Ultimate Net Bearing Capacity, q_{nu} :	41.0	T/m^2	**(For 0.55<e<0.75,Medium condition)**
Net Safe Bearing Capacity, $q_{net\text{-}safe}$:	16.4	T/m^2	**(For medium condition)**
Net Safe Bearing Capacity, q_{net} :	***16.4***	***T/m^2***	

(B) SAFE BEARING PRESSURE

Taking the maximum permissible settlement of 50 mm for Isolated foundation in sand and hard clay as IS:1904. The compressible strata (Depth 3.00 to 7.5 mtr) consists of same type of layer.

P = Safe Bearing Pressure in ton/mtr^2; ΔP = Pressure Increment, IB x P; IB = Influence Value for Stress

Settlement of the layer (Depth 3.00 to 7.5 mtr.)

$$S_f = \frac{25}{10} \times \frac{1}{0.5} \times \Delta P$$

$$= \frac{25}{10} \times \frac{1}{0.5} \times 0.48\,P \quad = \quad 2.42\,P\ \text{mm}$$

Total settlement after correction of depth factor (0.73)and rigidity factor(0.80)

S_f = 0.73 x 0.8 x 2.42 P mm

For P = 16.4 ton/mtr^2, S_f = 23 mm

Thus safe bearing pressure on the soil, P = **16.4** ton/mtr^2, ...(2)

(C) ALLOWABLE BEARING CAPACITY

The allowble bearing capacity shall be taken as either of the (1) and (2), whichever is less.

Allowable bearing capacity 16.4 ton/mtr^2,

CALCULATION OF NET SAFE BEARING CAPACITY

REFERENCE : Soil Investigation work at Mahanadi River for Water way's at Jagatpur,Odisha.

Design Assumption

Bore Hole NO	=	0 2	
Shape of the Footing	=	SQUARE SHAPE	
Width of the Footing,B	=	4.50	m
Length of the Footing,L	=	4.50	m
Depth of Foundation,D	=	4.50	m
Factor of Safty	=	2.5	

Calculation of Net Safe Bearing Capacity

As per IS-6403:1981 cl.5.1.2, Point (a),pp.8 & Table-1 pp.8 "**Net Ultimate Bearing Capacity**" q_{net}

General Shear Failure, qnet : $c\,N_c\,s_c\,d_c\,i_c + q\,(N_q-1)\,s_q\,d_q\,i_q + 0.5\,\gamma\,B\,N_\gamma\,s_\gamma\,d_\gamma\,i_\gamma\,W'$

Local Shear Failure, qnet : $c\,N_c'\,s_c\,d_c\,i_c + q\,(N_q'-1)\,s_q\,d_q\,i_q + 0.5\,\gamma\,B\,N_\gamma'\,s_\gamma\,d_\gamma\,i_\gamma\,W'$

where

c	: Cohesion for General Shear Failure	=	0	kgf/mtr^2
Φ	: Angle of Internal Friction for General Shear Failure	=	30.00	
c'	: Cohesion for Local Shear Failure = 2 / 3 c	=	0	kgf/mtr^2
Φ'	: Angle of Internal Friction for Local Shear Failure $\tan^{-1}(2/3 \tan\Phi)$	=	21.1	Deg.
γ_b	: Bulk Density of the Soil	=	1838	kg/mtr^3
γ	: Submerged Density of the Soil	=	982	kg/mtr^3
q	: Effective Surcharge at the base of the foundation		4420	kgf/mtr^2
e	: Void Ratio of the soil		0.68	
G	: Specific Gravity of the soil		2.65	
N_c, N_q & N_γ	: Bearing Capacity Factor for General Shear Failure			
N_c, N_q & N_γ	: Bearing Capacity Factor for Local Shear Failure			
S_c	: Shape Factor	=	1.30	
S_q	: Shape Factor	=	1.20	
S_γ	: Shape Factor	=	0.80	
d_c	: Depth Factor = $1+ 0.2D/B\,(N_\phi)^{1/2}$	=	1.35	
d_q	: Depth Factor = 1 for $\Phi<10$ or $1+0.1(D/B)(N_\phi)^{1/2}$ for $\Phi>10$	=	1.17	
d_γ	: Depth Factor = 1 for $\Phi<10$ or $1+0.1(D/B)(N_\phi)^{1/2}$ for $\Phi>10$	=	1.17	
i_c	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_q	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_γ	: Inclination Factor = $(1.0 - \alpha / \Phi)^2$	=	1.0	
W'	: Water Table Correction	=	0.5	
N_c	: $(N_q - 1) * \cot\Phi$	=	30.14	General Shear Failure
N_q	: $\exp(\pi * \tan(\Phi)) * \tan^2(45 + \Phi/2)$	=	18.40	
N_γ	: $2 * (N_q + 1) * \tan\Phi$	=	22.40	
N_c'	: $(N_q' - 1) * \cot\Phi'$	=	16.07	Local Shear Failure
N_q'	: $\exp(\pi * \tan(\Phi')) * \tan^2(45 + \Phi'/2)$	=	7.30	
N_γ'	: $2 * (N_q' + 1) * \tan\Phi'$	=	6.54	

Ultimate Net Bearing Capacity, q_{ns} :	151.7	T/m^2	**(For e < 0.55,Dense condition,General Shear Failure)**
Ultimate Net Bearing Capacity, q_{ns} :	51.9	T/m^2	**(For e > 0.75, Loose Condition,Local Shear Failure)**
Ultimate Net Bearing Capacity, q_{ns} :	86.8	T/m^2	**(For 0.55<e<0.75,Medium condition)**
Net Safe Bearing Capacity, $q_{net-safe}$:	34.7	T/m^2	**(For medium condition)**

Net Safe Bearing Capacity, q_{net} : 34.7 T/m^2

(B) SAFE BEARING PRESSURE

Taking the maximum permissible settlement of 50 mm for Isolated foundation in sand and hard clay as IS:1904. The compressible strata (Depth 4.50 to 11.3 mtr) consists of same type of layer.

P = Safe Bearing Pressure in ton/mtr^2; ΔP = Pressure Increment, IB x P; IB = Influence Value for Stress

Settlement of the layer (Depth 4.50 to 11.3 mtr.)

$$S_f = \frac{18}{10} \times \frac{1}{0.5} \times \Delta P$$

$$= \frac{18}{10} \times \frac{1}{0.5} \times 0.48\,P \quad = \quad 1.74\,P\ \text{mm}$$

Total settlement after correction of depth factor (0.73)and rigidity factor(0.80)

$$S_f = 0.73 \times 0.8 \times 1.74\,P\ \text{mm}$$

For $P = 34.7$ ton/mtr^2, $S_f = 35$ mm

Thus safe bearing pressure on the soil, P = **34.7** ton/mtr^2, ...(2)

(C) ALLOWABLE BEARING CAPACITY

The allowble bearing capacity shall be taken as either of the (1) and (2), whichever is less.

Allowable bearing capacity 34.7 ton/mtr^2,

CALCULATION OF NET SAFE BEARING CAPACITY

REFERENCE : Soil Investigation work at Mahanadi River for Water way's at Jagatpur,Odisha.

Design Assumption

Bore Hole NO	=	02	
Shape of the Footing	=	SQUARE SHAPE	
Width of the Footing,B	=	3.00	m
Length of the Footing,L	=	3.00	m
Depth of Foundation,D	=	3.00	m
Factor of Safty	=	2.5	

Calculation of Net Safe Bearing Capacity

As per IS-6403:1981 cl.5.1.2, Point (a),pp.8 & Table-1 pp.8 "**Net Ultimate Bearing Capacity**" q_{net}

General Shear Failure, qnet : $c\, N_c\, s_c\, d_c\, i_c + q\,(N_q\text{-}1)\, s_q\, d_q\, i_q + 0.5\,\gamma\, B\, N_\gamma\, s_\gamma\, d_\gamma\, i_\gamma\, W'$

Local Shear Failure, qnet : $c'\, N_c'\, s_c\, d_c\, i_c + q\,(N_q'\text{-}1)\, s_q\, d_q\, i_q + 0.5\,\gamma\, B\, N_\gamma'\, s_\gamma\, d_\gamma\, i_\gamma\, W'$

where

c	: Cohesion for General Shear Failure	=	0	kgf/mtr^2
ϕ	: Angle of Internal Friction for General Shear Failure	=	28.00	
c'	: Cohesion for Local Shear Failure = 2 / 3 c	=	0	kgf/mtr^2
ϕ'	: Angle of Internal Friction for Local Shear Failure $\tan^{-1}(2/3 \tan\phi)$	=	19.5	Deg.
γ_b	: Bulk Density of the Soil	=	1825	kg/mtr^3
γ	: Submerged Density of the Soil	=	971	kg/mtr^3
q	: Effective Surcharge at the base of the foundation		2912	kgf/mtr^2
e	: Void Ratio of the soil		0.7	
G	: Specific Gravity of the soil		2.65	
N_c, N_q & N_γ	: Bearing Capacity Factor for General Shear Failure			
N_c, N_q & N_γ	: Bearing Capacity Factor for Local Shear Failure			
S_c	: Shape Factor	=	1.30	
S_q	: Shape Factor	=	1.20	
S_γ	: Shape Factor	=	0.80	
d_c	: Depth Factor = $1+ 0.2D/B\,(N_\phi)^{1/2}$	=	1.33	
d_q	: Depth Factor = 1 for ϕ<10 or $1+0.1(D/B)(N_\phi)^{1/2}$ for ϕ >10	=	1.17	
d_γ	: Depth Factor = 1 for ϕ<10 or $1+0.1(D/B)(N_\phi)^{1/2}$ for ϕ >10	=	1.17	
i_c	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_q	: Inclination Factor = $(1.0 - \alpha / 90)^2$	=	1.0	
i_γ	: Inclination Factor = $(1.0 - \alpha / \phi)^2$	=	1.0	
W'	: Water Table Correction	=	0.5	
N_c	: $(N_q - 1) * \cot\phi$	=	26.37	General Shear Failure
N_q	: $\exp(\pi * \tan(\phi)) * \tan^2(45 + \phi/2)$	=	15.31	
N_γ	: $2 * (N_q + 1) * \tan\phi$	=	17.79	
N_c'	: $(N_q' - 1) * \cot\phi'$	=	14.46	Local Shear Failure
N_q'	: $\exp(\pi * \tan(\phi')) * \tan^2(45 + \phi'/2)$	=	6.16	
N_γ'	: $2 * (N_q' + 1) * \tan\phi'$	=	5.12	

Ultimate Net Bearing Capacity, q_{ns} :	81.0	T/m^2	**(For e < 0.55,Dense condition,General Shear Failure)**
Ultimate Net Bearing Capacity, q_{ns} :	27.6	T/m^2	**(For e > 0.75, Loose Condition,Local Shear Failure)**
Ultimate Net Bearing Capacity, q_{ns} :	41.0	T/m^2	**(For 0.55<e<0.75,Medium condition)**
Net Safe Bearing Capacity, $q_{net\text{-}safe}$:	16.4	T/m^2	**(For medium condition)**
Net Safe Bearing Capacity, q_{net} :	*16.4*	*T/m^2*	

(B) SAFE BEARING PRESSURE

Taking the maximum permissible settlement of 50 mm for Isolated foundation in sand and hard clay as IS:1904. The compressible strata (Depth 3.00 to 7.5 mtr) consists of same type of layer.

P = Safe Bearing Pressure in ton/mtr^2; ΔP = Pressure Increment, IB x P; IB = Influence Value for Stress

Settlement of the layer (Depth 3.00 to 7.5 mtr.)

$$S_f = \frac{22}{10} \times \frac{1}{0.5} \times \Delta P$$

$$= \frac{22}{10} \times \frac{1}{0.5} \times 0.48\,P \quad = \quad 2.13\,P\,mm$$

Total settlement after correction of depth factor (0.73)and rigidity factor(0.80)

$$S_f = 0.73 \times 0.8 \times 2.13\,P\,mm$$

For P = 16.4 ton/mtr^2, S_f = 20 mm

Thus safe bearing pressure on the soil, P = **16.4** ton/mtr^2, ...(2)

(C) ALLOWABLE BEARING CAPACITY

The allowble bearing capacity shall be taken as either of the (1) and (2), whichever is less.

Allowable bearing capacity 16.4 ton/mtr^2.

5.6. Berthing Structure

The peculiarity of the project location is the severe fluctuation in water-levels during various seasons. From the gauge discharge data at Naraj from 1968 to 2016, it can be inferred that the difference between minimum water level and maximum water level can go as high as 5m. Hence the structural components are designed such that the port operations can be carried out during various seasons of the year except during extreme weathers. It can be observed from secondary sources that, Orissa receives monsoonal rain during the month of July to September, with peak discharge in Mahanadi river near Cuttack during the month of September. October to February is winter season and March to June facing summer heat. The average highest water level which can be used for design as observed from the discharge data is around 25.5m w.r.t MSL and the average lowest normal water level for design of berthing structure is 21.5m w.r.t MSL. With this criterion, the possible options for the berthing structure are floating structure and RCC structure at different levels. The floating structures are mostly preferred to handle light cargoes which do not require huge handling space and facilities as in the case of passengers, liquid bulk etc. Thus, feasible solution seems to be of RCC jetty structure provided with levels, so that the port facilities can be used during normal water level and high-water level, but during the exceptional situations of extreme flood, the terminal have to be shut down for few days. During extreme summer, with non-availability of least available depth in the river, the terminal has to be shut down, till the depth is reestablished. Considering all the above factors, it is proposed to have two level berthing jetties.

Figure 5.6: Typical general cargo & dry bulk cargo RCC berths

The structural components of the berthing structure include:

- Piles: RCC piles to support the berthing structure.
- Pile muffs: Between the pile and the supported beams.
- Longitudinal Beams: Secondary beams along the length of the structure.
- Cross Beams: Main beams connecting the pile muffs.
- Deck Slab: Cast in-situ slab.

Apart from the above, quay structure accommodates facilities to moor the vessels and to absorb the impact force of the vessels. Fenders can absorb the impact force of the vessels, thereby reducing the impact force the quay structure need to suffer and bollards forms points of attachment for the vessels. The codes referred for arriving at the preliminary design of the structure includes IS 456, 875/3, 4651, etc. The design vessel size is 58m LOA, beam of 9m and draft of 1.5m

5.6.1. Fenders

Fenders provide the necessary interface between the berthing ship and the berth structure, and therefore the principal function of the fender is to transform the impact load from the berthing ship into reactions, which both the ship and berth structure can safely sustain. A properly designed fender system must therefore be able to gently stop a moving or berthing ship without damaging the ship, the berth structure or the fender itself. Fenders can be of various types based on their mechanism of absorbing energy, material of make, etc. For the present situation, since the design vessel is small and of inland vessel category, the fender can be of a D-type fixed system, with around 50 to 55% deflection.

Figure 5.7: D-Type fenders fixed to a quay

5.6.2. Bollards

They are mooring accessories which provide the docking facility with a convenient and reliable means of mooring a vessel while she is loading or unloading at berth. The basic requirements for mooring accessories are simplicity, reliability, fast operating, ability to be operated with least damage to mooring lines. Bollards are the most commonly used mooring accessory and usually may be of T-head type. It is usually manufactured from cast steel or cast iron and after installation, filled with concrete.

Figure 5.8: A typical bollard fixed to a quay

5.7. Terminal Infrastructure Including Equipment

The terminal infrastructure is planned considering the Class of waterway proposed and the design vessel. With the major portion of the waterway developed as Class III waterways with the terminal location falling in this region, the specifications of Class III waterways are considered. The design vessel is the one with maximum LOA of 58m, beam of 9m and draft of around 1.5m. The expected maximum loading capacity of the design vessel is around 500Tonnes.The Waterway is working only for 4-5 Months in a year as well as the use of waterway shall be only for a few Vessels. Therefore, extensive arrangements including the facility of collection for Pollutants generated onboard vessels are not recommended. Moreover as per gist of discussion held on 01-02-2018 and discussion held during the visit of site on 03-02-2019 it was general view that this project is not financially viable as below:

Gist of discussion on 1.2.2018 and discussions during site visit on 3.2.2018

S.No	Issues brought out in the presentation	Responses
1	The proposed stretch can now be modified from NW5 confluence as the state government is planning to have a state-owned terminal near the IFFCO plant.	Already accounted for in the report
2	Consider extending the water way up to Narag or further upstream.	Prohibitive Lock Cost at Jobra Barrage. Hence, the terminal location is downstream of Jobra Barrage
3	To consider the tourism potential and industrial cargoes likely to be generated due to upcoming investments by IOCL, etc., so that the water way can be extended to the upstream of Jobra barrage economically.	IOCL investments related to PCPIR would be coming up in Paradip's port hinterland. Also, no investments have been finalized as of yet.
4	Already around 600 hectares of area near Luna River is water logged and any intervention in the form of barrages can lead to pondage. In this case, to ensure protection of the area, the water regulating structure proposed shall be associated with drainage structures.	
5	For the Syphon cum bridge at Chitroptala, the horizontal clearance, vertical clearance and depth criteria are not satisfying the NW specs. Why can't it be considered to reroute the channel through left bank of the river.	
6	The bank protection and embankment strengthening activities are to be taken up in consultation with state WRD.	

S.No	Issues brought out in filed visit on 2.2.2018	Responses
	At Cuttack terminal location	
1	To check the viability of the project by providing floating pontoon and gangway instead of permanent facility.	
2	To check if dredging the channel will help to maintain waterway viable throughout the year.	
3	It is suggested from local observation that the monsoon period alone is likely to give a LAD of 2m throughout. This may be verified and considered.	
	At Chithroptala Syphon in Murkundi	
1	The Syphon may be bypassed by constructing a rectangular vertical channel with lock system.	
2	The land beside the syphon belongs to the government. So, any approach to bypass the syphon via that can be thought of without the burden of acquiring land.	
3	The details of syphon at Paika to be analyzed and to be included in the DPR.	
4	The location and details of the riverine port proposed by the state water resource department to be depicted in the DPR.	

Any terminal requires a group of items which are related functionally and helps perform a chain of activities efficiently and without delay. Major items of the terminal are:

5.7.1. Berth

Berth is the structure which enables uninterrupted and safe transfer of cargo. It accommodates facilities for breasting and mooring of the vessels and will have loading gears to ensure optimized cargo movement. The type and orientation of the berth depends on various factors as, site condition, waterfront land availability, purpose, water depth, etc. The minimum length of a berthing structure should be sufficient for mooring the design vessel. The berth may be multi-purpose, which serves different types of vessels, or may be sophisticated serving only a type of cargo. Multipurpose berths are preferred for small developing, younger terminals with limited traffic. In the present project, the major traffic projected is dry bulk even though local passenger movements exist. Thus, a multipurpose berth with a lower level and a high-level berth is proposed here.

5.7.2. Mechanical Equipment

An unloading/loading equipment to handle cargo between the vessel and the evacuation system is required at the berth. Another equipment of similar kind and a pay loader is required for the storage area.

A closed grab crane of 10 tonnes capacity is proposed for the berth. For dry bulk, grab crane is a common equipment used even though sophisticated equipment's for efficient transfer of dry bulk exist. For the storage area, a 5 tonne capacity crane can handle the dry bulk between storage heap and the truck. A payloader of 5 tonnes capacity can be used for moving the cargo within the storage area.

Dumpers can be used for the evacuation of the dry bulk from the berth to the storage area or to the site of usage; or for bringing the dry bulk from the area of production to storage area within the terminal premise or to the berth.

Figure 5.9: Grab crane unloading cement bulk

Dumpers: Dumper is a familiar sight on almost all ports. It comes in several different sizes for a variety of tasks. They are used to move bulk and break-bulk cargo from the berth to the storage area. The trucks proposed in the terminal as service vehicle are of dumper type with capacity of 8 tonnes/ truck.

Figure 5.10: A dumper unloading dry bulk cargo and dumper loaded at the berth

5.7.3. Storage Area

The space meant for temporary or permanent storage of cargo. The weathered cargo is stored in covered storage under normal temperature. Weather resistant cargo is stored in open space. In closed storage area called warehouse, the cargo is stored for a limited period say about 15 days or so, after which it must be removed. The dry bulks are stored as heaps of maximum 3m height, with 10m diameter and ensuring sufficient space for movement of crane, pay loader, dumper itself in case of requirement. Open storage area is a cleared and levelled area of land with boundary demarcated and with proper access.

5.7.4. Terminal Building

A building to house the important operational and administrative facilities is proposed. It can be single storied structure with different sections as administration, operation cum control, security, passenger amenities, etc.

Administration: Facilities for the administration of the port will vary considerably depending upon the system of administration, the geographical location of the port and its size. Comparing the methods used in different ports, it is difficult to find anything approaching a standard operation. However, a centralized administrative agency with broad powers is essential for the efficient and economical operation of a port. The administration of the port or terminal is vested to a body of government (here IWT) with jurisdiction over the cargo and passengers moving through the terminal. The port administration under the direction of the port captain, the port security or police, waiting room, first aid, and rest rooms are all centralized in one building close to the docks. Depending upon the standard of the port, the administrative block can have varying features. Direct communication is maintained from here to all locations within the terminal premise.

Operational cum control building: The operational functions of a port include:

- ✓ Facilitating arrival and departure of vessels
- ✓ Providing navigational aids and Vessel Traffic Separation (VTS) facilities
- ✓ Mooring activities
- ✓ Allocating berths, transit sheds, etc.
- ✓ Handling of cargo as loading, discharging, storage and distribution of cargo
- ✓ Facilitating supply chain logistics and management

Security building: Port security refers to the defense, law and treaty enforcement and counterterrorism activities that fall within the port domain. It includes the protection of terminal themselves, the protection and inspection of the cargo or passengers moving through the ports.

Passenger amenities: The facilities for waiting or arriving passengers are required.

5.7.5. Internal Connectivity

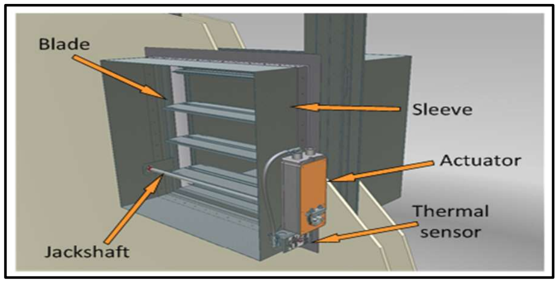
It is required to have through connectivity internally and with the hinterland. The following general principles were considered in the layout of internal roads:

- ✓ Through routes are provided wherever it is possible, to avoid trucks being forced to turn around.
- ✓ Road junctions or intersections with other routes are reduced to a minimum, and in any case, are placed only in situations where the temporary stoppage of lines of traffic does not obstruct other intersections or cross routes.
- ✓ Adequate parking places are ensured for vehicles which must wait for loads or to unload, due to various circumstances.
- ✓ Routes are recommended to be adequately signposted
- ✓ If the provision of through routes is not possible, adequate turning areas are provided.
- ✓ It is proposed to have a map of the road network exhibited in the premise.

5.7.6. Firefighting Equipment

Fire mains, fire pumps and hydrants, including hoses, nozzles, etc. are required.

Figure 5.11: Fire hydrants and associated connections & fire and smoke damper



- ✓ Fire detection, extinguishing and alarm systems.
- ✓ Ventilation systems, including fire and smoke dampers, fans and their controls, remote stops, to be installed in the terminal and storage buildings.
- ✓ Fuel and lubricating oil quick-closing devices shutdown.
- ✓ Fire doors, including their controls.
- ✓ General emergency alarm systems.
- ✓ EEBD (Emergency Escape Breathing Device) and fire fighters' outfits.

Figure 5.12: EEBD and fire fighters' outfits & general emergency fire alarm system

- ✓ Portable and non-portable fire extinguishers, including spare charges.

Table 5.9: Equipment in the structures.

Structure	Equipment	Items proposed

Berth	Mechanical Equipment	1. Closed grab crane (1 number) – 10 tonnes capacity – for both berth and dry bulk 2. Crane (1 number) – 5 tonne – for the storage area 3. Payloader (1 number)– 5 tonnes – for the storage area 4. Dumpers – 8 tonnes/truck – for the storage area
Terminal Building	Firefighting Equipment	1. Fire mains, fire pumps and hydrants 2. Fire detection, extinguishing and fire alarm. 3. EEBD (Emergency Escape Berthing Device) and fire fighters' outfit. 4. Fuel pump

Figure 5.13: Automatic firefighter in a jetty & fire extinguisher

5.8. Terminal Costing

The costing of terminal including the berthing structure, the storage area, terminal building etc, are worked out based on the MORTH standards, CPWD rates, CWC handbook wherever applicable, rest of the items are rated based on market rates.

5.8.1. Capital Cost

Table 5.10: Terminal costing

Structure	Amount
Berthing structure	₹ 6,97,28,251.30
Terminal building 225 sqm housing operation, administration, security and passenger amenities.	₹ 30,62,287.00
Storage with provision for covered storage, open storage	₹ 2,33,03,347.59

Landscaping (paving’s, lawn, etc.)	₹ 5,00,000.00
Auxiliary items (firefighting, water supply, safety gadgets, lightings, road networks, etc.)	₹ 2,55,00,000.00
Mechanical equipment	₹ 2,05,00,000.00

5.8.2. O&M Cost

For operation and maintenance, a percentage of initial cost is considered, which is shown in the table below.

Table 5-9: Operation and maintenance costing

Structure	Percentage of capex (%)	Amount
Berthing structure	2	₹ 5,32,697.13
Terminal building 225 sqm housing operation, administration, security and passenger amenities.	1	₹ 1,24,717.00
Storage with provision for covered storage, open storage	1	₹ 2,33,033.48
Landscaping (paving's, lawn, etc.)	1	₹ 5,000.00
Auxiliary items (fire-fighting, water supply, safety gadgets, lightings, road networks, etc.)	1	₹ 2,55,000.00
Mechanical equipment	5	₹ 10,25,000.00
Total		**₹ 21,75,447.61**

6. PRELIMINARY ENGINEERING DESIGNS

6.1. River Training

It implies the measures adopted on the river to direct and guide the river flow, to train and regulate the riverbed or to increase the low water depth. In the present case, training is done for depth, i.e., the river is trained to provide sufficient depth for navigation during low stage of water. The preliminary design is based on the Class III criteria of waterway and vessel size of maximum 58m LOA, 9m beam and loaded draft of 1.5m.

Dredging of the river channel is a requisite. Since the sediment materials are observed to be sandy soil with small amounts of silt and clay, maintenance dredging at intervals is to be considered.

Two options are considered regarding the extend of fair way development; first the navigational channel will remain non-functional during the summer season when depth of water available to carry the vessels are scarce. In this case, river can be utilized when water is available otherwise it cannot be depended upon. This situation may be continued till a justifiable traffic is generated. Once the traffic has reached a sustainable limit, structures like barrages and weirs can be considered. It is proposed to have a barrage upstream of the tidal influence zone cessation point say, near CH44km.From the hydrographic survey report it is inferred that, the barrage is likely to have a height of around 19m above the existing river bed. This will require construction of weirs to block the bypass of dammed water. At about CH 50, a weir of height 4m may be required, also at CH 68 and CH 85, weirs or check dams of height around 7.4 and 9.5m respectively are to be considered. These hydraulic structures are likely to cause inundation of occupied lands which may be at least 1000 ha. The more details of the hydraulic behavior of the catchment in the presence of these structures can be predicted only through good numerical modeling, which is beyond the scope of the present study. However, it can be inferred that considerable investment shall be required for barrage construction and associated works. Thus, this option may be considered at a later phase. The details of the proposed river training and conservancy works can be read from the drawings enclosed as Vol. II.

6.2. Bank Protection

The main aim of bank protection includes:

- Checking erosion of bank by currents or vessel wakes.
- Checking sliding of slope due to gradual steepening because of erosion.
- Checking sliding due to drawdown of floods, etc.

From the survey report, it is observed that few stretches of the embankment are protected but the rest are left unprotected. The erosion prone areas demand some precaution measures against the action of water especially during flood. Thus, it is suggested to have bank protection adjacent to the terminal location. It is recommended to have relatively soft solutions for bank protection. At critical locations, like the ones have very close proximity to terminal or the one with very sever velocities are suggested to have stone protections. Thus, the proposal is for laying riprap with vegetal cover.

The design of the riprap is based on IS 14262 (Planning and design of revetments guidelines) and IS 8237 (Protection of slopes for reservoir embankments). The major features considered for design includes, rock shape, size and gradation; bank slope and extend of protection; toe treatment; filter layer. It is proposed use a rock density of around 2500 kg/ cub. M. Assuming a side slope angle for the channel as 1 vertical to 2 horizontal and an angle of repose for the rip rap material as 30 degrees. As per IS 14262, the weight of the stone is given as,

$$W = \frac{0{\cdot}023\ 23}{K} \times \frac{S_s}{(S_s - 1)^3} V^6$$

Where, W- weight of stone in kg

Sg-specific gravity of stone

V-mean velocity of water in m/sec over the vertical under reference

K-correction factor for sloping face of the channel, can be obtained from Fig:1 of IS 14262.

Size of the stone is given as,

$$D_s = 0 \cdot 124 \sqrt[3]{\frac{W}{S_s}}$$

And thickness of protection layer is given as,

$$T = \frac{V^2}{2g(S_s - 1)}$$

Where, g: acceleration due to gravity.

A filter layer of 300mm thick confirming to IS 8237 is required to be provided below the revetment to prevent failure by sucking action of high velocity flow. From the site investigation, it is observed that the soil there is granular with less than 50 percent or less fines by weight. Hence the following is to be satisfied,

$$\frac{\text{85\% passing size of bed material (mm)}}{\text{Equivalent opening size of bed of fabric (mm)}} \geqslant 1 \cdot 0$$

Also, the provisions of IS 14262, shall be satisfied. It is recommended to provide a 150mm thick sand layer over the filter fabric to prevent the mechanical rupture of the fabric while placing the stones. To prevent the sliding and failure of the revetment on slope, toe protection is recommended. Assuming that unerodable strata is available at the riverbed at a reasonable depth, it is recommended to provide a toe key.

Thus, the proposed weight of stones to be used for embankment protection is minimum 3kg, with minimum diameter around 0.15m, minimum thickness of the protection layer around 0.15m. The drawing showing the typical cross section of the riprap is enclosed at the end of the report as Annexure I.

The construction practices include clearing and grubbing the slopes and dressed to a smooth surface. Loose, soft materials and large rock projections through the slope are removed and potholes filled with non-cohesive materials and compacted. Toe trench for scour protection is prepared. The filter layer materials are spread evenly on the prepared bank without any compaction. Over that rocks are placed using a crane. Live plants can be used in conjunction with structural measures. Vegetation recommended is local species.

6.3. Aids to Navigation

They are provided to give the ship navigator warning of hidden dangers such as rocks, lack of depth, or other obstacles hidden underwater. They are also installed to mark the width and important turns in navigation channels and to guide the vessel safely at maximum possible speed through canals, rivers or along the coast. The types of aids required vary from location to location. They could be either floating or fixed structures, until or equipped with required lighting, sound-warning, or radar reflectors. Routinely, navigation lights are installed on structures as piers, quays, dolphins, bridges, mooring accessories to mark their location and outline their limits. The following navigating aids are commonly used for inland navigation:

Figure 6.1: Typical beacon and range

- Day beacon: An unlit aid primarily used to assist the ship during the daylight hours where sight navigation is practical or, when it is not practical to operate a light.
- Range: An aid which consists of two or more fixed navigation marks situated at different elevations to provide a leading line for ship navigation. The range may or may not exhibit lights.

The buoys are proposed to be placed at a spacing of 1000 to 1500m along straight stretches of the channel on both the boundaries and in curves to enable proper navigability; they are proposed to be placed at a spacing of 300 to 500m. The ranges are placed along the center line of the channels along straight stretches so that the vessels can align themselves within the channel about them. The arrangements and spacing of the proposed markings are shown in the drawings enclosed as Vol. II.

Annexure 1, also shown stretch wise in drawings. Tabulation of the navigational aids based on chainage provided in table 3.5.

6.4. Cargo Terminals and River Ports

The codes referred for arriving at the preliminary design of the structure includes IS 456, 875/3, 4651, etc. The design vessel size is 58m LOA, beam of 9m and draft of 1.5m.

6.4.1. Berth Structure

The berthing quay is designed as RCC structure using precast members. The berth is to have short beams resting on the pile cap and the long beams makes the secondary beams. Portions of beams can be precast and laid in place for easy execution. The top slab can be cast-in-situ. The facia beam to receive the fender is designed specially to accommodate the increased impact load. Live load considered on the deck is uniformly distributed load of 5t/ sq.m. The piles are to be of friction type of 24m founding depth and 1000mm diameter. Grade of concrete is M-35.

The length of the berth is taken 10% more than the length of the design vessel, for safe mooring and berthing. The width is taken as 10.5m, considering the width of proposed mobile crane for unloading and a safe margin. From the min and maximum water levels in Mahanadi for around last 10 years, submitted by the hydrographical survey team and assuming summer season from March to June, monsoon from July to October, it can be arrived that the average high-water value comes around +25.5m w.r.t MSL, excluding scattered exceptionally high values indicating flood. The average low water level except for very severe summer is around + 21.5m wrt MSL. Thus, with a freeboard of 1m, the deck elevations are proposed as +26.5m MSL and +22.5m MSL for high and low-level jetty respectively. The pile layout, beam arrangement and sizing of members are given in the drawing attached as Annexure. Sample Pile design and the Pile Lay out diagrams are given below.

JETTY TOP LEVEL	=	22.5	m
PILE CAP TOP LEVEL	=	21.5	m
PILE CUT OFF LEVEL	=	21	m
PILE FOUNDING LEVEL	=	-3.0	m
GROUND LEVEL	=	9.0	m

PILE CAP THICKNESS	=	0.5	m
PILE LENGTH	=	24	m

Maximum Load Pile can take : (Refer intraction curve)

Case 1 : when maximum uplift

For tension of -448 tonnes it can take moment of 45 tm

Case 2 : Maximum moment

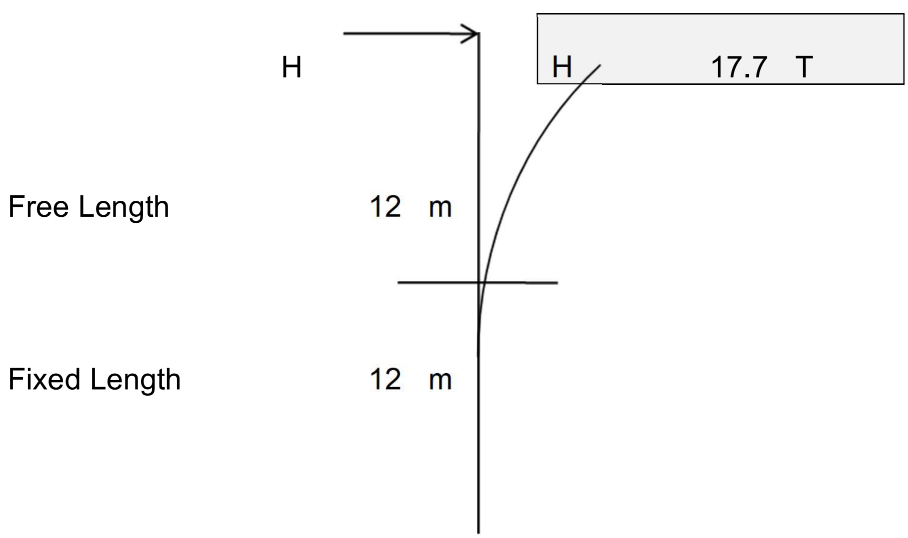
For Maximum moment of 236 tm it can take load of 458 tonnes

Case 3 : Maximum Vertical Load

For Maximum compression of 1658 tonnes it can take moment of 10 tm

Case 4 : Maximum Horizontal Load

Maximum Horizontal Load limit is 17.7 tonnes which produces moment of 236 tm



Material Used

Concete	M35
Steel	Fe500

Permessible Stresses

Concrete	0.36fck	=	12.60	Mpa
Steel	0.6Fy	=	300.00	Mpa

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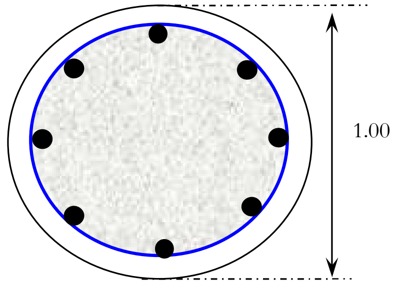
PILE Interaction Diagram

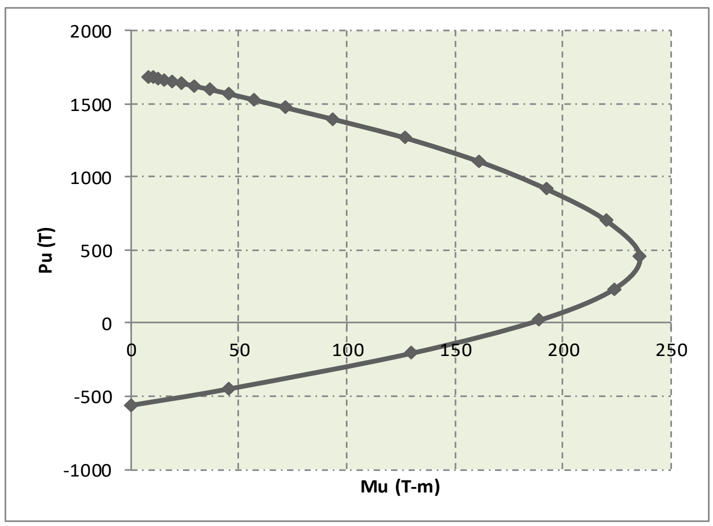


Pile Dia D	=	1000 mm
d'/D	=	0.10
Clear cover	=	75 mm
Dia of bar	=	32
Nos. of Bars	=	16 Nos
Effective cover	=	103 mm
Reinf Circular dia	=	794 mm
Spacing	=	156 mm
Area of steel provided	=	12868 mm2
% steel provided	=	1.64 % OK
Minimum % steel	=	0.40 % OK
p/fck	=	0.04681

Material Properties:		
fck	=	35 N/mm^2
fyk	=	500 N/mm^2
Es	=	200000 N/mm^2

Check of Min Steel as per 16.2.2 - IRC:112-2011			
Min Steel 0.1Ned/Fyd	=	772 mm2	
0.002Ac	=	1571 mm2	OK

xu/D	Pu T	Mu Tm	
1E-09	-559	0	1E-09
0.1	-448	45	0.1
0.2	-205	130	0.2
0.3	21	189	0.3
0.4	236	224	0.4
0.5	458	236	0.5
0.6	700	220	0.6
0.7	918	193	0.7
0.8	1107	161	0.8
0.9	1269	127	0.9
1	1398	93	1.0
1.1	1476	72	1.1
1.2	1530	57	1.2
1.3	1570	46	1.3
1.4	1601	37	1.4
1.5	1624	29	1.5
1.6	1642	23	1.6
1.7	1655	19	1.7
1.8	1666	15	1.8
1.9	1674	12	1.9
2.0	1680	10	2.0
2.1	1685	8	2.1



Transverse Reinforcement (Cl. 16.2.3 IRC:112-2011)

Diameter of Transverse Reinforcement 12 mm OK

Spacing of Transverse Reinforcement shall be minimum of followng

384 mm

1000 mm

200 mm

Provide 12 dia @ 200 mm OK

6.4.2. Fender

The selection of fender system is based on the following factors:

- ✓ The fender system must have sufficient energy absorption capacity
- ✓ The reaction force from the fender system does not exceed the loading capacity of the berthing system
- ✓ The pressure exerted from the fender system does not exceed the ship's hull pressure capacity
- ✓ The capital construction cost and maintenance costs are considered during the design of both the berth structure and fender system

To determine the size and capacity of the fenders, the following methodology is adopted. When a vessel strikes a berth, horizontal forces acts on the berth. The magnitude of force depends on the kinetic energy that can be absorbed by the fendering system. The kinetic energy, E, imparted to a fendering system, by a vessel moving with velocity V (m/s) is given by

$$E = \frac{W_D V^2}{2g} C_m C_e C_s$$

Where,

- E = Berthing energy in T-m
- WD = Displacement tonnage in T
- V = Berthing velocity in m/sec
- Cm = Mass coefficient
- Ce = Eccentricity coefficient
- Cs = Softness coefficient
- g = Acceleration due to gravity in m/sec2

As per the latest code provisions, a factor of safety of 2.0 is applied over the ultimate energy absorption capacity. (IS 4651 – Part 4, 2014, Clause 9.3.e).

The parameters used in the design are LOA of vessel 58m; beam 9m; draft 1.5m; blockage ratio 0.025. With this a vessel displacement tonnage works out to be 19.575

tonnes. The coefficient of mass works out to be 6.2359; and assuming softness coefficient as 0.95; coefficient of eccentricity as 1; configuration coefficient as 1 and normal velocity of vessel as 0.25 m/sec, considering sheltered and difficult berthing condition, the energy to be absorbed by the fender works out to be around 3.7kNm. It is proposed to have D-Type fender, of DD series, with width 200mm, height 200mm for outer D and 100mm size for inner D. The reaction force is around 153kN.

6.4.3. Bollards/ Mooring points

As per IS4651, part III, the line pull is around 10 tonnes, for a vessel of displacement ton 2000. In the present case, the displacement ton is around 20. Considering future expansion plans, and bollards being a fixed element, it is proposed to provide bollards to suffer 10 tonnes pull. The proposed type is T-head bollard of cast iron material. The basic mooring lines required for a vessel to be held with stability is as shown in the figure below.

Figure 6.2: Typical mooring lines

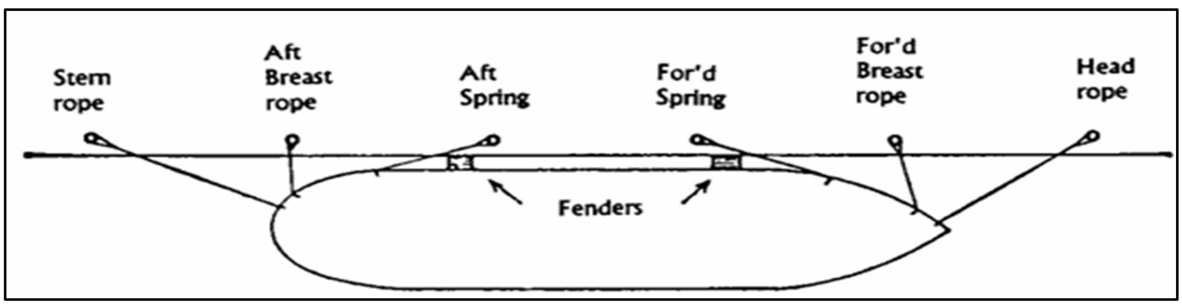


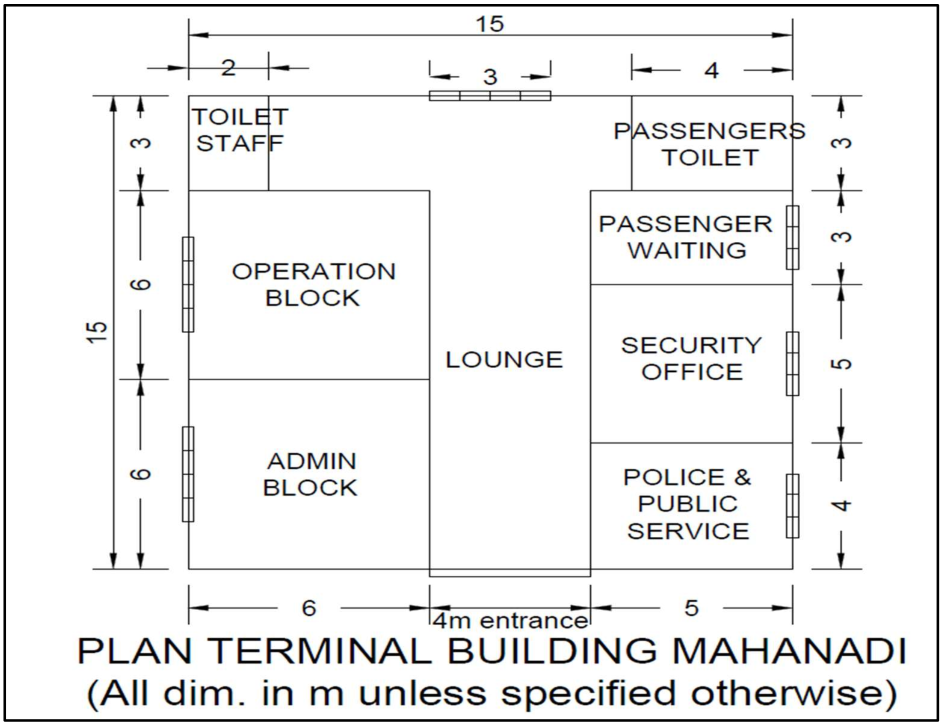
Table 6-1: Name and purpose of mooring lines

Name	Purpose
Head line	Keep forward part of the ship against the dock
Forward Breast Line	Keep close to pier
Forward Spring	Prevent from advancing
Aft Spring	Prevent from moving back
Aft Breast line	Keep close to pier
Stern line	Prevent forwards movement

6.4.4. Terminal Building

This building houses the facilities for operation, administration, security, etc. The major requirements are locating the passengers comfortably, office space for the terminal employees and basic amenities. Thus, it is a suggested to have a 15m X 15m single store framed building which may be made multi storied subsequently in future. The basic loads considered for the building is 5kN/sqm live load including 1 kN/ sqm for light weight partitions. Isolated open footings are proposed based on the recommendations of the geotechnical investigation report and bore hole logs attached in the investigation report. It is observed that at around 4m below ground level, an SBC of around 30tonnes/ sqm can be obtained. Hence it is proposed to have the footing base at 4m below the ground level. The detailed drawings for the proposed building are enclosed as Vol. II: drawings.

Figure 6.3: Plan for terminal building at Cuttack



6.4.5. Storage area

The storage area is designed for 75% of design vessel capacity, i.e., 75% of 500 tonnes or 375 tonnes. The dry bulk is proposed to be placed as heaps of maximum height 3m and base radius maximum 10m and a minimum spacing of around 3m between heaps. Closed and open storages are proposed. For the storage area, a live load of 10kN/sqm is considered apart from the load contribution by the crane. Provisions for a transit shed is proposed for easy handling of expected cargo. The cargo handling area is expected to accommodate a crane of 5 tonnes handling capacity. It is proposed to have isolated open footing for the storage area, founded 4m below the ground surface. The drawings for the same can be read from the Vol. II, enclosed.

6.4.6. Parking area

The calculation of required areas for truck parking is based on the following assumption,

- Throughput: 0.5 MMTPA

- Average load per truck: 8 tonnes
- Average working days per year: 270 days
- Berth occupancy: 70%
- Time available for pick-up and delivery: 8hrs/ day
- Average no. of truck required: 232 trucks /day

Assuming a peak factor of 2, two periods of 4 hrs per day and 25% of the trucks arriving at the beginning of the period, parking space required is 58 trucks or approximately 5800sq.m. It is safe to plan for 50 percent of the requirement till assured traffic is generated. Thus, a parking space for around 30 trucks are proposed.

6.5. Construction Schedule

The precast members are made by the time the pile foundation for the quay is getting ready. The construction must be planned to cope with the prevailing weather condition of the area. The independent targets shall be achieved parallel to have satisfactory progress.

The sequence of construction activities for shall be as mentioned below:

n). Dredging of the entire channel and site clearance at the terminal location and at locations of cut-offs proposed.

o). Temporary works for piling activities to be initiated and foundation for terminal and storage building to be constructed.

p). In-situ casting and installation of piles for jetty, construction of substructure for terminal building and storage area.

q). Modifications to bridges.

r). Land based casting for semi precast beams and fabrication of steel truss for storage building.

s). In-situ casting and installation of pile muff and procurement of fenders and bollards for the berth.

t). Installation of semi-precast transverse beams for wharf.

u). Installation of semi-precast longitudinal beams for wharf.

v). In-situ casting of beams and slabs for wharf.

w). Demarcating the channel and fixing aids to navigation.

x). Laying the road networks and installing other infrastructure amenities (water, light, etc.)

y). Installation of fixtures and superstructure elements like warehouse roof.

z). Setting the landscape and opening for public.

7. VESSELDESIGN

7.1. General Review

A logical decision must be made about the vessels to be permitted in the water way so that the expected performance of the water way can be ensured. The proposed characteristics of the vessel is arrived at considering the cargo to be handled, forecasted traffic data, river regime, etc. The traffic study of the waterway reveals that there is potential for cargo movement from Paradip sea mouth to Cuttack industrial area. Based on the hydrographic survey report, it is possible to develop the river as Class III waterways with comparatively limited dredging and serving the purpose of handling cargo. Syntax tank provision for collecting the pollutants is shown in the Typical masterplan of the proposed terminal Figure No 7.3

The Waterway is working only for 5-6 Months in a year as well as the use of waterway shall be only for a few Vessels. Therefore, extensive arrangements including the facility of collection for Pollutants generated onboard vessels are not recommended. Internal toilet is proposed in the terminal buildings. The provision for soakpit, septic tank and the RWH shall provide. Refer DWG No. FIPL/IWAI/38

7.2. Design Basis

The vessel dimensions are arrived at primarily based on the horizontal and vertical dimensions of the water way under consideration. The design also considers the safety aspects while maneuvering in the shallow waters and the availability of local resources. The vessel dimensions applicable to the considered channel specifications can be arrived based on the ‘The Inland Waterways Authority of India Act 1985’. The design is based on the channel dimensions of the terminal location as minimum depth 1.7m, bottom width 50m and bend radius 700m.Also, the vessel is required to carry cargoes.

7.3. Type of proposed Vessels

Vessels or barges that can accommodate bulk cargo like cement, iron, minerals, fertilizers, etc. are proposed. At the same time criteria for draft of 1.7m must be satisfied.

7.4. Proposed Vessel Size and Specifications

The size of vessel is related to channel width and depth of waterway available for navigation. The maximum beam of design vessel is limited to1/5th of the width of navigable water and its length is assumed between 4 to 8 times the vessel's beam. Being a protected water, no natural severe wave action is expected, also due to low speed of the vessel owing to soft bed and bank materials, the under-keel clearance can be limited to some10% of max draft. When a vessel is navigating in a shallow channel, its manoeuvrability as well as speed suffers due to a kind of drag that is imposed on the moving hull by the relative lack of water around it. This is explained by a factor 'n' defined as the ratio of wetted cross-sectional area of the channel to the wetted largest cross-sectional area of the vessel, should be large, around 10 or above with a lower tolerable limit of 6. Hence the maximum draft for the design vessel is limited to 1.25m for 1.5m deep channel. From speed consideration, the longer vessels yield a faster speed for a given engine. It is, however, important to note one limitation on vessel length viz. that the length of vessel on water-line (LWL) should be less than the width of the channel. If the length is kept the same or more than this, it would become virtually impossible for a vessel to be turned around even in an emergency. This would be an unacceptable condition for obvious reason, unless special turning areas are provided at relatively short intervals. It is also necessary to turn vessels around in rivers through which the route passes. With the option of Class from III, the bottom width requirement is 50m and 1.7m minimum depth, a vessel size of 9m moulded breadth 58m LOA and a loaded draft of 1.5m is proposed based on 'IWAI Act 1985'. The carrying capacity is around 500DWT and is of self-propelled type. In this manner, the following dimensions of the various types of vessels are permissible under the present study:

Table 7-1: Proposed vessel dimensions

Type	LOA (m)	Beam (m)	Draft (m)
Cargo vessels/ barges	40-58	Max. 9	1-1.5
Country boat	30-45	5-8	1.0-1.2

Figure 7.1: Cargo moved by IWT Assam vessel in NW2

Figure 7.2: Cargo vessel in Brahmaputra

7.5. Turnaround Time

Turnaround time has been defined as the gross time spent by a vessel in port, i.e., the time difference between the hour when a vessel leaves the port limits and the hour when it arrived within the terminal area and it measures the precise time in hours and minutes which the ship spent in the terminal area. It is the length of the time between arriving at a terminal, unloading and loading the cargo, refueling, etc. and being set to depart from that point. Apart from the actual time for loading/ unloading cargo, additional time is required for other activities such as berthing and de-berthing, waiting for clearance for navigation etc. Including a berthing and de-berthing time of 4 hours, an average of 5hours/ vessel is allowed. It is proposed to use mobile harbor cranes with closed grab to unload or load the cargo. A 10 tonnes crane is proposed, thus considering 70% efficiency and considering around 20 lifts per hours, around 140 tonnes can be transferred in an hour. Thus, an average loading or unloading time comes around 3.5 to 4 hours. Hence keeping a margin, an average of 5 hours/ vessel is proposed.

7.6. Number of Vessel Required

The number of vessels to be deployed to serve the hinterland is arrived at based on the projected traffic data. In the present scene since the focus is on shifting the modes of existing cargo movements to the waterways, the exact value of cargo cannot be obtained now. But it can be optimistically assumed that 2 vessels are sufficient. It is proposed to have private parties involved for the operation of vessels.

7.7. Vessel Costing

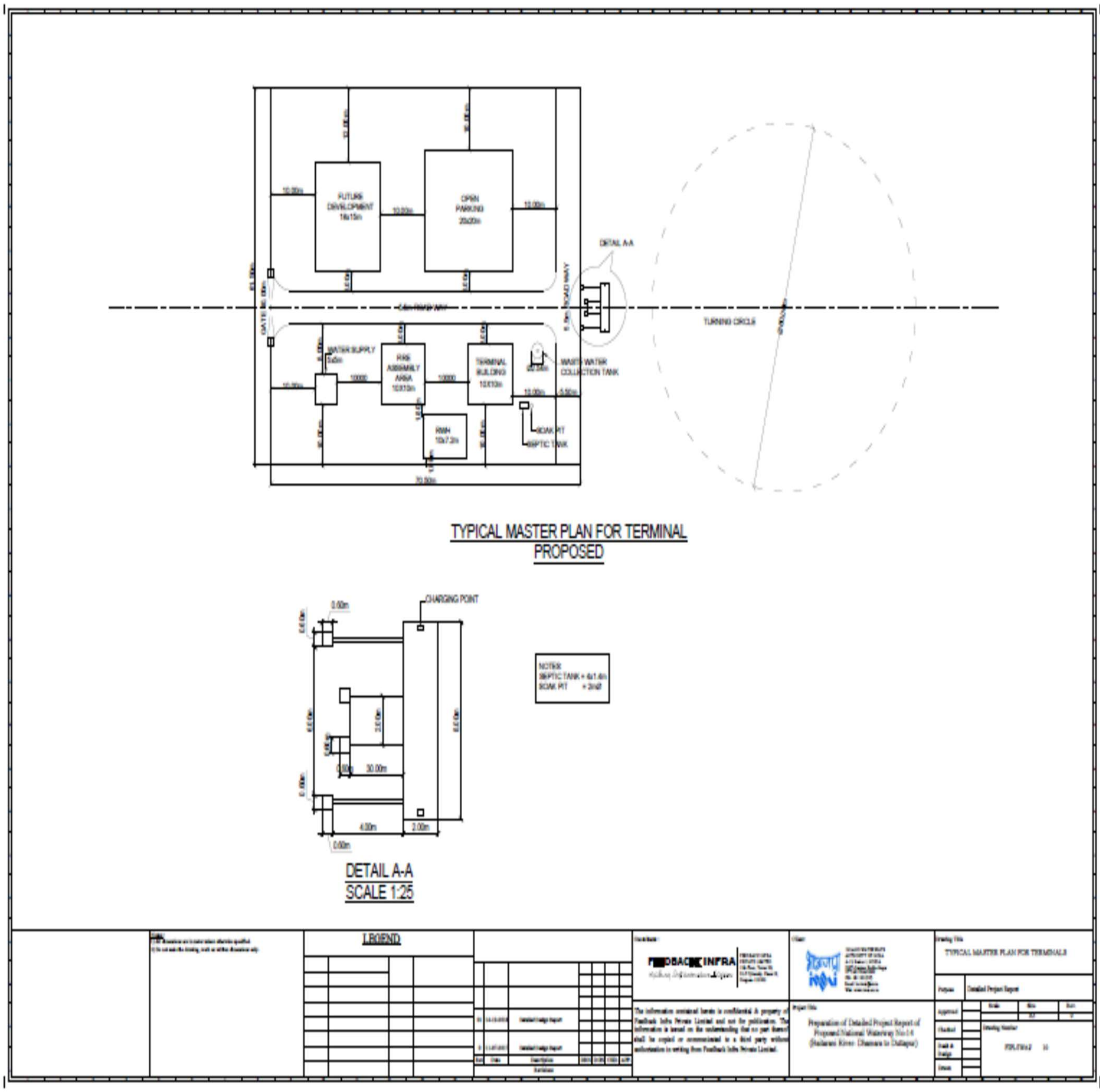
7.7.1. Capital Cost

As the vessel is proposed to be operated by private parties, cost must be taken care of by them. Based on a rule of thumb, for the proposed vessel of maximum LOA 58, beam 9m, draft 1.5m, the cost is around 15.00 lakhs per vessel.

7.7.2. O&M Cost

Around 10% of the initial cost is to be considered as operational and maintenance cost. This must be suffered by the private operator.

Figure 7.3: Typical Masterplan of proposed Terminal



NB: The Waterway is working only for 4-5 Months in a year as well as the use of waterway shall be only for a few Vessels. Therefore, extensive arrangements including the facility of collection for Pollutants generated onboard vessels are not recommended. Moreover as per gist of discussion held on 01-02-2018 and discussion held during the visit of site on 03-02-2019 it was general view that this project is not financially viable as below:

Gist of discussion on 1.2.2018 and discussions during site visit on 3.2.2018

S.No	Issues brought out in the presentation	Responses
1	The proposed stretch can now be modified from NW5 confluence as the state government is planning to have a state-owned terminal near the IFFCO plant.	Already accounted for in the report
2	Consider extending the water way up to Narag or further upstream.	Prohibitive Lock Cost at Jobra Barrage. Hence, the terminal location is downstream of Jobra Barrage
3	To consider the tourism potential and industrial cargoes likely to be generated due to upcoming investments by IOCL, etc., so that the water way can be extended to the upstream of Jobra barrage economically.	IOCL investments related to PCPIR would be coming up in Paradip's port hinterland. Also, no investments have been finalized as of yet.
4	Already around 600 hectares of area near Luna River is water logged and any intervention in the form of barrages can lead to pondage. In this case, to ensure protection of the area, the water regulating structure proposed shall be associated with drainage structures.	
5	For the Syphon cum bridge at Chitroptala, the horizontal clearance, vertical clearance and depth criteria are not satisfying the NW specs. Why can't it be considered to reroute the channel through left bank of the river.	
6	The bank protection and embankment strengthening activities are to be taken up in consultation with state WRD.	

S.No	Issues brought out in filed visit on 2.2.2018	Responses
	At Cuttack terminal location	
1	To check the viability of the project by providing floating pontoon and gangway instead of permanent facility.	
2	To check if dredging the channel will help to maintain waterway viable throughout the year.	
3	It is suggested from local observation that the monsoon period alone is likely to give a LAD of 2m throughout. This may be verified and considered.	
	At Chithroptala Syphon in Murkundi	

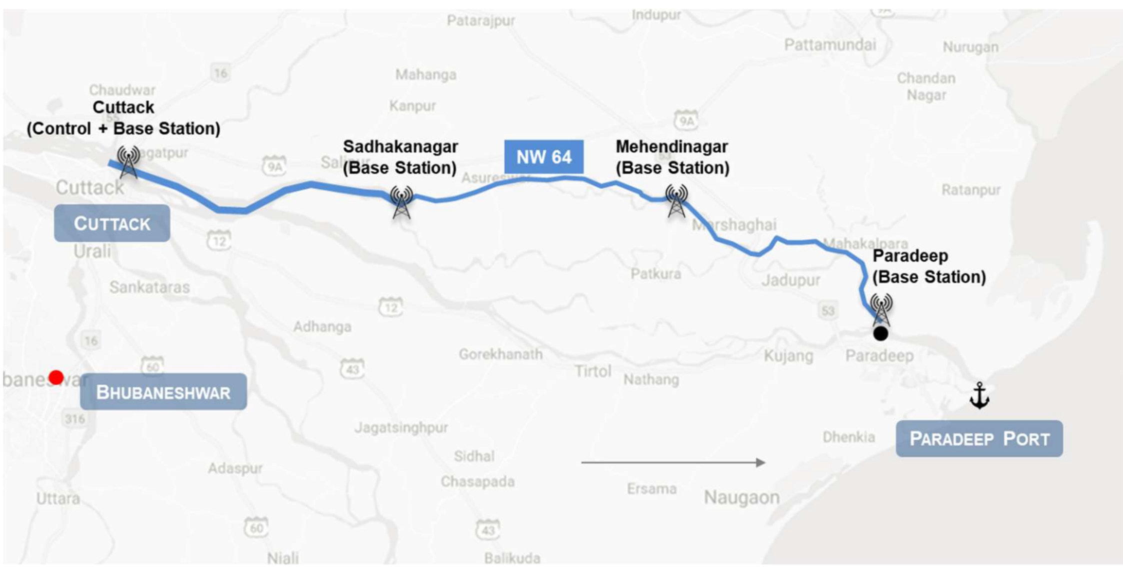
1	The Syphon may be bypassed by constructing a rectangular vertical channel with lock system.	
2	The land beside the syphon belongs to the government. So, any approach to bypass the syphon via that can be thought of without the burden of acquiring land.	
3	The details of syphon at Paika to be analyzed and to be included in the DPR.	
4	The location and details of the riverine port proposed by the state water resource department to be depicted in the DPR.	

8. NAVIGATION AND COMMUNICATION SYSTEM

8.1. General Requirements

To ensure the safety of vessels and cargo and to have an uninterrupted telecommunication between the different agencies involved in the terminal operation, in both land and waterside, the communication facilities play a major role. This chapter also includes the requirement of dedicated trained staff for operating the communication facilities.

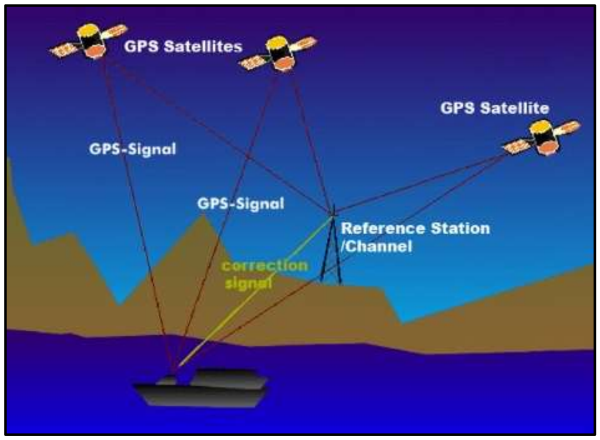
Communication stations (base stations for RIS) are proposed to be established at locations shows in the map below. Each communication station is effective within a radius of 25 km. Hence, **4 such stations** have been proposed for the length of the waterway (98 km).



8.1.1. DGPS

DGPS (Differential Global Positioning System) – It is an enhancement over convention GPS system and provides much accurate location (within 10 cm) as compared to conventional GPS (10-15 meters). All the vessels operating in this water way is proposed to be DGPS based. The DGPS system is proposed to be installed at the Cuttack base station. The system has a range of ~150 km and would cover the entire subject waterway stretch. The system components include - beacon station with 100W radio modem, transmission antennae, back up battery, etc. DGPS receivers would also be installed on the waterway vessels.

Figure 8.1: Line diagram showing the principle of DGPS



8.1.2. River Information Service (RIS) System

River Information Service (RIS) system is one among the latest technology introduced in Inland Water Transport. In the RIS system, a group of internet base stations are located at 50-60Kms intervals. These base stations will have 30 kms (approx.) radial coverage and two-way communication between vessels and base stations. RIS helps in avoiding navigational risks (ship to ship collision, ship to bridge collisions and vessel groundings). It also provides fairway information, traffic information, calamity abatement support etc.

RIS System includes the following major components –

- **VHF (Very High Frequency)** – VHF, also known as Maritime Mobile Band, refers to the radio frequency range between 156.0 and 174 MHz It enables the vessel crew to communicate with other vessels and shore station (e.g. ports, locks, bridges and marinas) on operational, navigation and safety matters, as well as calling for help in an emergency.
- **Automatic Identification Systems (AIS)** – AIS systems provide automated vessel tracking, with help of AIS transponders installed on the barges / vessels. It also helps in identification of navigational marks.

- **Meteorological station** / Weather Monitoring and Forecast System – Meteorological sensors would be required for weather data collection, weather forecasting and providing early warnings to take timely precautions. Thus, it is suggested to also include a weather forecast receiving system and warning systems within the RIS framework to take timely precautions.
- **Radar** – While the radar system further supplements tracking of waterway vessels, installation of such radar is cost intensive. Hence it is suggested that radars may be **considered at a later stage,** with sufficient build-up of waterway traffic. Further, Terma radar would be suitable given their superlative accuracy, range and overall performance.

The installation of RIS system would involve setting up of Base Stations (at 4 locations, as indicated in the map above) and a Control Station, as per the framework suggested below –

- **Control Station** - The control station carries out all standing orders and collect the data of cargo/vessel movement and keep back up for analysis and further improvement of efficiency. Setting up control station includes Central Servers (for AIS data record), WEB Servers (for Web interface), RIS software, and Operator Workstations. Operators have comprehensive tabular information about traffic, wide variety of navigational alarms, traffic management tools like zones, reporting lines, routes, traffic prediction tools, control of AIS base stations. The entire system is completely IP based. Periskal software is suggested for RIS, given their wide experience in European Waterways.

- **Base Station** – A series of sensors are deployed at base stations for exchange of information (such as navigable depth, channel limits with virtual buoys, terminal facilities, port clearance etc.) between the control station and the vessels. Two porta cabins would be provided at the stations. Land requirement of 1 hectare (100 m x 100 m) is proposed for base stations. At Cuttack, the station would be integrated with the Terminal only. It is proposed to take the required land on lease. Given that proposed locations are remote villages, a minimal rental of INR 20,000 to INR 30,000 per annum would be sufficient to cover lease expense. Following equipment, as explained above, would be installed at base station –

- **Automatic Identification Systems (AIS) Transponders x 2**
- **Meteorological Station**
- **VHF**
- **Power back-up –** Gen-Set 10 KVA, UPS 5 KVA
- **Monopole Tower** of 30 m height is recommended for providing coverage for 20-25 km radius. This would be coupled with 6 m pole on vessels and AIS Transponders (Inland Class -A).

Coverage Chart for various height of Mast and Vessel Antenna

Vessel Antenna Ht (in m)	Coverage =(12.746Xheight)$^{1/2}$ (in Kms)	Base station Mast Ht (in m)	Coverage =(12.746Xheight)$^{1/2}$ (in Kms)	AIS/VHF Range for various height of vessel antenna height (M)										
				0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
1	3.57	10	11.29	11.3	14.9	16.3	17.5	18.4	19.3	20.0	20.7	21.4	22.0	22.6
2	5.05	20	15.97	16.0	19.5	21.0	22.1	23.1	23.9	24.7	25.4	26.1	26.7	27.3
3	6.18	30	19.55	19.6	23.1	24.6	25.7	26.7	27.5	28.3	29.0	29.7	30.3	30.8
4	7.14	40	22.58	22.6	26.1	27.6	28.8	29.7	30.6	31.3	32.0	32.7	33.3	33.9
5	7.98	50	25.24	25.2	28.8	30.3	31.4	32.4	33.2	34.0	34.7	35.3	36.0	36.5
6	8.75	60	27.65	27.7	31.2	32.7	33.8	34.8	35.6	36.4	37.1	37.8	38.4	38.9
7	9.45	70	29.87	29.9	33.4	34.9	36.1	37.0	37.9	38.6	39.3	40.0	40.6	41.2
8	10.10	80	31.93	31.9	35.5	37.0	38.1	39.1	39.9	40.7	41.4	42.0	42.6	43.2
9	10.71	90	33.87	33.9	37.4	38.9	40.1	41.0	41.9	42.6	43.3	44.0	44.6	45.2
10	11.29	100	35.70	35.7	39.3	40.8	41.9	42.8	43.7	44.4	45.1	45.8	46.4	47.0

8.1.3. Survey equipment

The following survey equipment is recommended to aid the RIS network and DGPS System. The survey equipment would aid in periodic surveys to ensure the safe navigability of the channels.

- **1 Total Station** - Total station is a combination of electromagnetic distance measuring instrument and electronic theodolite. It is used to measure horizontal and vertical angles as well as sloping distance of object to the instrument.
- **1 Auto-Level** – Used in conjunction with levelling staff, the instrument is used for height and levelling measurements
- **1 Echo-sounder** – They are used to measure depth. They may be either single-beam (SBES) or multi-beam type. A side scan sonar system used in conjunction with the eco-sounder enable to have a complete seabed in sonification for small target detection.
- **1 Current Meter** – Required for flow measurement

- **2 Hypack software** – Hydrographic survey software for data collection, terrain imaging
- **4 Automatic Tide Gauge (ATG)** – Required for measuring change in sea level relative to vertical datum
- **1 DGPS Receiver** – Required for on-site / survey team
- **1 PC and 1 Workstation** - Required for on-site / survey team

Figure 8.2: Total station survey

Figure 8.3: Dumpy level and Telescopic Staff

Figure 8.2: Typical figure showing conduct of eco sounding

8.2. Existing System

No system exists.

8.3. Additional requirement

The above said systems are very essential for a properly established terminal and waterway system. No additional navigation and communication system are proposed.

8.4. Costing

8.4.1. Capital Cost

The cost for the navigation and communication systems proposed are given in the table below.

Table 8-1: Summary of capital cost required for navigation and communication system

Sr. No.	Equipment	Qty	Unit Price	Total
Base Station, Control Station				
1	AIS Base Station	8	30,00,000	2,40,00,000
2	Meteorological Sensor	4	8,00,000	32,00,000
3	ATG	4	11,00,000	44,00,000
4	VHF	4	5,00,000	20,00,000
5	DG Set 10 KVA	4	7,00,000	28,00,000
6	UPS	8	5,00,000	40,00,000
7	DGPS Station	1	2,50,00,000	2,50,00,000
8	RIS Software	1	65,00,000	65,00,000
9	RIS Hardware	1	1,20,00,000	1,20,00,000
10	Installation Testing & Commissioning	4	20,00,000	80,00,000
11	Porta cabin	8	12,00,000	96,00,000
12	Monopole Tower	4	7,50,000	30,00,000
Survey Equipment & Software				
13	Total Station	1	8,50,000	8,50,000
14	Auto-Level	1	30,000	30,000
15	Echo-Sounder	1	11,20,000	11,20,000
16	DGPS Receiver	1	2,50,000	2,50,000
17	Hypack Software	2	8,00,000	16,00,000
18	Current Gauge	1	50,000	50,000
19	1 PC and Workstation	1	80,000	80,000
			Total	**10,84,80,000**

8.4.2. O&M Cost

Operation and maintenance cost are ~**5% of the installation cost**. In addition, each of the **base stations** is manned 2 operators and 1 security staff. As **Cuttack would double as Base cum Control station**, it would require 1 Engineer, 3 operators and 3 security staff. The security personnel requirement can be accommodated with staffing proposed in Institutional Requirements. The operated should be IALA trained and can be effectively utilized for ensuring proper running of RIS system and other equipment. As highlighted above, an area of **~1 hectare would be leased out** at the proposed base station locations. The expected rental is INR 25,000 per annum per base station. If required, operations of base and control stations can be outsourced through comprehensive AMAC contracts.

Table 8.3: Manpower Requirement for Operations of Communication and Navigation Equipment

Sr. No.	Description	CTC (INR lakh)	Staffing Requirement	Total Cost (INR lakh)
1	Engineer	4.8	1	4.8
2	Operator	3.0	9	27.0

9. ENVIRONMENTAL AND SOCIAL ASPECTS

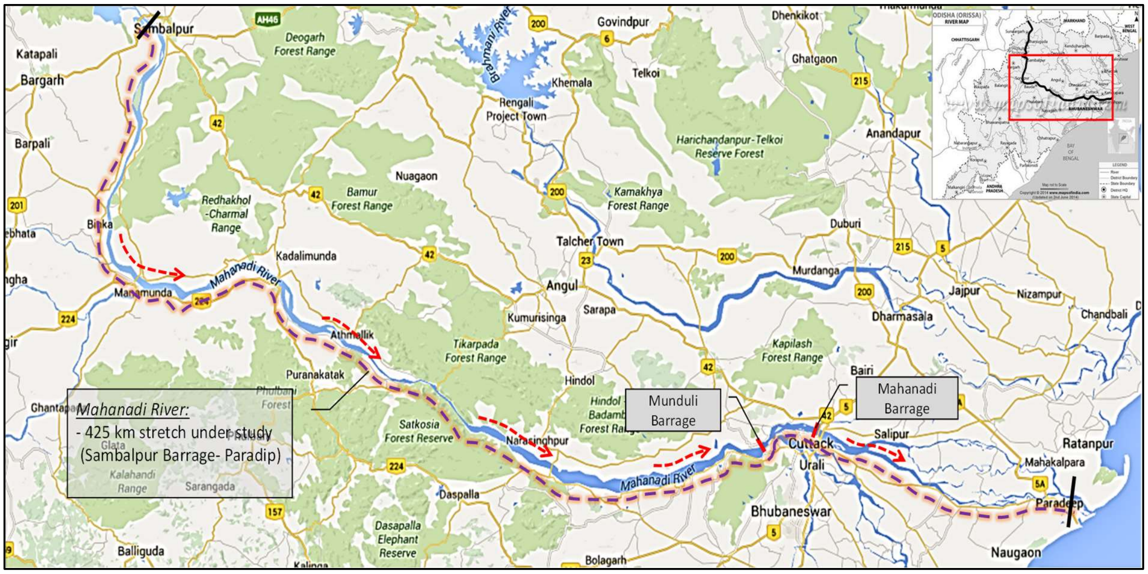
9.1. Objective of Environmental and Social Studies

The development of any infrastructure project causes various environmental and social impacts during different stages of its implementation. The objective of this study focuses on assessment of associated environmental and social impacts (for all its offshore as well as onshore components), during designing, construction as well as operational stages of proposed waterways project. Present chapter discusses all the aspects of environment starting from baselines assessment and assessment of impacts, development of mitigation plan then development of monitoring plans in order to have a check on successful implementation of mitigations measures. Institutional mechanism is also designed to ensure an effective implementation of proposed EMP. This chapter also covers some important points as mentioned in Environment Impact Assessment Guidance Manual of MoEF & CC guidelines for carrying out EIA study.

9.1.1. Project Stretch

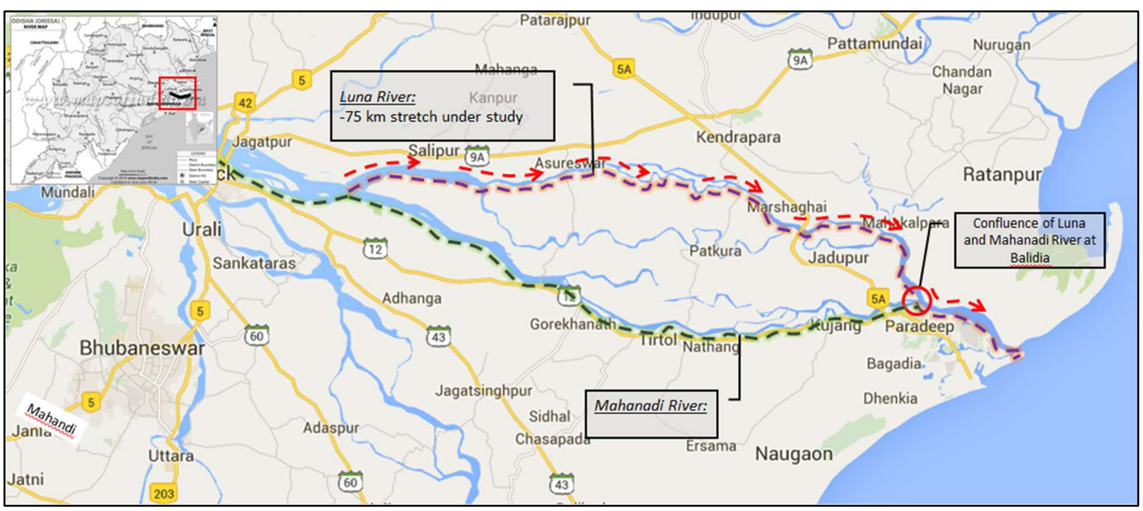
A total of 98 km of Mahanadi River system from Jobra barrage (Cuttack barrage) to Bay of Bengal mouth near Paradip and 75km stretch of Luna River were studied. The study area extends from Cuttack Barrage at Latitude 20°29'24.45"N, Longitude 85°55'05.57"E to Paradip at Latitude 20°19'38.12"N, Longitude 86°40'16.96"E. The Mahanadi River stretch under study is shown as Figure 9.1 below.

Figure 9.1: Mahanadi River stretch under study



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 of Luna River is shown in Figure 9.2 below.

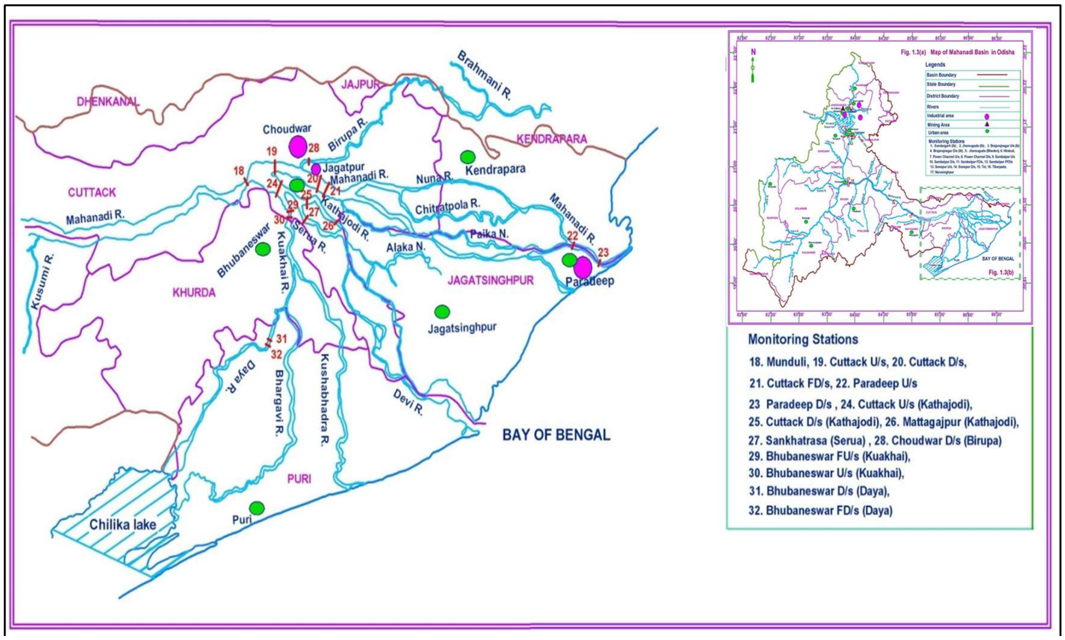
Figure 9.2: Luna River stretch under study



After feasibility assessment Luna River was found more feasible to develop as Inland Waterways, and, hence scope of environment assessment is focused in on Luna River

Stretch. Project river stretch is the park of Cuttack, Kendrapara and Jagatsinghpur District. Location map of Project section in respect to Mahanadi River basin is shown as Figure 9.3.

Figure 9.3: Project Location map in respect to Mahanadi River Basin



Source: Odisha State Pollution Control Board

9.2. Environmental Setting in the Project Area

The Mahanadi River is located in the Central part of Odisha. Length of total river stretch under project scope is about 98 km (including part of Mahanadi and Part of Luna River). Single line bathymetry/topography survey was carried out during site survey from 10th February 2016 to 13th February 2016.

Major Environmental as well as social feature like Forest, Wildlife Sanctuary, National Park, Eco-sensitive area etc. were recorded during field survey. According to prelim survey no forest land is observed to be getting affected due to proposed development. However, exact demarcation of forest land is subject matter of Joint verification with Forest department.

Chandaka Dampara Wildlife Sanctuary and Nandankanan Zoological Park are located at a distance of about 10.0 km in the South from the starting point (Jobra barrage) of project river stretch. During survey a lot of island formations were observed along the river stretches, mainly of sand. Mahanadi rive is flowing from North West to South East and crosses various settlements along the project waterways.

9.3. Physiography

On the basis of homogeneity, continuity and physiographical characteristics, Odisha has been divided into five major physio-morphological regions:

- **The Odisha Coastal Plains** are the depositional landforms of recent origin and geologically belong to the post-tertiary period. 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 "Hex deltaic region". Project river stretch is the part of the Odisha Coastal Plains morphology.
- **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).
- **The Central plateaus** are mostly eroded plateaus forming the western slopes of the Eastern Ghats. 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.
- **Major Flood Plains** are in the southern part of the Odisha state.

9.4. Geology and Seismicity

9.4.1. Geology

The State of Odisha exposes rocks ranging in age from Meso Archaean to Recent. The geographic distributions of the major Precambrian litho-tectonic domains are:

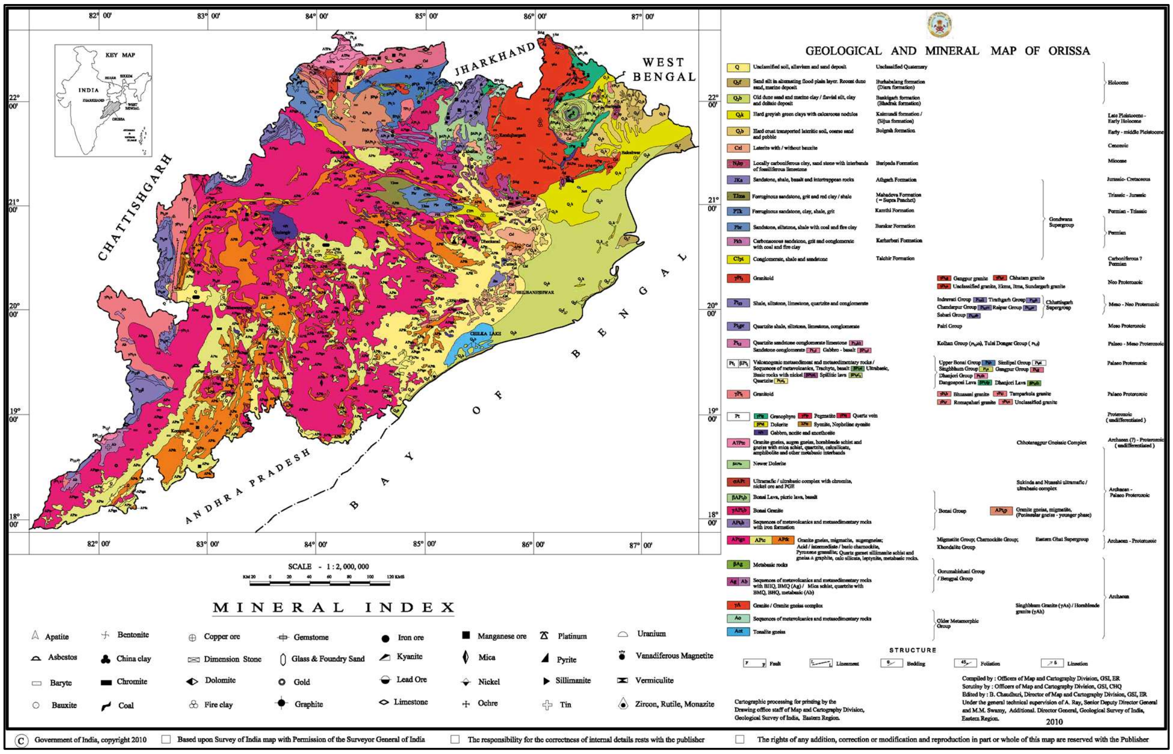
Eastern Indian Craton (North Odisha Craton) and Singhbhum-Gangpur Odisha Mobile Belt, Mobile Belt	Northern and North-western
Part of Bastar Craton	Western Odisha
Part Eastern Ghats Mobile Belt (EGMB)	Central and Southern Odisha

Odisha, situated on the eastern seaboard of India is one of the gifted parts of the world, where a gamut of mineral resources exists in bounty. The state is endowed with large reserves of bauxite, china clay, chromite, coal, dolomite, fireclay, graphite, gemstones, iron ore, limestone, manganese ore, mineral sand, nickel ore, pyrophyllite and quartz. Recent discovery of diamond in the Dharambandha area of Nuapada district by the State Directorate of Geology has added a colored feather in the cap of the state. Other minerals of the state include copper ore, lead ore, titanium bearing veneniferous magnetite, talc/soap stone and high magnesia igneous rocks. Recent boom of the mineral industry has turned the state into a hotspot, with entrepreneurs from all over the world crowding for their share of fortune.

The rich mineral wealth of the state is attributed to its favorable geological set-up. Situated on the eastern fringe of the peninsular India, Odisha has about 72.5% of the area occupied by Precambrian metamorphic rocks (of Archaean and Proterozoic age) which host the majority of the minerals. The Gondwanas hosting the coal resources occur over about 8% of the land mass. The Tertiary and Quaternary formations, occupying rest of the area, provide avenues for aluminous / nickeliferous laterite and heavy minerals (in beach sand).

Geological and Mineral map of Odisha is given below.

Figure 9.4: Geological Map of Odisha



Source: Geological Survey of India

The project districts can broadly be divided into four distinct geomorphic units

(1) Tidal flat
(2) Coastal plain
(3) Alluvial plain
(4) Flood plain.

The fine sediments carried by the rivers get deposited along the coast because of tidal action, as tidal flat / mud flat. The width of this tidal flat varies from 2 to 5 km.

The coastal plain is a gently sloping plain occurring parallel to the coast and mainly formed by fluvic–marine action and is intersected by network of creeks, which are mainly saline due to tidal action. The area is marshy with shrubby vegetation. The width of this coastal plain varies from 5 to 25 km. The coastal plain encompasses a series of beach ridges characterized by sand dunes of varied relief and extends for some kilometers, almost parallel to the coast.

The gently sloping alluvial plain occurs to the west of the coastal plain and forms the most fertile part of the district. The alluvial plain can be further divided into two i.e. (i) Older alluvial plain (ii) Younger alluvial plain.

9.4.2. Seismicity

Odisha has witnessed earthquakes in the past. Though seismic zone II and III are under moderate and low risk, the Mahanadi basin can be vulnerable as it is not a passive plate and can cause earthquakes. Of course, earthquakes of magnitude 7 on the Richter scale are quite unlikely, but tremors of magnitude 6 to 6.5 on the Richter scale can’t be ruled out.

9.5. Climate

9.5.1. Climate

Project region is characterized by tropical monsoon climate having three distinct seasons in the year, viz. winter, summer and rainy seasons. The Bay of Bengal, which forms the eastern boundary of the project region, plays a prominent role in controlling the climate of the area.

The winter commences from late November and continues till end of February. The winter is followed by the summer season, which extends up to mid-June. During the period between April and May 3 to 4 cyclonic storms accompanied with rains generally occur in the district. The rainy season sets-in at the advent of the southwest monsoon, generally from the middle of June and continues till end of September.

Agro-climatic Zoning of Odisha along with average rainfall is given in Table below and shown in Figure 9.5. As per agro-climatic classification, project districts are the part of Eastern and South-eastern coastal plain.

Table 9-1: Agro-climatic Zone of Odisha

S. No.	Agro-Climatic Zone	Climate	Mean Annual Rainfall (mm)	Soil group
1	North Western Plateau	Hot & Moist	1648	Red & Yellow
2	North Central Plateau	Hot & Moist	1535	Red loamy
3	North Eastern coastal plateau	Hot & moist sub-humid	1568	Alluvial
4	East & South Eastern Plateau	Hot & humid	1449	Coastal alluvial saline
5	North Eastern Ghats	Hot & moist Sub-humid	1597	Laterite and brown forest
6	Eastern Ghats high land	Warm & humid	1522	Red
7	South Eastern Ghats	Warm & humid	1522	Red, mixed red and yellow
8	Western undulating	Warm & moist	1527	Black, mixed red & black
9	West Central table land	Hot & moist	1527	Red, heavy textured color
10	Mid Central table land	Hot & dry sub-humid	1421	Red loamy, laterite mixed red & black

Source: NDIM Odisha

Figure 9.5: Agro-climatic Zone of Odisha

Source: NDIM Odisha

9.5.2. Meteorology

Indian Meteorological Department is continuously monitoring meteorological scenario at three locations namely, Cuttack, Bhubaneshwar and Chandbali. The approximate distance of Cuttack, Bhubaneshwar and Chandbali IMD Stations from the project river stretch is 1 km, 24 km and 41 km respectively. Thirty (30) years IMD data since year 1981 to year 2010 was collected to assess the baseline meteorological status of the project region. The summary of meteorology is presented in Table below.

Table 9-2: Summary of Micro-meteorology (1981-2010)

S. No.	Month	Temperature (°C) Avg. Monthly		Avg. Humidity (%)		Avg. Monthly Rainfall (mm)	Pre-dominant Wind Direction	Avg. Wind Speed (kmph)
		Minimum	Maximum	Morning	Evening			
Cuttack								
1	January	10.8	32.3	78	54	13.7	E	2.6
2	February	13.6	35.7	78	50	23.3	E & SE	2.5
3	March	17.1	39.7	76	52	28.2	S & SE	3.8
4	April	19.7	41.3	73	58	41.7	S & SE	4.3
5	May	19.9	41.8	73	61	96.3	S & SE	5.5
6	June	21.2	40.7	78	70	211.9	S & SE	4.5
7	July	21.5	36.4	83	79	339.0	S & W	4.3
8	August	22.1	35.1	85	81	396.8	S & W	3.6
9	September	21.8	35.8	83	79	250.8	S & SE	2.9
10	October	19.1	35.2	79	71	143.0	E	2.4
11	November	14.1	33.4	75	63	42.7	E	2.0
12	December	11.2	31.4	75	57	4.8	E	1.8
Annual Average				**78**	**65**	**1592.0**	**S & SE**	**3.4**
Bhubaneswar								
1	January	11.7	32.7	74	53	13.6	NE & E	4.2
2	February	14.4	36.1	74	51	24.5	S & SW	5.5
3	March	18.4	39.6	73	56	24.9	S & SW	7.7
4	April	20.8	41.2	70	62	37.2	S & SW	11.8
5	May	21.4	41.8	72	65	85.6	S & SW	11.2
6	June	22.4	40.5	80	73	223.4	S & SW	9.1
7	July	23.2	36.3	86	83	351.5	SW & S	7.4
8	August	23.3	34.7	87	85	403.5	SW & W	7.2
9	September	22.7	35.0	85	83	262.8	SW & S	5.6
10	October	19.5	34.4	80	76	163.0	NE & N	4.3
11	November	14.9	33.1	72	65	43.1	NE & N	4.3
12	December	12.0	31.9	70	56	5.0	NE & N	4.1

S. No.	Month	Temperature (°C) Avg. Monthly		Avg. Humidity (%)		Avg. Monthly Rainfall (mm)	Pre-dominant Wind Direction	Avg. Wind Speed (kmph)
		Minimum	Maximum	Morning	Evening			
Annual Average				**77**	**67**	**1638.0**	**SW & S**	**6.9**
Chandbali								
1	January	10.2	32.0	77	65	11.1	N & NE	1.7
2	February	13.3	35.3	78	65	30.5	SE & S	2.0
3	March	17.6	39.0	77	63	36.1	S & SE	3.7
4	April	20.1	40.9	74	65	43.9	S & SE	5.1
5	May	20.7	41.3	75	70	101.4	S	5.4
6	June	21.7	39.9	80	77	242.6	S & SW	4.2
7	July	22.8	36.5	84	80	258.6	S & SW	3.7
8	August	22.8	35.1	85	82	358.6	S & SE	3.5
9	September	22.8	35.4	84	82	262.5	S	2.8
10	October	19.8	34.8	81	79	206.0	N & S	1.9
11	November	13.9	33.2	77	72	54.4	N	1.7
12	December	11.1	31.1	76	67	6.1	N & NE	1.7
Annual Average				**79**	**72**	**1611.9**		**3.1**

Source: Climatological Normals (1981-2000)

The average monthly lowest and the highest temperatures (1980-2010) in the project region are 10.2°C and 41.8°C respectively. The normal average annual rainfall ranges from 1592.0mm at Cuttack to 1638.0 mm at Bhubaneshwar.

The mean annual wind velocity in the project region was found in the range of 3.1 kmph to 6.9 kmph. The wind speed during cyclonic storms becomes very high and ranges from 70 to 100 kmph or even more. Major direction of wind is from south and south-west. The relative humidity, on an average, varies from 65% to 79% during the year and during monsoon it is much more. The detailed monthly average long-term Climatological tables are attached as **Enclosure I**.

9.6. Soil Characteristics

Based on the physical and chemical characteristics, mode of origin and occurrence, soils of the project region may be classified into three groups namely Alfisols, Aridisols and Entisols.

9.6.1. Alfisols

This includes deltaic alluvial soils and this type of soils occupies nearly 90% of the entire district area. The deltaic alluvial soils are generally deficient in phosphate (P2O5) and nitrogen (N). Both the total and available potassium are fairly adequate, and PH varies between 7.38 and 8.16.

9.6.2. Aridisols:

These are saline and saline alkali soils and occur in small pockets in the north eastern and south eastern corner of the district near coast. These are rich in calcium, magnesium and also consist of half decomposed organic matter.

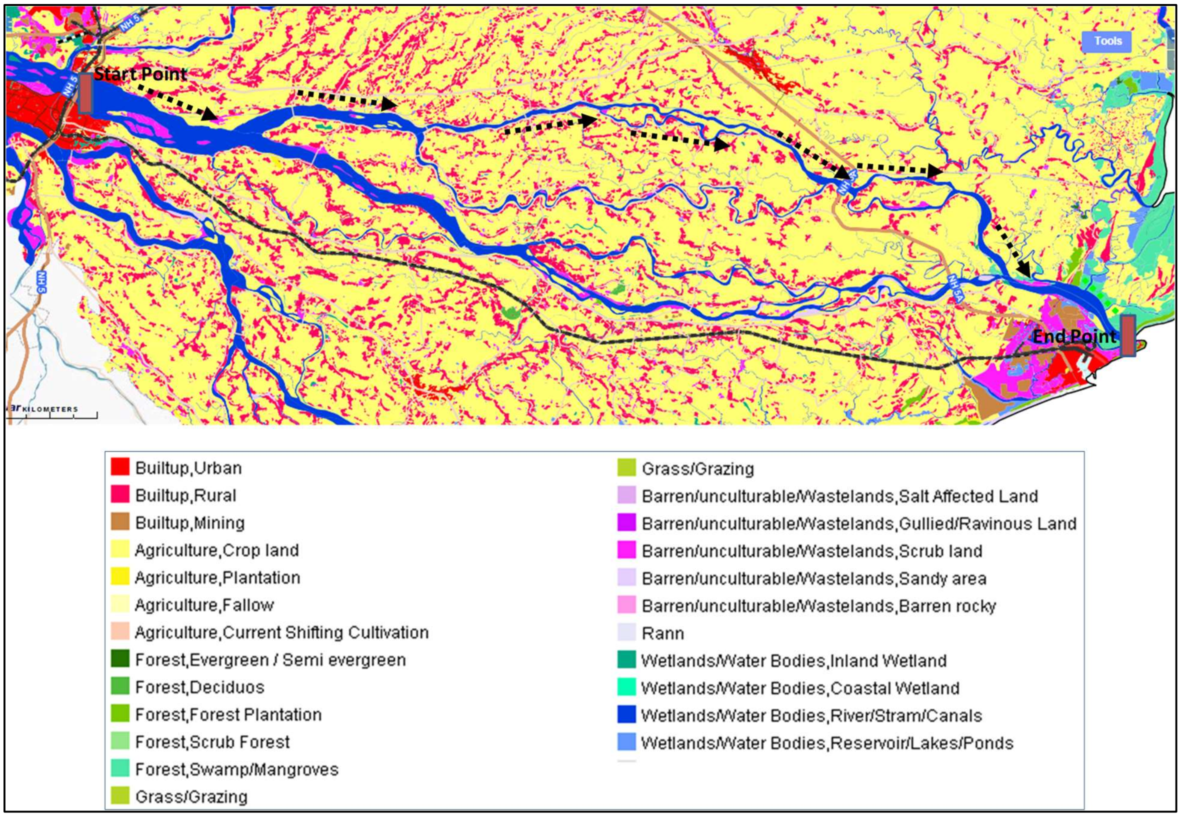
9.6.3. Entisols:

This includes coastal sandy soils and occurs as narrow elongated ridge along the coastline. The soils are deficient in nitrogen, phosphoric acid and humus, but not in potash and lime.

9.7. Land Use Pattern

Most of the land along the proposed project is Agriculture, then settlement and Barren. Land use pattern of the project area is given below.

Figure 9.6: Land-use Map of Project Region



Source: Bhuvan

9.8. Ambient Air Quality

SPCB is continuously monitoring the ambient air quality three locations in Cuttack City. The details of ambient air quality as monitored by SPCB are given in Table below.

Table 9-3: Ambient Air Quality Status in Cuttack Area

Location	PM10 (µg/m^3)	PM2.5 (µg/m^3)
Traffic Tower Badambadi	98	60
R.O. Building, Surya Vihar	69	60
PHD Office, Barabati	73	53
NAAQ Standards (24 hourly Annual Average)	**100**	**60**

Source: OSPCB

Ambient air quality in Cuttack City is found in compliance to the National Ambient Air Quality Standards. The ambient air quality along the project river stretch shall also be well below the prescribed standards in absence of any major pollution generating source.

Detailed Baseline Environment Study shall be the part of Environment Impact Assessment Report

9.9. Noise Levels

No major noise generating source was observed along the project stretch. Traffic and small-scale industries alongside the river stretch are the sources of noise pollution in the area. Noise level alongside the river stretch found within acceptable level during site visit. Cuttack and Paradip are the two major settlements along the river stretch. Noise level inside these settlements is slightly on a higher side due to high traffic density and commercial activities.

Water Quality

Hydrogeology and Ground Water Characteristics

Based on the behavior and occurrence of ground water, the regional ground water flow system of the region can be described under two distinct categories viz.

Shallow aquifer zone to a depth of 50m and

The area is traversed by innumerable nalas, mostly perennial, besides the mainstream and presents a favorable ground water condition. The shallow aquifer occurring within a depth of 50m from land surface is consisting of a mixture of sand and clay with little gravel at places.

Deeper aquifer zone between 50 and 300 m or more.

The aquifers occurring at the depth range of 50 to 300m bgl are grouped in this category. There is considerable variation in the granularity and thickness of the aquifers of the area. At greater depth, the aquifer zone becomes thicker, but alteration of clay bands continues except some areas where there are no clay bands even up to a depth of 200m bgl.

Project region is occupied by many perennial and seasonal waterbodies, also, the project region is in very adjacent to Bay of Bengal. Therefore, sufficient ground water is available in shallow aquifer. The depth of water level in the project districts ranges from 0.57 mbgl in Jagatsinghpur to 8.17 mbgl in Cuttack district.

There is no large-scale pollution observed in the project region except in some isolated patches where concentration of some pollutants like fluoride and nitrate are found higher. However, this is localized phenomena and limited for few dug wells only.

Surface Water Characteristics

OSPCB is regularly monitoring the water quality at five location within project river stretch of Mahanadi. The location includes upstream and downstream of Cuttack and Paradip. The water quality of Mahanadi River as monitored in Year 2015 is presented below.

Table 9-4: Water Quality Mahanadi River

S. No.	Parameters	Unit	Cuttack U/s	Cuttack D/s	Cuttack FD/s	Paradip U/s	Paradip D/s
			Avg Conc. (Min-Max)				
1	pH		8.0 (7.1-8.4)	8.2 (7.1-8.5)	8.1 (7.5-8.5)	7.9 (7.5-8.4)	7.9 (6.7-8.4)
2	Electrical Conductivity (EC)	µS/cm	199 (153-270)	219 (190-280)	210 (165-262)	3971 (192-10960)	14312 (267-29160)
3	Total Suspended Solids	mg/l	24 (4-81)	32 (4-145)	34 (4-157)	25 (3-61)	42 (8-109)
4	Total Dissolve Solids	mg/l	112 (88-148)	125 (112-150)	119 (95-140)	2769 (110-8310)	11196 (142-23960)
5	Total Hardness	mg/l	75 (56-90)	86 (76-96)	82 (70-94)	459 (76-1020)	1692 (84-4300)
6	Total Alkalinity	mg/l	75 (48-96)	82 (60-98)	82 (58-102)	96 (68-116)	119 (68-216)
7	Ammoniacal Nitrogen (NH_4-N)	mg/l	0.079 (0.056-0.112)	0.075 (0.056-0.224)	0.075 (0.056-0.168)	0.056 (0.056-0.056)	0.056 (0.056-0.056)
8	Free Nitrogen as	mg/l	0.006 (0-0.014)	0.007 (0-0.022)	0.006 (0.001-0.016)	0.003 (0.001-0.007)	0.003 (0-0.007)

S. N o.	Parameters	Unit	Cuttack U/s	Cuttack D/s	Cuttack FD/s	Paradip U/s	Paradip D/s
			Avg Conc. (Min-Max)				
	Ammonia (NH_3-N)						
9	Total Kedah Nitrogen (TKN)	mg/l	1.14 (0.84-1.40)	1.17 (0.84-1.40)	1.05 (0.84-1.12)	1.07 (0.84-1.40)	1.05 (0.84-1.40)
10	Sodium Absorption Ratio (SAR)		0.40 (0.30-0.53)	0.37 (0.26-0.49)	0.41 (0.33-0.53)	15.82 (0.31-47.53)	38.58 (0.53-65.04)
11	Chloride (Cl-)	mg/l	10.5 (7.8-11.7)	10.4 (7.8-12.7)	10.6 (8.8-13.7)	1382.5 (8.8-4696.8)	5905.4 (13.7-12714.0)
12	Nitrate as NO_3^-	mg/l	3.192 (0.155-6.851)	8.603 (2.817-23.343)	5.829 (1.678-12.086)	3.339 (0.881-9.747)	8.145 (0.903-18.232)
13	Phosphate (PO_4^{3-}P)	mg/l	0.093 (0.015-0.223)	0.079 (0.031-0.266)	0.208 (0.033-1.248)	0.071 (0.01-0.143)	0.222 (0.033-1.234)
14	Sulphate (SO_4^-)	mg/l	10.2 (2.4-21.5)	13.6 (2.9-24.9)	11.0 (3.6-21.9)	245.7 (11.2-808.4)	855.1 (14.2-1853.2)
15	Fluoride	mg/l	0.387 (0.298-0.536)	0.378 (0.272-0.524)	0.378 (0.302-0.510)	0.514 (0.320-0.910)	0.652 (0.462-0.900)
16	Boron (B)	mg/l	0.034 (0.003-0.138)	0.043 (0.003-0.112)	0.043 (0.003-0.138)	0.380 (0.003-1.171)	1.177 (0.042-2.274)
17	Iron (Fe)	mg/l	2.309 (0.050-7.220)	2.496 (<0.005-7.450)	2.365 (0.040-6.710)	1.102 (0.120-3.850)	1.823 (0.390-6.040)
18	Hexavalent Chromium	mg/l	0.010 (<0.002-0.033)	0.011 (<0.002-0.031)	0.010 (<0.002-0.035)	0.012 (<0.002-0.028)	0.010 (<0.002-0.040)
19	Total Chromium	mg/l	0.029 (0.013-0.055)	0.041 (0.015-0.076)	0.036 (0.013-0.076)	0.038 (0.013-0.087)	0.046 (0.005-0.131)

S. No.	Parameters	Unit	Cuttack U/s	Cuttack D/s	Cuttack FD/s	Paradip U/s	Paradip D/s
			Avg Conc. (Min-Max)				
20	Nickle (Ni)	mg/l	0.007 (0.002-0.012)	0.012 (0.007-0.017)	0.012 (0.007-0.020)	0.020 (0.008-0.051)	0.017 (0.007-0.028)
21	Copper (Cu)	mg/l	0.003 (0.001-0.008)	0.005 (0.002-0.013)	0.004 (0.001-0.009)	0.009 (0.004-0.013)	0.013 (0.006-0.021)
22	Zinc (Zn)	mg/l	0.005 (0.001-0.009)	0.006 (0.001-0.013)	0.006 (0.002-0.014)	0.010 (0.001-0.019)	0.015 (0.008-0.023)
23	Cadmium (Cd)	mg/l	0.0032 (0.0007-0.0067)	0.0039 (0.0011-0.0076)	0.0028 (0.0007-0.0059)	0.0018 (0.0005-0.0065)	0.0027 (0.0011-0.0074)
24	Mercury (Hg)	mg/l	0.00011 (<0.00006-0.00038)	0.00022 (<0.00006-0.00070)	0.00015 (<0.00006-0.00032)	0.00016 (<0.00006-0.00057)	0.00021 (0.00006-0.00038)
25	Lead (Pb)	mg/l	0.009 (0.004-0.014)	0.012 (0.007-0.017)	0.009 (0.004-0.015)	0.013 (0.005-0.021)	0.016 (0.011-0.027)
26	Dissolve Oxygen (DO)	mg/l	7.8 (6.6-9.0)	7.2 (5.8-8.1)	7.4 (6.6-8.4)	7.6 (6.8-8.9)	7.2 (6.5-8.2)
27	Biological Oxygen Demand (BOD)	mg/l	1.0 (0.5-2.0)	2.2 (1.5-2.8)	1.5 (1.0-2.0)	1.1 (0.2-2.2)	1.9 (0.8-2.9)
28	Chemical Oxygen Demand (COD)	mg/l	9.8 (6.1-15.2)	16.1 (9.2-27.6)	11.4 (5.5-18.3)	14.3(6.7-24.4)	24.5 (8.3-35.2)
29	Fecal Coliform (FC)	MPN/100ml	600 (20-1300)	36248 (780-160000)	21502 (170-54000)	2165 (230-5400)	3231 (130-13000)
30	Total Coliform (TC)	MPN/100ml	1748 (130-5400)	51017 (3300-160000)	39549 (490-92000)	4953 (460-16000)	6756 (230-24000)

Source: Odisha State Pollution Control Board, Odisha

Water Quality doesn't confirm the compliance of parameter concentration as per designated Class C of IS 2296. The reason as stated by the OSPCB is biological contamination due to human activities.

9.10. Susceptibility to Natural Hazards

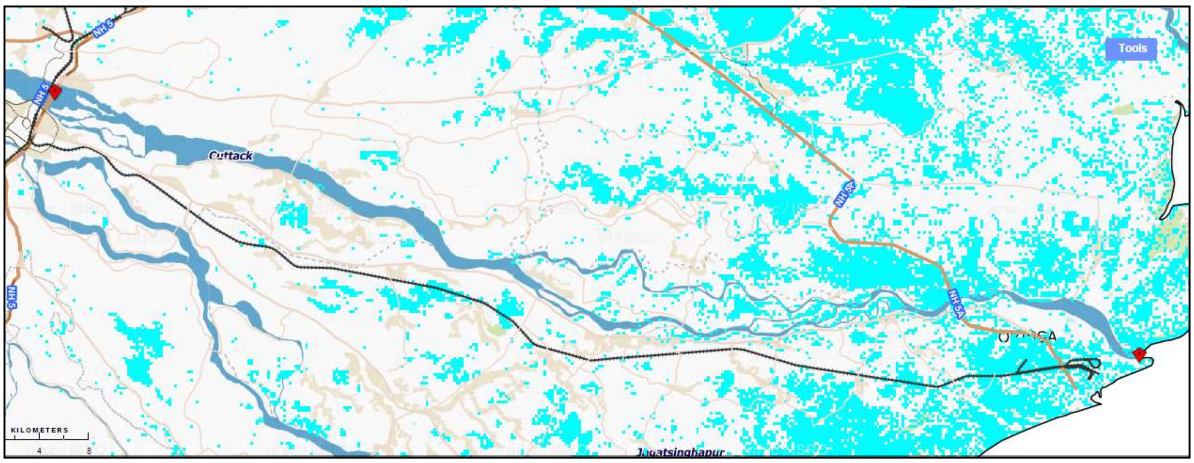
Odisha has a history of recurring natural disasters. While the coastal districts of Odisha are exposed to floods and cyclones, western Odisha is prone to acute droughts; a large section of the State is also prone to earthquakes. In addition, the State is also affected by disasters like heat waves, epidemics, forest fire, road accidents etc. The history of disasters substantiates the fact that about 80% of the State is prone to one or more forms of natural disasters. The two successive cyclones in October 1999, the severe cyclone which hit Ganjam coast and the Super Cyclone damaged the infrastructure in 14 districts of the State and disrupted public life. With millions of trees uprooted during the super cyclone, the State, especially the coastal belt has become extremely vulnerable.

With 80% of annual rainfall concentrated over 3 months, the State is highly vulnerable to floods. High population density, encroachment on the flood plains, poor socio-economic condition, weak infrastructure and mud houses increase the vulnerability. Out of total geographical area of 15.751 lakh hectares 1.40 lakh hectares are flood prone. There are 516 nos. of vulnerable points in Odisha. Floods are the most recurrent disasters in the State. In the last 25 years, floods have occurred 12 times with varying severity. Report says floods occurred in 27 districts in July-August 2006 with a loss of 90 human beings, 1656 livestock. 3.104 lakh hectares of crop and 120446 nos. of houses damaged.

9.10.1. Cyclones

Odisha is always vulnerable to cyclones in April-May and September-November. Once every few decades a super cyclone strikes Odisha. Recent Super Cyclone that hit Odisha in the last Century were in 1942, 1971 and 1999. The Super Cyclone of 1999 killed about 10,000 and traumatized millions who survived its wrath. Over 15 million people were affected. Throughout India's massive coastline, there are 250 cyclone-warning sets, of which 34 are in Odisha, covering 480 Km of coastline. Odisha Disaster Mitigation Authority (OSDMA) promotes Community Based Disaster Preparedness activities so that people can face emergencies in an organized manner. OSDMA was formed to coordinate and implement the reconstruction work after the super cyclone, keeping in mind the need for disaster preparedness to face any future eventuality. During Super Cyclone of 1999, 97 nos. of blocks and 28 ULBs and about 12569000 populations were affected. The total agricultural land affected was 1733000 hectares with 9885 nos. of human casualties. The cyclone hazard map of the project area is presented in Figure 9.7 below.

Figure 9.7: Cyclone Map of Project Region



Source: Bhuvan

9.10.2. Aggregated Inundation Flood

The 482 km long of coastline of Orissa exposes the State to flood, cyclones and storm surges. Heavy rainfall during monsoon causes floods in the rivers. In Orissa, rivers such as the Mahanadi, Subarnarekha, Brahmani, Mahanadi, Rushikulya, Vansadhara and their many tributaries and branches flowing through the State expose vast areas to floods. Damages are caused due to floods mainly in the Mahanadi, the Brahmani, and the Mahanadi. These rivers have a common delta where flood waters intermingle, and when in spate simultaneously, wreak considerable havoc. This problem becomes even more acute when floods coincide with high tide. The entire coastal belt is prone to storm surges. The storms that produce tidal surges are usually accompanied by heavy rain fall making the coastal belt vulnerable to both floods and storm surges. People die; livestock perish; houses are washed away; paddy and other crops are lost, and roads and bridges are damaged. The floods of 1980, 1982, 2001 and 2003 in the

State were particularly severe; property worth crores of rupees were destroyed in the floods.

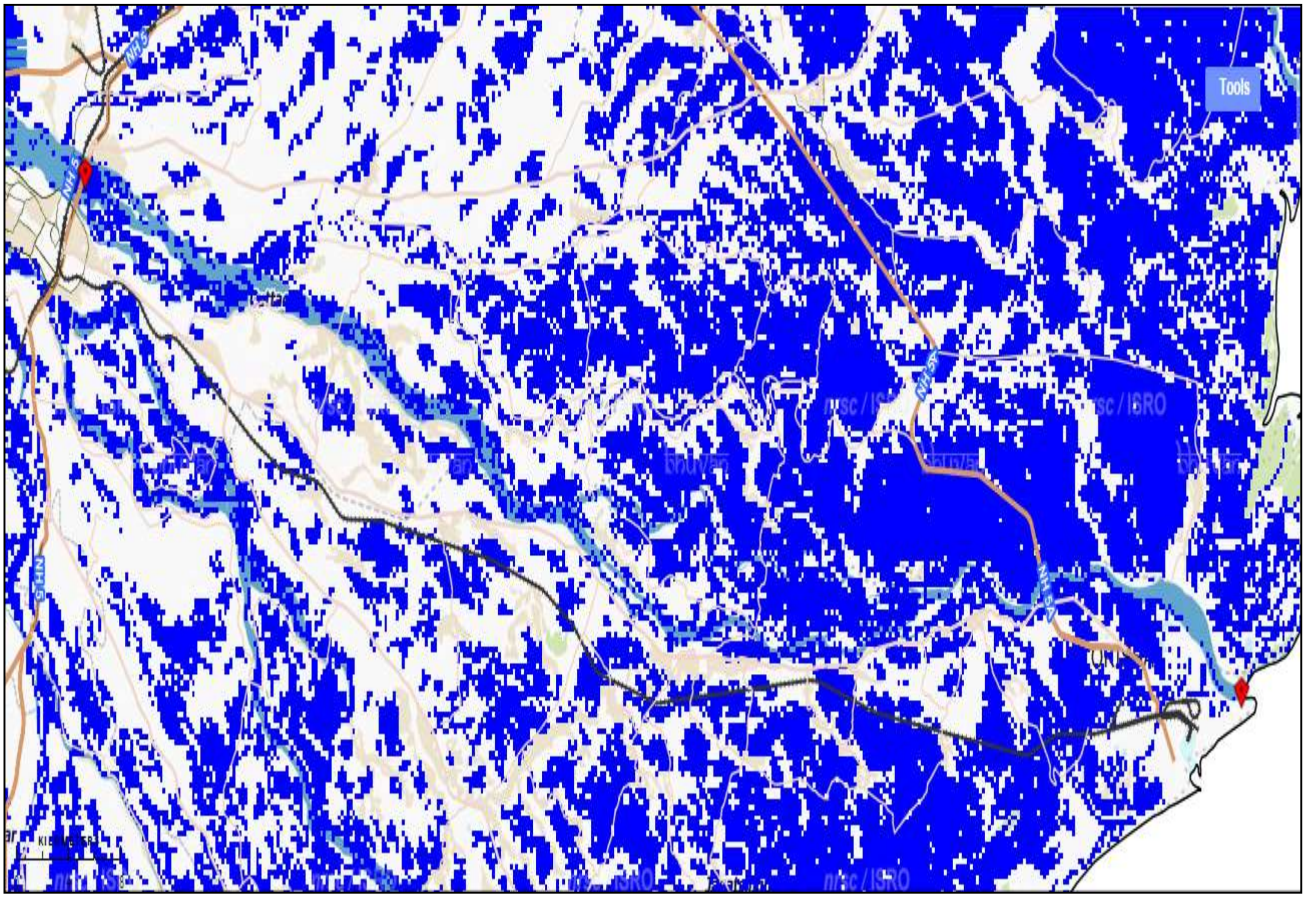
Due to flood/heavy rain in 2006, 245 Blocks, 3574 GPs, 18912 Villages, 67.39 lakh Population and 4.90 lakh hectare crop areas of the State was affected. 105 persons lost their lives due to flood/heavy rain. 28,327 hectares of crop area were under sand cast due to the floods.

Due to continuous heavy downpour over upper & lower catchments of river Subarnarekha, Jalaka, Mahanadi, Budhabalanga and their tributaries from 4th to 6th July,2007 flood brought havoc in five districts namely Balasore, Bhadrak, Jajpur, Keonjhar and Mayurbhanj in the first week of July. Storm surge and saline inundation affected parts of Kendrapara district during the said period.

The State of Orissa was ravaged by floods in June and September during the year 2008. The floods that occurred in June 2008 and in September 2008 are unprecedented. The floods of June and September 2008 were calamities of rare severity. The floods in June'08 brought havoc in districts namely Balasore, Bhadrak, Jajpur, Mayurbhanj and Keonjhar. The flood in September 2008 was due to heavy rainfall in the upper as well as in lower catchments of the Mahanadi River System resulting out of the effect of a deep depression in the Bay of Bengal from 16th to 21st September 2008. During September, 19 districts namely, Angul, Bargarh, Bhadrak, Bolangir, Boudh, Cuttack, Gajapati, Jagatsinghpur, Jajpur, Kalahandi, Kendrapara, Keonjhar, Khurda, Nayagarh, Puri, Rayagada, Sambalpur, Nuapara and Subarnapur had been seriously affected.

Flood 2009 affected 15 districts namely Balasore, Bhadrak, Cuttack, Ganjam, Jajpur,Kalahandi, Kandhamal, Kendrapada, Keonjhar, Khurda, Koraput, Nayagarh, Puri, Subarnapur & Sundergarh. About 56 people lost their lives in the flood. Area adjacent to project river stretch is prone to inundation. Inundation Hazard Map of the project region is presented in Figure 9.8 below.

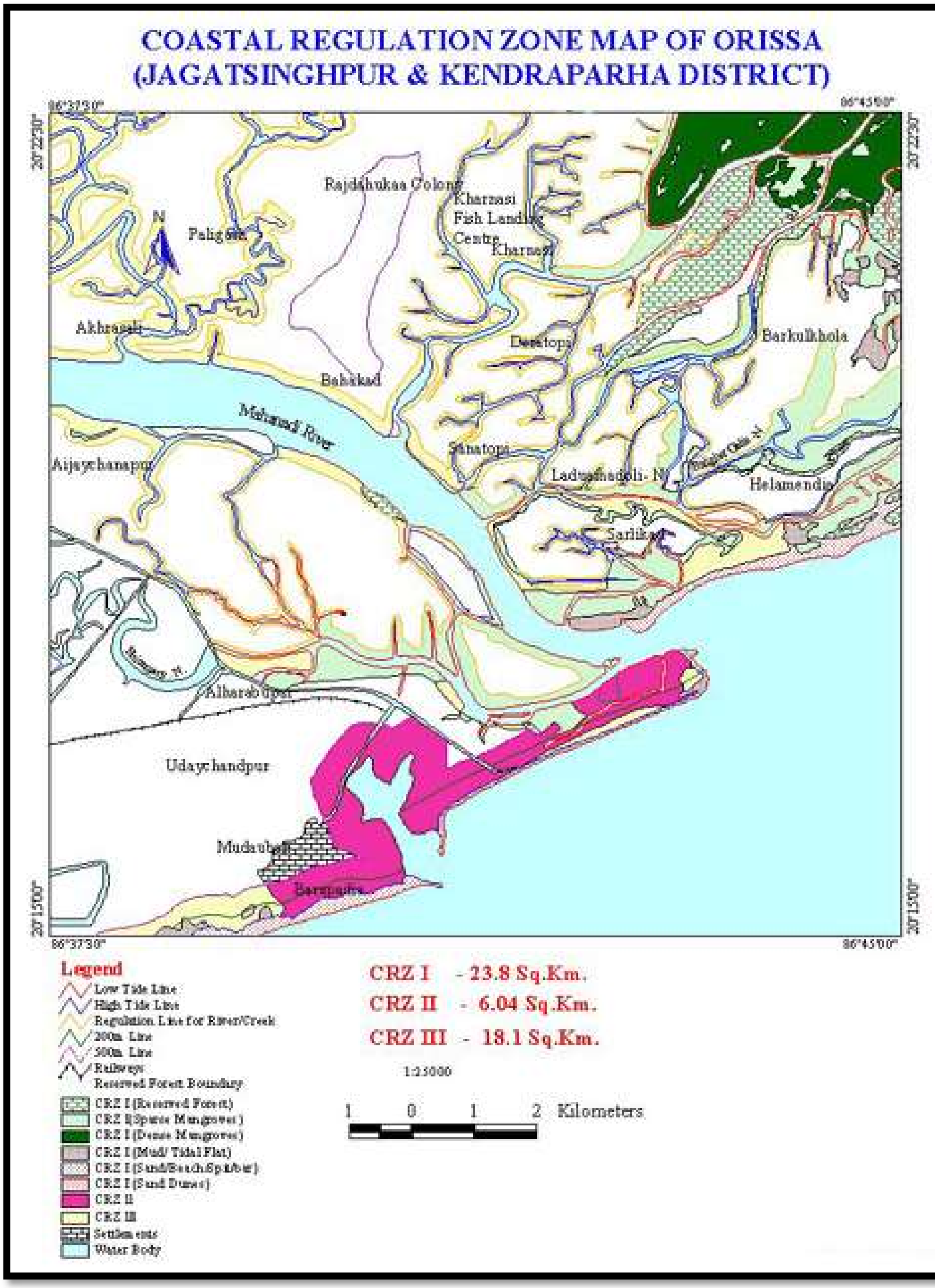
Figure 9.8: Inundation Hazard Map of Project Region


Tools

9.11. Coastal Regulation Zone

Coastal zone area of the Mahanadi River is notified under CRZ-I, II & III. The Coastal Regulation Zone map of Mahanadi river basin is presented in Figure 9.9 below.

Figure 9.9: Coastal Zoning Map of Project River Stretch



9.12. Archaeological and Heritage Locations

Baladevjew Temple (Temple built during Maratha occupation of Odisha) found approx. 3km in the north of project river stretch. No notified archaeological site / monument found along or within 2.0 km of the project river stretch.

9.13. Flora and Fauna

Flora as present in project region are listed below.

Table 9-5: List of Flora

Sl. No.	Local Name	Botanical Name
TREES		
1	Achhu	*Morinda tinctoria*
2	Ambada	*Spondias mangifera*
3	Bandhan	*Ougeinia oojeinensis*
4	Char	*Buchanania lanjan*
5	Chhuin patuli	*Stereospermum angustifolium*
6	Dhauranja	*Holoptelia integrifolia*
7	Gambhari	*Gmelina arboria*
8	Genduli	*Sterculia urens*
9	Hinjal	*Barringtonia acutangula*
10	Handiphuta	*Butea parviflora*
11	Jarasanda	*Litsaea sebifere*
12	Karada	*Cleistanthus collinus*
13	Harida	*Terminalia chebula*
14	Kendu	*Diospyros melanoxylon*
15	Kusum	*Schleichera oleosa*
16	Kasi	*Bridellia retusa*
17	Kumbhi	*Careya arboria*
18	Kangada	*Xylia xylocarpa*
19	Khirkoli	*Monilkra hexandra*

Sl. No.	Local Name	Botanical Name
20	Khaira	*Acacia catechu*
21	Lodha	*Symplocos recemosa*
22	Mahula	*Madhuca indica*
23	Mai	*Lannea coromondelica*
23	Mahala	*Ailanthus excels*
24	Mankada Kendu	*Diospyros embryopteris*
25	Nimba	*Azadirachta indica*
26	Piasal	*Pterocarpus marsupium*
27	Phasi	*Anogeissus acuminate*
28	Phanphana	*Oroxylon indicum*
29	Sal	*Shorea robusta*
30	Simili	*Bombax ceiba*
31	Pahadi Sisoo	*Dalbergia latifolia*
32	Salai	*Boswellia serrate*
33	Sahada	*Streblus asper*
34	Samarsinga	*Cordia macleodii*
35	Rakta Chandan	*Pterocarpus santalinus*
36	Tentuli	*Tamarindus indica*
37	Nageswar	*Messua ferrea*
38	Kamini	*Murraya paniculata*
39	Piasal/ Bijasal	*Pterocarpus marsupium*
40	Ashoka	*Saraca indica*
41	Chandan	*Santalum album*
42	Ritha	*Sapindus emarginatus*
43	Nirmala	*Strychnos patatorum*
44	Arjuna	*Terminalia arjuna*
45	Asana / Sahaja	*Terminalia tomentosa*
46	Teak / Saguan	*Tectona grandis*

Sl. No.	Local Name	Botanical Name
47	Bela	*Aegle marmelos*
SHRUBS		
1	Bana Tulasi	*Perilla ocmoides*
2	Bisalya Karani	*Tridex procumbens*
3	Patalgaruda	*Raowolfia serpentine*
4	Pengu- Lai Lata	*Celastrus paniculata*
5	Satabari	*Asparagus recemosus*
6	Sabai grass	*Eulaliopsis binata*
7	Kia Ketaki	*Pandanus tectorius*
HERBS		
1	Apamaranga	*Achyranthus aspera*
2	Bhuinnimba	*Andrographis paniculata*
3	Gheekuanri	*Aloe vera*
4	Palua	*Curcuma aromatica*
5	Kashatandi	*Saccharum spontaneum*
6	Salaparni	*Desmodium gangeticum*
7	Saptapheni	*Opuntia dillenii*
CLIMBERS		
1	Atundi	*Combretum decandrum*
2	Akanabindhi	*Cissamplelos perira*
3	Dantari	*Acacia torta*
4	Siali	*Bauhinia vahlii*
5	Takua Lai	*Vitis repanda*
6	Guluchi	*Tinospora cordifolia*
7	Kankada	*Memordica dioica*
BAMBOOS AND CANES		
1	Beta	*Calamus tenuis*
2	Salia Baunsa	*Dendrocalamus strictus*

Sl. No.	Local Name	Botanical Name
3	Kanta Baunsa	*Bambusa bambos*
4	Daba Baunsa	*Bambusa bambos Var–gigantea*
5	Dangi Baunsa	*Schizostachyum pergracile*
6	Pani Baunsa	*Gigantochloa robusta*
	MANGROVES	
1	Hental	*Phoenix paludosa*
2	Bani	*Avicinia officinalis*
3	Sundari	*Heritiera littoralis*

Biodiversity along the project area has a presence of Amphibians 20 nos., Birds 369 nos., Fishes 60 nos., Invertebrates 99 nos. and Reptile 34 nos. List of Fauna as data collected through Ibat tool is presented in Table below.

Table 9-6: Faunal Diversity in Project Region

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
		Amphibians		
1	Amphibians	*Duttaphrynus melanostictus*	Black-spectacled Toad	LC
2	Amphibians	*Duttaphrynus stomaticus*		LC
3	Amphibians	*Euphlyctis cyanophlyctis*		LC
4	Amphibians	*Euphlyctis hexadactylus*	Indian Green Frog	LC
5	Amphibians	*Fejervarya limnocharis*	Asian Grass Frog	LC
6	Amphibians	*Fejervarya orissaensis*	Orissa Frog	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
7	Amphibians	*Fejervarya syhadrensis*	Bombay Wart Frog	LC
8	Amphibians	*Hoplobatrachus crassus*	Jerdon's Bullfrog	LC
9	Amphibians	*Hoplobatrachus tigerinus*	Indian Bullfrog	LC
10	Amphibians	*Hydrophylax malabaricus*		LC
11	Amphibians	*Microhyla ornata*	Ant Frog	LC
12	Amphibians	*Polypedates maculatus*	Himalayan Tree Frog	LC
13	Amphibians	*Sphaerotheca breviceps*		LC
14	Amphibians	*Sphaerotheca dobsonii*		LC
15	Amphibians	*Sphaerotheca rolandae*		LC
16	Amphibians	*Uperodon globulosus*		LC
17	Amphibians	*Uperodon systoma*	Marbled Balloon Frog	LC
18	Amphibians	*Uperodon taprobanicus*	Sri Lankan Bullfrog	LC
19	Amphibians	*Uperodon variegatus*	Eluru Dot Frog	LC
Avi-fauna				
1	Birds	*Accipiter badius*	Shikra	LC
2	Birds	*Accipiter nisus*	Eurasian Sparrowhawk	LC
3	Birds	*Accipiter trivirgatus*	Crested Goshawk	LC
4	Birds	*Accipiter virgatus*	Besra	LC
5	Birds	*Acridotheres fuscus*	Jungle Myna	LC
6	Birds	*Acridotheres tristis*	Common Myna	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
7	Birds	*Acrocephalus agricola*	Paddyfield Warbler	LC
8	Birds	*Acrocephalus dumetorum*	Blyth's Reed-warbler	LC
9	Birds	*Acrocephalus stentoreus*	Clamorous Reed-warbler	LC
10	Birds	*Actitis hypoleucos*	Common Sandpiper	LC
11	Birds	*Aegithina tiphia*	Common Iora	LC
12	Birds	*Aethopyga siparaja*	Crimson Sunbird	LC
13	Birds	*Alauda gulgula*	Oriental Skylark	LC
14	Birds	*Alcedo atthis*	Common Kingfisher	LC
15	Birds	*Alcedo meninting*	Blue-eared Kingfisher	LC
16	Birds	*Alcippe poioicephala*	Brown-cheeked Fulvetta	LC
17	Birds	*Amandava amandava*	Red Avadavat	LC
18	Birds	*Amaurornis phoenicurus*	White-breasted Waterhen	LC
19	Birds	*Anas crecca*	Common Teal	LC
20	Birds	*Anas poecilorhyncha*	Indian Spot-billed Duck	LC
21	Birds	*Anastomus oscitans*	Asian Openbill	LC
22	Birds	*Anhinga melanogaster*	Oriental Darter	NT
23	Birds	*Anser albifrons*	Greater White-fronted Goose	LC
24	Birds	*Anser indicus*	Bar-headed Goose	LC
25	Birds	*Anthracoceros albirostris*	Oriental Pied Hornbill	LC
26	Birds	*Anthracoceros coronatus*	Malabar Pied Hornbill	NT
27	Birds	*Anthropoides virgo*	Demoiselle Crane	LC
28	Birds	*Anthus godlewskii*	Blyth's Pipit	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
29	Birds	*Anthus hodgsoni*	Olive-backed Pipit	LC
30	Birds	*Anthus richardi*	Richard's Pipit	LC
31	Birds	*Anthus rufulus*	Paddyfield Pipit	LC
32	Birds	*Apus affinis*	Little Swift	LC
33	Birds	*Apus pacificus*	Pacific Swift	LC
34	Birds	*Aquila fasciata*	Bonelli's Eagle	LC
35	Birds	*Aquila nipalensis*	Steppe Eagle	EN
36	Birds	*Ardea alba*	Great White Egret	LC
37	Birds	*Ardea cinerea*	Grey Heron	LC
38	Birds	*Ardea intermedia*	Intermediate Egret	LC
39	Birds	*Ardea purpurea*	Purple Heron	LC
40	Birds	*Ardeola grayii*	Indian Pond-heron	LC
41	Birds	*Argya caudata*	Common Babbler	LC
42	Birds	*Artamus fuscus*	Ashy Woodswallow	LC
43	Birds	*Arundinax aedon*	Thick-billed Warbler	LC
44	Birds	*Asio flammeus*	Short-eared Owl	LC
45	Birds	*Athene brama*	Spotted Owlet	LC
46	Birds	*Aythya baeri*	Baer's Pochard	CR
47	Birds	*Aythya ferina*	Common Pochard	VU
48	Birds	*Aythya fuligula*	Tufted Duck	LC
49	Birds	*Bubo bengalensis*	Rock Eagle-owl	LC
50	Birds	*Bubo coromandus*	Dusky Eagle-owl	LC
51	Birds	*Bubulcus ibis*	Cattle Egret	LC
52	Birds	*Burhinus indicus*	Indian Thick-knee	LC
53	Birds	*Butastur teesa*	White-eyed Buzzard	LC
54	Birds	*Butorides striata*	Green-backed Heron	LC
55	Birds	*Cacomantis passerinus*	Grey-bellied Cuckoo	LC
56	Birds	*Cacomantis sonneratii*	Banded Bay Cuckoo	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
57	Birds	*Calandrella dukhunensis*	Eastern Short-toed Lark	LC
58	Birds	*Calidris alpina*	Dunlin	LC
59	Birds	*Calidris temminckii*	Temminck's Stint	LC
60	Birds	*Calliope calliope*	Siberian Rubythroat	LC
61	Birds	*Caprimulgus affinis*	Savanna Nightjar	LC
62	Birds	*Caprimulgus asiaticus*	Indian Nightjar	LC
63	Birds	*Caprimulgus atripennis*	Jerdon's Nightjar	LC
64	Birds	*Caprimulgus indicus*	Jungle Nightjar	LC
65	Birds	*Caprimulgus macrurus*	Large-tailed Nightjar	LC
66	Birds	*Carpodacus erythrinus*	Common Rosefinch	LC
67	Birds	*Cecropis daurica*	Red-rumped Swallow	LC
68	Birds	*Centropus sinensis*	Greater Coucal	LC
69	Birds	*Ceryle rudis*	Pied Kingfisher	LC
70	Birds	*Chaetornis striata*	Bristled Grassbird	VU
71	Birds	*Chalcophaps indica*	Grey-capped Emerald Dove	LC
72	Birds	*Charadrius alexandrinus*	Kentish Plover	LC
73	Birds	*Charadrius dubius*	Little Ringed Plover	LC
74	Birds	*Chlidonias hybrida*	Whiskered Tern	LC
75	Birds	*Chloropsis aurifrons*	Golden-fronted Leafbird	LC
76	Birds	*Chloropsis jerdoni*	Jerdon's Leafbird	LC
77	Birds	*Chrysocolaptes festivus*	White-naped Woodpecker	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
78	Birds	*Chrysocolaptes guttacristatus*	Greater Flameback	LC
79	Birds	*Chrysomma sinense*	Yellow-eyed Babbler	LC
80	Birds	*Chrysophlegma flavinucha*	Greater Yellownape	LC
81	Birds	*Cinnyris asiaticus*	Purple Sunbird	LC
82	Birds	*Circaetus gallicus*	Short-toed Snake-eagle	LC
83	Birds	*Circus aeruginosus*	Western Marsh-harrier	LC
84	Birds	*Circus macrourus*	Pallid Harrier	NT
85	Birds	*Circus melanoleucos*	Pied Harrier	LC
86	Birds	*Cisticola juncidis*	Zitting Cisticola	LC
87	Birds	*Clamator coromandus*	Chestnut-winged Cuckoo	LC
88	Birds	*Clamator jacobinus*	Jacobin Cuckoo	LC
89	Birds	*Clanga clanga*	Greater Spotted Eagle	VU
90	Birds	*Clanga hastata*	Indian Spotted Eagle	VU
91	Birds	*Columba livia*	Rock Dove	LC
92	Birds	*Columba punicea*	Pale-capped Pigeon	VU
93	Birds	*Copsychus saularis*	Oriental Magpie-robin	LC
94	Birds	*Coracias benghalensis*	Indian Roller	LC
95	Birds	*Coracina macei*	Indian Cuckoo-shrike	LC
96	Birds	*Corvus macrorhynchos*	Large-billed Crow	LC
97	Birds	*Corvus splendens*	House Crow	LC
98	Birds	*Coturnix coromandelica*	Rain Quail	LC
99	Birds	*Coturnix coturnix*	Common Quail	LC
100	Birds	*Cuculus micropterus*	Indian Cuckoo	LC

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101	Birds	*Cuculus poliocephalus*	Lesser Cuckoo	LC
102	Birds	*Culicicapa ceylonensis*	Grey-headed Canary-flycatcher	LC
103	Birds	*Cursorius coromandelicus*	Indian Courser	LC
104	Birds	*Cyanecula svecica*	Bluethroat	LC
105	Birds	*Cyanoderma rufifrons*	Rufous-fronted Babbler	LC
106	Birds	*Cyornis rubeculoides*	Blue-throated Blue-flycatcher	LC
107	Birds	*Cyornis tickelliae*	Tickell's Blue-flycatcher	LC
108	Birds	*Cypsiurus balasiensis*	Asian Palm-swift	LC
109	Birds	*Delichon dasypus*	Asian House Martin	LC
110	Birds	*Dendrocitta vagabunda*	Rufous Treepie	LC
111	Birds	*Dendrocopos macei*	Fulvous-breasted Woodpecker	LC
112	Birds	*Dendrocygna bicolor*	Fulvous Whistling-duck	LC
113	Birds	*Dendrocygna javanica*	Lesser Whistling-duck	LC
114	Birds	*Dicaeum agile*	Thick-billed Flowerpecker	LC
115	Birds	*Dicaeum erythrorhynchos*	Pale-billed Flowerpecker	LC
116	Birds	*Dicrurus aeneus*	Bronzed Drongo	LC
117	Birds	*Dicrurus caerulescens*	White-bellied Drongo	LC
118	Birds	*Dicrurus hottentottus*	Hair-crested Drongo	LC
119	Birds	*Dicrurus leucophaeus*	Ashy Drongo	LC
120	Birds	*Dicrurus macrocercus*	Black Drongo	LC

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121	Birds	*Dicrurus paradiseus*	Greater Racquet-tailed Drongo	LC
122	Birds	*Dinopium benghalense*	Black-rumped Flameback	LC
123	Birds	*Ducula aenea*	Green Imperial-pigeon	LC
124	Birds	*Dumetia hyperythra*	Tawny-bellied Babbler	LC
125	Birds	*Egretta garzetta*	Little Egret	LC
126	Birds	*Elanus caeruleus*	Black-winged Kite	LC
127	Birds	*Eremopterix griseus*	Ashy-crowned Sparrow-lark	LC
128	Birds	*Esacus recurvirostris*	Great Thick-knee	NT
129	Birds	*Eudynamys scolopaceus*	Western Koel	LC
130	Birds	*Eumyias thalassinus*	Verditer Flycatcher	LC
131	Birds	*Euodice malabarica*	Indian Silverbill	LC
132	Birds	*Falco amurensis*	Amur Falcon	LC
133	Birds	*Falco chicquera*	Red-headed Falcon	NT
134	Birds	*Falco naumanni*	Lesser Kestrel	LC
135	Birds	*Falco peregrinus*	Peregrine Falcon	LC
136	Birds	*Falco tinnunculus*	Common Kestrel	LC
137	Birds	*Ficedula albicilla*	Red-throated Flycatcher	LC
138	Birds	*Ficedula superciliaris*	Ultramarine Flycatcher	LC
139	Birds	*Francolinus pictus*	Painted Francolin	LC
140	Birds	*Francolinus pondicerianus*	Grey Francolin	LC
141	Birds	*Fulica atra*	Common Coot	LC
142	Birds	*Gallicrex cinerea*	Watercock	LC
143	Birds	*Gallinago gallinago*	Common Snipe	LC
144	Birds	*Gallinago stenura*	Pintail Snipe	LC

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145	Birds	*Gallinula chloropus*	Common Moorhen	LC
146	Birds	*Galloperdix lunulata*	Painted Spurfowl	LC
147	Birds	*Galloperdix spadicea*	Red Spurfowl	LC
148	Birds	*Gallus gallus*	Red Junglefowl	LC
149	Birds	*Geokichla citrina*	Orange-headed Thrush	LC
150	Birds	*Glareola lactea*	Little Pratincole	LC
151	Birds	*Glareola maldivarum*	Oriental Pratincole	LC
152	Birds	*Glaucidium radiatum*	Jungle Owlet	LC
153	Birds	*Gracula indica*	Southern Hill Myna	LC
154	Birds	*Gracula religiosa*	Common Hill Myna	LC
155	Birds	*Gracula robusta*	Nias Hill Myna	CR
156	Birds	*Gracula venerata*	Tenggara Hill Myna	EN
157	Birds	*Gracupica contra*	Asian Pied Starling	LC
158	Birds	*Gymnoris xanthocollis*	Chestnut-shouldered Bush-sparrow	LC
159	Birds	*Gyps bengalensis*	White-rumped Vulture	CR
160	Birds	*Gyps indicus*	Indian Vulture	CR
161	Birds	*Haematopus ostralegus*	Eurasian Oystercatcher	NT
162	Birds	*Halcyon smyrnensis*	White-breasted Kingfisher	LC
163	Birds	*Haliaeetus leucoryphus*	Pallas's Fish-eagle	VU
164	Birds	*Haliastur indus*	Brahminy Kite	LC
165	Birds	*Harpactes fasciatus*	Malabar Trogon	LC
166	Birds	*Hemiprocne coronata*	Crested Treeswift	LC
167	Birds	*Hemipus picatus*	Bar-winged Flycatcher-shrike	LC
168	Birds	*Hieraaetus pennatus*	Booted Eagle	LC

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169	Birds	*Hierococcyx sparverioides*	Large Hawk-cuckoo	LC
170	Birds	*Hierococcyx varius*	Common Hawk-cuckoo	LC
171	Birds	*Himantopus himantopus*	Black-winged Stilt	LC
172	Birds	*Hirundo rustica*	Barn Swallow	LC
173	Birds	*Hirundo smithii*	Wire-tailed Swallow	LC
174	Birds	*Hydrophasianus chirurgus*	Pheasant-tailed Jacana	LC
175	Birds	*Hypothymis azurea*	Black-naped Monarch	LC
176	Birds	*Ictinaetus malaiensis*	Black Eagle	LC
177	Birds	*Iduna caligata*	Booted Warbler	LC
178	Birds	*Irena puella*	Asian Fairy-bluebird	LC
179	Birds	*Jynx torquilla*	Eurasian Wryneck	LC
180	Birds	*Ketupa zeylonensis*	Brown Fish-owl	LC
181	Birds	*Kittacincla malabarica*	White-rumped Shama	LC
182	Birds	*Lalage melanoptera*	Black-headed Cuckoo-shrike	LC
183	Birds	*Lalage melaschistos*	Black-winged Cuckoo-shrike	LC
184	Birds	*Lanius cristatus*	Brown Shrike	LC
185	Birds	*Lanius schach*	Long-tailed Shrike	LC
186	Birds	*Lanius vittatus*	Bay-backed Shrike	LC
187	Birds	*Larus ichthyaetus*	Pallas's Gull	LC
188	Birds	*Larvivora brunnea*	Indian Blue Robin	LC
189	Birds	*Leiopicus mahrattensis*	Yellow-crowned Woodpecker	LC
190	Birds	*Leptocoma zeylonica*	Purple-rumped Sunbird	LC
191	Birds	*Leptoptilos javanicus*	Lesser Adjutant	VU

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192	Birds	*Limosa limosa*	Black-tailed Godwit	NT
193	Birds	*Lonchura atricapilla*	Chestnut Munia	LC
194	Birds	*Lonchura malacca*	Tricoloured Munia	LC
195	Birds	*Lonchura punctulata*	Scaly-breasted Munia	LC
196	Birds	*Lonchura striata*	White-rumped Munia	LC
197	Birds	*Loriculus vernalis*	Vernal Hanging-parrot	LC
198	Birds	*Lymnocryptes minimus*	Jack Snipe	LC
199	Birds	*Machlolophus xanthogenys*	Black-lored Tit	LC
200	Birds	*Mareca strepera*	Gadwall	LC
201	Birds	*Megalurus palustris*	Striated Grassbird	LC
202	Birds	*Merops orientalis*	Asian Green Bee-eater	LC
203	Birds	*Merops philippinus*	Blue-tailed Bee-eater	LC
204	Birds	*Metopidius indicus*	Bronze-winged Jacana	LC
205	Birds	*Microcarbo niger*	Little Cormorant	LC
206	Birds	*Micropternus brachyurus*	Rufous Woodpecker	LC
207	Birds	*Milvus migrans*	Black Kite	LC
208	Birds	*Mirafra affinis*	Jerdon's Bushlark	LC
209	Birds	*Mirafra erythroptera*	Indian Bushlark	LC
210	Birds	*Mirafra javanica*	Horsfield's Bushlark	LC
211	Birds	*Mixornis gularis*	Pin-striped Tit-babbler	LC
212	Birds	*Monticola cinclorhyncha*	Blue-capped Rock-thrush	LC
213	Birds	*Monticola solitarius*	Blue Rock-thrush	LC
214	Birds	*Motacilla alba*	White Wagtail	LC
215	Birds	*Motacilla cinerea*	Grey Wagtail	LC
216	Birds	*Motacilla citreola*	Citrine Wagtail	LC

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217	Birds	*Motacilla flava*	Western Yellow Wagtail	LC
218	Birds	*Motacilla maderaspatensis*	White-browed Wagtail	LC
219	Birds	*Muscicapa dauurica*	Asian Brown Flycatcher	LC
220	Birds	*Mycteria leucocephala*	Painted Stork	NT
221	Birds	*Neophron percnopterus*	Egyptian Vulture	EN
222	Birds	*Netta rufina*	Red-crested Pochard	LC
223	Birds	*Nettapus coromandelianus*	Cotton Pygmy-goose	LC
224	Birds	*Ninox scutulata*	Brown Boobook	LC
225	Birds	*Nisaetus cirrhatus*	Changeable Hawk-eagle	LC
226	Birds	*Numenius arquata*	Eurasian Curlew	NT
227	Birds	*Nycticorax nycticorax*	Black-Crowned Night Heron	LC
228	Birds	*Nyctyornis athertoni*	Blue-bearded Bee-eater	LC
229	Birds	*Ocyceros birostris*	Indian Grey Hornbill	LC
230	Birds	*Oriolus chinensis*	Black-naped Oriole	LC
231	Birds	*Oriolus kundoo*	Indian Golden Oriole	LC
232	Birds	*Oriolus xanthornus*	Black-hooded Oriole	LC
233	Birds	*Orthotomus sutorius*	Common Tailorbird	LC
234	Birds	*Otus bakkamoena*	Indian Scops-owl	LC
235	Birds	*Otus sunia*	Oriental Scops-owl	LC
236	Birds	*Pandion haliaetus*	Osprey	LC
237	Birds	*Parus major*	Great Tit	LC
238	Birds	*Passer domesticus*	House Sparrow	LC
239	Birds	*Pavo cristatus*	Indian Peafowl	LC
240	Birds	*Pelargopsis capensis*	Stork-billed Kingfisher	LC

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241	Birds	*Pelecanus philippensis*	Spot-billed Pelican	NT
242	Birds	*Pellorneum ruficeps*	Puff-throated Babbler	LC
243	Birds	*Perdicula asiatica*	Jungle Bush-quail	LC
244	Birds	*Perdicula erythrorhyncha*	Painted Bush-quail	LC
245	Birds	*Pericrocotus cinnamomeus*	Small Minivet	LC
246	Birds	*Pericrocotus erythropygius*	White-bellied Minivet	LC
247	Birds	*Pericrocotus ethologus*	Long-tailed Minivet	LC
248	Birds	*Pericrocotus flammeus*	Scarlet Minivet	LC
249	Birds	*Pericrocotus roseus*	Rosy Minivet	LC
250	Birds	*Pernis ptilorhynchus*	Oriental Honey-buzzard	LC
251	Birds	*Petrochelidon fluvicola*	Streak-throated Swallow	LC
252	Birds	*Phaenicophaeus tristis*	Green-billed Malkoha	LC
253	Birds	*Phaenicophaeus viridirostris*	Blue-faced Malkoha	LC
254	Birds	*Phalacrocorax carbo*	Great Cormorant	LC
255	Birds	*Phoenicurus ochruros*	Black Redstart	LC
256	Birds	*Phylloscopus affinis*	Tickell's Leaf-warbler	LC
257	Birds	*Phylloscopus burkii*	Green-crowned Warbler	LC
258	Birds	*Phylloscopus griseolus*	Sulphur-bellied Warbler	LC
259	Birds	*Phylloscopus humei*	Hume's Leaf-warbler	LC

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260	Birds	*Phylloscopus inornatus*	Yellow-browed Warbler	LC
261	Birds	*Phylloscopus magnirostris*	Large-billed Leaf-warbler	LC
262	Birds	*Phylloscopus occipitalis*	Western Crowned Leaf-warbler	LC
263	Birds	*Phylloscopus reguloides*	Blyth's Leaf-warbler	LC
264	Birds	*Phylloscopus tristis*	Siberian Chiffchaff	LC
265	Birds	*Phylloscopus trochiloides*	Greenish Warbler	LC
266	Birds	*Picoides nanus*	Indian Pygmy Woodpecker	LC
267	Birds	*Picumnus innominatus*	Speckled Piculet	LC
268	Birds	*Picus chlorolophus*	Lesser Yellownape	LC
269	Birds	*Picus guerini*	Black-naped Woodpecker	LC
270	Birds	*Picus xanthopygaeus*	Streak-throated Woodpecker	LC
271	Birds	*Pitta brachyura*	Indian Pitta	LC
272	Birds	*Plegadis falcinellus*	Glossy Ibis	LC
273	Birds	*Ploceus philippinus*	Baya Weaver	LC
274	Birds	*Pluvialis squatarola*	Grey Plover	LC
275	Birds	*Podiceps cristatus*	Great Crested Grebe	LC
276	Birds	*Pomatorhinus horsfieldii*	Indian Scimitar-babbler	LC
277	Birds	*Porphyrio porphyrio*	Purple Swamphen	LC
278	Birds	*Prinia buchanani*	Rufous-fronted Prinia	LC

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279	Birds	*Prinia hodgsonii*	Grey-breasted Prinia	LC
280	Birds	*Prinia inornata*	Plain Prinia	LC
281	Birds	*Prinia socialis*	Ashy Prinia	LC
282	Birds	*Prinia sylvatica*	Jungle Prinia	LC
283	Birds	*Psilopogon haemacephalus*	Coppersmith Barbet	LC
284	Birds	*Psilopogon lineatus*	Lineated Barbet	LC
285	Birds	*Psilopogon zeylanicus*	Brown-headed Barbet	LC
286	Birds	*Psittacula cyanocephala*	Plum-headed Parakeet	LC
287	Birds	*Psittacula eupatria*	Alexandrine Parakeet	NT
288	Birds	*Psittacula krameri*	Rose-ringed Parakeet	LC
289	Birds	*Pterocles indicus*	Painted Sandgrouse	LC
290	Birds	*Ptyonoprogne concolor*	Dusky Crag Martin	LC
291	Birds	*Pycnonotus cafer*	Red-vented Bulbul	LC
292	Birds	*Pycnonotus flaviventris*	Black-crested Bulbul	LC
293	Birds	*Pycnonotus jocosus*	Red-whiskered Bulbul	LC
294	Birds	*Pycnonotus luteolus*	White-browed Bulbul	LC
295	Birds	*Rallina eurizonoides*	Slaty-legged Crake	LC
296	Birds	*Recurvirostra avosetta*	Pied Avocet	LC
297	Birds	*Rhipidura albicollis*	White-throated Fantail	LC
298	Birds	*Rhipidura albogularis*	White-spotted Fantail	LC
299	Birds	*Rhipidura aureola*	White-browed Fantail	LC
300	Birds	*Rostratula benghalensis*	Greater Painted snipe	LC
301	Birds	*Sarcogyps calvus*	Red-headed Vulture	CR

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302	Birds	*Sarkidiornis melanotos*	African Comb Duck	LC
303	Birds	*Saxicola caprata*	Pied Bushchat	LC
304	Birds	*Saxicola torquatus*	Common Stonechat	LC
305	Birds	*Saxicoloides fulicatus*	Indian Robin	LC
306	Birds	*Sitta castanea*	Indian Nuthatch	LC
307	Birds	*Sitta frontalis*	Velvet-fronted Nuthatch	LC
308	Birds	*Spatula clypeata*	Northern Shoveler	LC
309	Birds	*Spatula querquedula*	Garganey	LC
310	Birds	*Spilopelia senegalensis*	Laughing Dove	LC
311	Birds	*Spilopelia suratensis*	Western Spotted Dove	LC
312	Birds	*Spilornis cheela*	Crested Serpent-eagle	LC
313	Birds	*Sterna acuticauda*	Black-bellied Tern	EN
314	Birds	*Sterna aurantia*	River Tern	NT
315	Birds	*Streptopelia decaocto*	Eurasian Collared-dove	LC
316	Birds	*Streptopelia orientalis*	Oriental Turtle-dove	LC
317	Birds	*Streptopelia tranquebarica*	Red Turtle-dove	LC
318	Birds	*Strix leptogrammica*	Brown Wood-owl	LC
319	Birds	*Strix ocellata*	Mottled Wood-owl	LC
320	Birds	*Sturnia malabarica*	Chestnut-tailed Starling	LC
321	Birds	*Sturnia pagodarum*	Brahminy Starling	LC
322	Birds	*Surniculus dicruroides*	Fork-tailed Drongo-cuckoo	LC
323	Birds	*Sylvia crassirostris*	Eastern Orphean Warbler	LC
324	Birds	*Synoicus chinensis*	Asian Blue Quail	LC
325	Birds	*Sypheotides indicus*	Lesser Florican	EN

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326	Birds	*Taccocua leschenaultii*	Sirkeer Malkoha	LC
327	Birds	*Tachybaptus ruficollis*	Little Grebe	LC
328	Birds	*Tephrodornis pondicerianus*	Common Wood-shrike	LC
329	Birds	*Tephrodornis virgatus*	Large Wood-shrike	LC
330	Birds	*Terpsiphone paradisi*	Indian Paradise-flycatcher	LC
331	Birds	*Threskiornis melanocephalus*	Black-headed Ibis	NT
332	Birds	*Treron bicinctus*	Orange-breasted Green-pigeon	LC
333	Birds	*Treron curvirostra*	Thick-billed Green-pigeon	LC
334	Birds	*Treron phoenicopterus*	Yellow-footed Green-pigeon	LC
335	Birds	*Tringa glareola*	Wood Sandpiper	LC
336	Birds	*Tringa nebularia*	Common Greenshank	LC
337	Birds	*Tringa ochropus*	Green Sandpiper	LC
338	Birds	*Tringa totanus*	Common Redshank	LC
339	Birds	*Turdoides striata*	Jungle Babbler	LC
340	Birds	*Turdus unicolor*	Tickell's Thrush	LC
341	Birds	*Turnix suscitator*	Barred Buttonquail	LC
342	Birds	*Turnix sylvaticus*	Common Buttonquail	LC
343	Birds	*Turnix tanki*	Yellow-legged Buttonquail	LC
344	Birds	*Tyto alba*	Common Barn-owl	LC
345	Birds	*Tyto longimembris*	Eastern Grass-owl	LC
346	Birds	*Upupa epops*	Common Hoopoe	LC

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347	Birds	*Vanellus duvaucelii*	River Lapwing	NT
348	Birds	*Vanellus indicus*	Red-wattled Lapwing	LC
349	Birds	*Vanellus malabaricus*	Yellow-wattled Lapwing	LC
350	Birds	*Zapornia akool*	Brown Crake	LC
351	Birds	*Zapornia pusilla*	Baillon's Crake	LC
352	Birds	*Zoonavena sylvatica*	White-rumped Spinetail	LC
353	Birds	*Zoothera dauma*	Scaly Thrush	LC
354	Birds	*Zoothera major*	Amami Thrush	NT
355	Birds	*Zosterops palpebrosus*	Oriental White-eye	LC
Fishes				
1	Fishes	*Amblypharyngodon microlepis*	Indian Carplet	LC
2	Fishes	*Anguilla bengalensis*	Indian Mottled Eel	NT
3	Fishes	*Arius arius*	Threadfin Sea Catfish	LC
4	Fishes	*Awaous grammepomus*	Scribbled Goby	LC
5	Fishes	*Badis badis*		LC
6	Fishes	*Bagarius yarrelli*		NT
7	Fishes	*Bangana ariza*	Ariza Labeo	LC
8	Fishes	*Brachirus pan*	Pan Sole	LC
9	Fishes	*Channa gachua*	Dwarf Snakehead	LC
10	Fishes	*Channa marulius*		LC
11	Fishes	*Cirrhinus mrigala*	Mrigal	LC
12	Fishes	*Cirrhinus reba*	Reba Carp	LC
13	Fishes	*Clarias batrachus*		LC
14	Fishes	*Eleotris fusca*	Brown Spinecheek Gudgeon	LC
15	Fishes	*Esomus danrica*	Flying barb	LC

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16	Fishes	*Exyrias puntang*	Puntang Goby	LC
17	Fishes	*Glossogobius giuris*	Bareye Goby	LC
18	Fishes	*Hippichthys heptagonus*	Reticulated Freshwater Pipefish	LC
19	Fishes	*Johnius coitor*	Big-eyed Jewfish	LC
20	Fishes	*Labeo angra*	Angra Labeo	LC
21	Fishes	*Labeo bata*	Minor Carp	LC
22	Fishes	*Labeo boggut*	Boggut labeo	LC
23	Fishes	*Leiognathus equulus*	Common Ponyfish	LC
24	Fishes	*Lepidocephalus guntea*	Peppered Loach	LC
25	Fishes	*Mastacembelus armatus*	Spiny eel	LC
26	Fishes	*Monopterus albus*	Rice swampeel	LC
27	Fishes	*Nandus nandus*		LC
28	Fishes	*Nemacheilus denisoni*		LC
29	Fishes	*Neotropius atherinoides*		LC
30	Fishes	*Notopterus notopterus*		LC
31	Fishes	*Omobranchus ferox*	Gossamer Blenny	LC
32	Fishes	*Ompok bimaculatus*		NT
33	Fishes	*Ophiocara porocephala*	Spangled Gudgeon	LC
34	Fishes	*Ophisternon bengalense*	Bengal mudeel	LC
35	Fishes	*Oreichthys cosuatis*		LC
36	Fishes	*Oryzias dancena*	Indian ricefish	LC
37	Fishes	*Osteobrama vigorsii*	Godavari Osteobrama	LC

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38	Fishes	*Parachiloglanis hodgarti*	Torrent Catfish	LC
39	Fishes	*Parambassis lala*	Highfin Glassy Perchlet	NT
40	Fishes	*Parambassis ranga*	Indian Glassy Fish	LC
41	Fishes	*Pisodonophis boro*		LC
42	Fishes	*Platycephalus indicus*	Bartail Flathead	DD
43	Fishes	*Plicofollis dussumieri*	Blacktip Sea Catfish	LC
44	Fishes	*Pomadasys argenteus*	Silver Javelin	LC
45	Fishes	*Pseudapocryptes elongatus*		LC
46	Fishes	*Puntius vittatus*		LC
47	Fishes	*Rasbora daniconius*	Slender Barb	LC
48	Fishes	*Rita chrysea*	Mahanadi rita	LC
49	Fishes	*Schistura dayi*		LC
50	Fishes	*Setipinna phasa*		LC
51	Fishes	*Silonia silondia*	Silong Catfish	LC
52	Fishes	*Sperata aor*	Long-whiskered Catfish	LC
53	Fishes	*Tenualosa ilisha*	Hilsa	LC
54	Fishes	*Wallago attu*		NT
Invertebrates				
1	Invertebrates	*Aciagrion occidentale*		LC
2	Invertebrates	*Acisoma panorpoides*	Grizzled Pintail	LC
3	Invertebrates	*Aethriamanta brevipennis*		LC
4	Invertebrates	*Agriocnemis dabreui*		LC
5	Invertebrates	*Agriocnemis lacteola*		LC
6	Invertebrates	*Agriocnemis pygmaea*	Wandering Midget	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
7	Invertebrates	*Amphiallagma parvum*		LC
8	Invertebrates	*Anax ephippiger*	Vagrant Emperor	LC
9	Invertebrates	*Anax guttatus*	Lesser Green Emperor	LC
10	Invertebrates	*Anax indicus*		LC
11	Invertebrates	*Archibasis oscillans*		LC
12	Invertebrates	*Assiminea francesiae*		LC
13	Invertebrates	*Assiminea theobaldiana*		LC
14	Invertebrates	*Assiminea woodmasoniana*		LC
15	Invertebrates	*Auriculodes gangetica*		DD
16	Invertebrates	*Bellamya bengalensis*		LC
17	Invertebrates	*Bithynia pulchella*		LC
18	Invertebrates	*Brachydiplax sobrina*		LC
19	Invertebrates	*Brachythemis contaminata*		LC
20	Invertebrates	*Bradinopyga geminata*		LC
21	Invertebrates	*Caridina babaulti*		LC
22	Invertebrates	*Ceriagrion cerinorubellum*		LC
23	Invertebrates	*Ceriagrion coromandelianum*		LC
24	Invertebrates	*Ceriagrion olivaceum*		LC
25	Invertebrates	*Cerithium coralium*	Coral Cerith	LC
26	Invertebrates	*Clenchiella microscopica*		LC
27	Invertebrates	*Clithon reticularis*		LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
28	Invertebrates	*Coeliccia didyma*		LC
29	Invertebrates	*Copera marginipes*		LC
30	Invertebrates	*Corbicula striatella*		LC
31	Invertebrates	*Cratilla lineata*		LC
32	Invertebrates	*Cratilla metallica*		LC
33	Invertebrates	*Diplacodes trivialis*		LC
34	Invertebrates	*Epophthalmia vittata*		LC
35	Invertebrates	*Ferrissia baconi*		LC
36	Invertebrates	*Ferrissia verruca*		LC
37	Invertebrates	*Gangetia miliacea*		LC
38	Invertebrates	*Globitelphusa bakeri*		DD
39	Invertebrates	*Gyraulus convexiusculus*		LC
40	Invertebrates	*Gyraulus velifer*		DD
41	Invertebrates	*Indochinamon asperatum*		DD
42	Invertebrates	*Indoplanorbis exustus*		LC
43	Invertebrates	*Indothemis limbata*		LC
44	Invertebrates	*Intha umbilicalis*		LC
45	Invertebrates	*Iravadia ornata*		LC
46	Invertebrates	*Iravadia rohdei*		LC
47	Invertebrates	*Ischnura senegalensis*	Tropical Bluetail	LC
48	Invertebrates	*Lamellidens corrianus*		LC
49	Invertebrates	*Lestes concinnus*	Dusky Spreadwing	LC
50	Invertebrates	*Lestes elatus*	Emerald Spreadwing	LC
51	Invertebrates	*Lestes nodalis*		LC
52	Invertebrates	*Lestes thoracicus*		LC
53	Invertebrates	*Lestes umbrinus*		DD

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
54	Invertebrates	*Lymnaea acuminata*		LC
55	Invertebrates	*Lymnaea luteola*		LC
56	Invertebrates	*Maydelliathelphusa falcidigitis*		DD
57	Invertebrates	*Mekongia crassa*		LC
58	Invertebrates	*Melampus sincaporensis*		LC
59	Invertebrates	*Melanoides tuberculata*		LC
60	Invertebrates	*Neosolen aquaedulcioris*		LC
61	Invertebrates	*Neritina sulculosa*		LC
62	Invertebrates	*Neritina violacea*	Red-mouth Nerite Snail	LC
63	Invertebrates	*Neurobasis chinensis*		LC
64	Invertebrates	*Onychargia atrocyana*		LC
65	Invertebrates	*Orthetrum chrysis*		LC
66	Invertebrates	*Orthetrum luzonicum*		LC
67	Invertebrates	*Orthetrum testaceum*		LC
68	Invertebrates	*Pantala flavescens*	Wandering Glider	LC
69	Invertebrates	*Parreysia caerulea*		LC
70	Invertebrates	*Parreysia corrugata*		LC
71	Invertebrates	*Parreysia favidens*		LC
72	Invertebrates	*Parreysia pachysoma*		LC
73	Invertebrates	*Parreysia shurtleffiana*		LC
74	Invertebrates	*Pila globosa*		LC
75	Invertebrates	*Pisidium prasongi*		LC
76	Invertebrates	*Polymesoda bengalensis*	Bengali Geloina	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
77	Invertebrates	*Polymesoda expansa*	Marsh Clam	LC
78	Invertebrates	*Pomacea lineata*		LC
79	Invertebrates	*Pseudagrion hypermelas*		LC
80	Invertebrates	*Pseudagrion malabaricum*		LC
81	Invertebrates	*Pseudagrion rubriceps*		LC
82	Invertebrates	*Rhinocypha biforata*		LC
83	Invertebrates	*Rhyothemis variegata*		LC
84	Invertebrates	*Sartoriana spinigera*		LC
85	Invertebrates	*Scaphula celox*		LC
86	Invertebrates	*Scaphula deltae*		LC
87	Invertebrates	*Sermyla riqueti*		LC
88	Invertebrates	*Spiralothelphusa hydrodroma*		LC
89	Invertebrates	*Stenothyra blanfordiana*		LC
90	Invertebrates	*Tarebia granifera*		LC
91	Invertebrates	*Tarebia lineata*		LC
92	Invertebrates	*Thiara rudis*		LC
93	Invertebrates	*Tholymis tillarga*	Old World Twister	LC
94	Invertebrates	*Tramea basilaris*	Keyhole Glider	LC
95	Invertebrates	*Tramea limbata*	Ferruginous Glider	LC
96	Invertebrates	*Trithemis aurora*		LC
97	Invertebrates	*Trithemis kirbyi*	Orange-winged Dropwing	LC
98	Invertebrates	*Trithemis pallidinervis*	Dancing Dropwing	LC
99	Invertebrates	*Urothemis signata*		LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
100	Invertebrates	*Zygonyx torridus*	Ringed Cascader	LC
Mammals				
1	Mammals	*Anathana ellioti*	Madras Treeshrew	LC
2	Mammals	*Antilope cervicapra*	Blackbuck	NT
3	Mammals	*Aonyx cinereus*	Asian Small-clawed Otter	VU
4	Mammals	*Axis axis*	Chital	LC
5	Mammals	*Bandicota bengalensis*	Lesser Bandicoot Rat	LC
6	Mammals	*Bandicota indica*	Greater Bandicoot Rat	LC
7	Mammals	*Boselaphus tragocamelus*	Nilgai	LC
8	Mammals	*Canis aureus*	Golden Jackal	LC
9	Mammals	*Cuon alpinus*	Dhole	EN
10	Mammals	*Cynopterus sphinx*	Greater Shortnosed Fruit Bat	LC
11	Mammals	*Elephas maximus*	Asian Elephant	EN
12	Mammals	*Felis chaus*	Jungle Cat	LC
13	Mammals	*Funambulus palmarum*	Common Palm Squirrel	LC
14	Mammals	*Funambulus pennantii*	Five-striped Palm Squirrel	LC
15	Mammals	*Golunda ellioti*	Indian Bush-rat	LC
16	Mammals	*Herpestes auropunctatus*	Small Indian Mongoose	LC
17	Mammals	*Herpestes edwardsii*	Indian Grey Mongoose	LC
18	Mammals	*Herpestes smithii*	Ruddy Mongoose	LC
19	Mammals	*Hesperoptenus tickelli*	Tickell's Bat	LC
20	Mammals	*Hipposideros fulvus*	Fulvus Leaf-nosed Bat	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
21	Mammals	*Hipposideros speoris*	Schneider’s Leaf-nosed Bat	LC
22	Mammals	*Lepus nigricollis*	Indian Hare	LC
23	Mammals	*Lutrogale perspicillata*	Smooth-coated Otter	VU
24	Mammals	*Macaca mulatta*	Rhesus Monkey	LC
25	Mammals	*Madromys blanfordi*	White-tailed Wood Rat	LC
26	Mammals	*Manis crassicaudata*	Indian Pangolin	EN
27	Mammals	*Megaderma lyra*	Greater False Vampire	LC
28	Mammals	*Mellivora capensis*	Honey Badger	LC
29	Mammals	*Melursus ursinus*	Sloth Bear	VU
30	Mammals	*Moschiola indica*	Indian Chevrotain	LC
31	Mammals	*Muntiacus vaginalis*	Northern Red Muntjac	LC
32	Mammals	*Mus booduga*	Little Indian Field Mouse	LC
33	Mammals	*Mus musculus*	House Mouse	LC
34	Mammals	*Mus terricolor*	Earth-colored Mouse	LC
35	Mammals	*Panthera pardus*	Leopard	VU
36	Mammals	*Panthera tigris*	Tiger	EN
37	Mammals	*Paradoxurus hermaphroditus*	Common Palm Civet	LC
38	Mammals	*Pipistrellus ceylonicus*	Kelaart's Pipistrelle	LC
39	Mammals	*Pipistrellus coromandra*	Coromandel Pipistrelle	LC
40	Mammals	*Pipistrellus tenuis*	Least Pipistrelle	LC
41	Mammals	*Prionailurus bengalensis*	Leopard Cat	LC
42	Mammals	*Prionailurus rubiginosus*	Rusty-spotted Cat	NT
43	Mammals	*Pteropus giganteus*	Indian Flying Fox	LC
44	Mammals	*Rattus rattus*	House Rat	LC

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
45	Mammals	*Ratufa indica*	Indian Giant Squirrel	LC
46	Mammals	*Rhinolophus lepidus*	Blyth's Horseshoe Bat	LC
47	Mammals	*Rhinolophus rouxii*	Rufous Horseshoe Bat	LC
48	Mammals	*Rhinopoma hardwickii*	Lesser Mouse-tailed Bat	LC
49	Mammals	*Rousettus leschenaultii*	Leschenault's Rousette	LC
50	Mammals	*Rusa unicolor*	Sambar	VU
51	Mammals	*Scotophilus heathii*	Greater Asiatic Yellow House Bat	LC
52	Mammals	*Scotophilus kuhlii*	Lesser Asiatic Yellow House Bat	LC
53	Mammals	*Scotozous dormeri*	Dormer's Pipistrelle	LC
54	Mammals	*Semnopithecus entellus*	Northern Plains Gray Langur	LC
55	Mammals	*Suncus murinus*	House Shrew	LC
56	Mammals	*Sus scrofa*	Wild Boar	LC
57	Mammals	*Taphozous longimanus*	Long-winged Tomb Bat	LC
58	Mammals	*Taphozous melanopogon*	Black-bearded Tomb Bat	LC
59	Mammals	*Tatera indica*	Indian Gerbil	LC
60	Mammals	*Tetracerus quadricornis*	Four-horned Antelope	VU
Reptiles				
1	Plants	*Anacyclus pyrethrum*	Atlas Daisy	VU
2	Plants	*Isachne globosa*	Swamp Millet	LC
3	Plants	*Medicago sativa*	Alfalfa	LC
4	Plants	*Prunus bifrons*		DD

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
1	Reptiles	*Atretium schistosum*	Olive Keelback Water Snake	LC
2	Reptiles	*Boiga forsteni*	Reddish Peninsular Cat Snake	LC
3	Reptiles	*Bungarus fasciatus*	Banded Krait	LC
4	Reptiles	*Calodactylodes aureus*	Indian Golden Gecko	LC
5	Reptiles	*Chamaeleo zeylanicus*	Asian Chameleon	LC
6	Reptiles	*Chitra indica*	Indian Narrow-headed Softshell Turtle	EN
7	Reptiles	*Crocodylus palustris*	Mugger	VU
8	Reptiles	*Crocodylus porosus*	Salt-water Crocodile	LR/lc
9	Reptiles	*Cyrtodactylus nebulosus*	Clouded Indian Gecko	LC
10	Reptiles	*Eublepharis hardwickii*	Eastern Indian Leopard Gecko	LC
11	Reptiles	*Eutropis allapallensis*	Schmidt's Mabuya	LC
12	Reptiles	*Eutropis carinata*	Keeled Indian Mabuya	LC
13	Reptiles	*Eutropis trivittata*	Three-banded Mabuya	LC
14	Reptiles	*Gavialis gangeticus*	Gharial	CR
15	Reptiles	*Hemidactylus frenatus*	Common House Gecko	LC
16	Reptiles	*Lissemys punctata*	Indian Flapshell Turtle	LR/lc
17	Reptiles	*Lycodon jara*	Yellow-speckled Wolfsnake	LC
18	Reptiles	*Lycodon travancoricus*	Travancore Wolf Snake	LC
19	Reptiles	*Nilssonia gangetica*	Indian Softshell Turtle	VU

S. No.	Taxonomic group	Species	Common name	IUCN Red List Category
20	Reptiles	*Nilssonia hurum*	Indian Peacock Softshell Turtle	VU
21	Reptiles	*Oligodon taeniolatus*	Streaked Kukri Snake	LC
22	Reptiles	*Ophiophagus hannah*	King Cobra	VU
23	Reptiles	*Pangshura tecta*	Indian Roofed Turtle	LR/lc
24	Reptiles	*Pangshura tentoria*	Indian Tent Turtle	LR/lc
25	Reptiles	*Psammophilus blanfordanus*	Blanford's Rock Agama	LC
26	Reptiles	*Psammophis condanarus*	Indo-chinese Sand Snake	LC
27	Reptiles	*Pseudocerastes persicus*	Perisan Horned Viper	LC
28	Reptiles	*Sitana ponticeriana*	Fan Throated Lizard	LC
29	Reptiles	*Trimeresurus gramineus*	Common Bamboo Viper	LC
30	Reptiles	*Varanus bengalensis*	Common Indian Monitor	LC
31	Reptiles	*Varanus salvator*	Common Water Monitor	LC

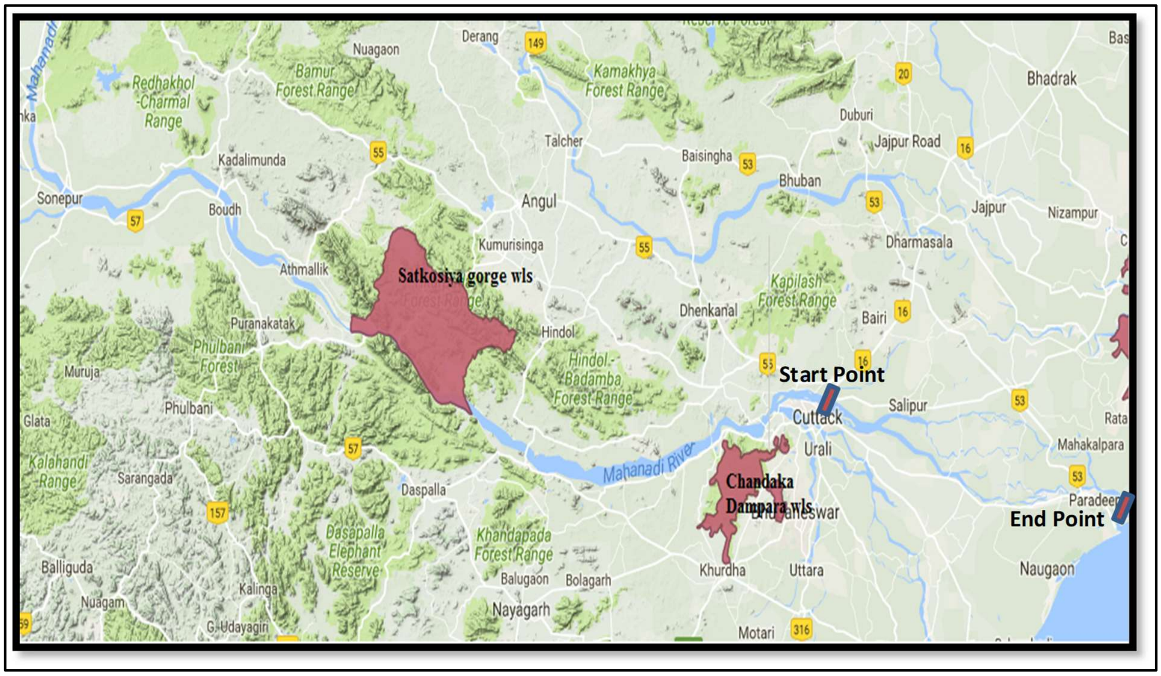
Source: i-bat alliance

9.14. National Parks, Forests, Wildlife Sanctuaries and Reserves

The project river stretch under study is not crossing any national park wildlife sanctuaries and conservation reserves as per data collected from secondary sources. The same will be verified during joint inspection with forest and wildlife department.

Chandaka Dampara Wildlife Sanctuary and Nandankanan Zoological Park is about 10.0 km in the South from the starting point (Jobra barrage) of project river stretch. Project river stretch in respect to eco-logically sensitive areas is presented in Figure 9.10.

Figure 9.10: Project River Stretch in respect to Ecologically Sensitive Areas



During survey a lot of island formations were observed along the river stretches, mainly of sand. Mahanadi rive is flowing from North West to South East and crosses various settlements along the project waterways.

Chandaka-Dampara Wildlife Sanctuary was declared primarily to preserve wild elephants and elephant habitat. Indian elephant is the flagship species and indicative of the potential productivity of the habitat. Leopard is in the apex of biological pyramid. Chital, barking deer, mouse deer, wild pig, common langur, rhesus monkey, small Indian civet, common Indian mongoose, small Indian mongoose, ruddy mongoose, pangolin, sloth bear, ratel, Indian wolf and hyena are other mammals of the area. Chital or spotted deer’s are commonly encountered in groups of 3-7 on forest roads, forest openings, grass lands, foreshore of water bodies and even near guard camps. Wild dogs are occasionally seen.

Prominent birds of the sanctuary are peafowl, red junglefowl, crested serpent eagle, great horned owl, black headed oriole, paradise flycatcher, coucal and stone curlew. Kumarkhunti reservoir, during winter, serve as transient roosting and feeding ground for several migratory duck species, notably, garganey and common teal, pintail, spot billed and Brahminy duck and white eyed pochard. Lesser whistling teal, dabchick, cotton teal, nakfa, lesser cormorant, bronze winged jacana, white breasted waterhen, pied, white breasted and little blue kingfishers and red wattle lapwings are other resident birds around. In July the reservoir transforms into an abode of migratory birds, mainly, open billed storks, pond heron, egrets and cormorants. Butterflies are abundant during monsoon and post monsoon months.

Forest maps of all three district are attached as **Enclosure II**.

9.15. Socio-economic Profile

Orissa is the tenth largest state in area and eleventh in population in the country, accounting for 5% of the geographical area and 4% of the population of the country. Cultivators and Agricultural labors constitute 65% of the total workforce. Agriculture provides direct or indirect employment to 65% of the total work force and contributes 26% of the net state domestic product.

9.15.1. Agriculture

The state has a cultivated area of 62 lakh hectares out of which 27 lakh hectares is high land, 19 lakh hectares medium and 16 lakh hectares low land. The paddy area during kharif is about 42 lakh & during Rabi 2.5 lakh hectares.

Kharif is the main cropping season and rice is the principal crop during kharif season. Cropping during Rabi season is mainly confined to irrigated areas and areas with residual moisture. Other important crops produced in the state are pulses (Arhar, Mung, Biri, Kulthi), Oil seeds (Groundnut, Til, Mustard and Niger), Fibers (Jute, Mesta, Cotton), Sugarcane, Vegetables and Spices, Mango, Banana, Coconut & Cashew Nut are the main Horticultural crops of the state.

Due to frequent occurrence of these natural calamities there is always reduction in kharif rice production. Similarly, in drought years there is considerable loss in production of pulses and oilseed crops during Rabi season and kharif season. Another problem in the state is operational household along with poverty line. The average size of the holding is only 1-3 hectares out of cultivable area of 65-99 lakh hectares, about 41% is under irrigated conditions. The total irrigation potential created so far from all sources is about 39.31 lakh hectares (kharif 26.65 lakh and rabi 12.66 lakh hectares). The gross irrigated cropped area is 27 lakh hectares.

Total geographical area of the state is 155.71 lakh hectares out of which 58.13 lakh hectares is forest area, 4.82 lakh hectares of miscellaneous tree & groves, 4.43 lakh hectares of permanent pasture, 3.92 lakh hectares culturable waste land and 8.43 lakh hectares barren & unculturable land. The State has a cultivated area of 62 lakh hectares out of which 27 lakh hectares is high land, 19 lakh hectares medium and 16 lakh hectares low land.

9.15.2. Settlements along the Project River basin

There are about 57 settlements varying in size and populations project along the project river stretch. The details of settlements are given in the following table.

Table 9-7: Settlements along Project Road

S.No.	Village Name	District
1	Besrapur	Cuttack
2	Murkundie	Cuttack
3	Raghavpur	Cuttack
4	Goayamera	Cuttack
5	Balesahie	Cuttack
6	Balarampur	Cuttack
7	Maraha	Cuttack
8	Gopenathpur	Cuttack
9	Kendupratna	Cuttack
10	Sadhakanagar	Cuttack
11	Jamunapur	Cuttack
12	Demando	Cuttack
13	Baleaprada	Cuttack
14	Asurespar	Cuttack
15	Ravanagar	Cuttack
16	Aturmul	Kendrapara
17	Danpur	Kendrapara
18	Praneaulla	Kendrapara

S.No.	Village Name	District
19	Sathelau	Kendrapara
20	Mundalau	Kendrapara
21	Baleharie	Kendrapara
22	Desheprrie	Kendrapara
23	Harasahie	Kendrapara
24	Bandhasahie	Kendrapara
25	Sansalara	Kendrapara
26	Jalapoka	Kendrapara
27	Buspara	Kendrapara
28	Kare	Kendrapara
29	Talagan	Kendrapara
30	Aagarventh	Kendrapara
31	Dalanta	Kendrapara
32	Jamprar	Kendrapara
33	Karandeya Prarna	Kendrapara
34	Badhre	Kendrapara
35	Manetere	Kendrapara
36	Godhar	Kendrapara
37	Batunga	Kendrapara
38	GarjangaPralallie	Kendrapara
39	Narayanpur	Kendrapara
40	Kurpal	Kendrapara
41	Badpral	Kendrapara
42	Balekuda	Kendrapara
43	Yaetepur	Kendrapara
44	Gopenathpur	Kendrapara

S.No.	Village Name	District
45	Badkul	Kendrapara
46	Benupral	Kendrapara
47	Gopalpur	Kendrapara
48	Tenrajan	Kendrapara
49	Bolapara	Kendrapara
50	Goja Bandha	Kendrapara
51	Gokha Khatie	Kendrapara
52	Sreerampur	Kendrapara
53	Garrometa	Kendrapara
54	Hamrajpur	Kendrapara
55	Baledeya	Kendrapara
56	Nungarh	Kendrapara
57	Agyanasie	Kendrapara

Source: Google earth

9.15.3. Social Profile

Project river stretch under study is the part of three districts namely, Kendrapara, Cuttack and Jagatsinghpur. Social profile of the project districts in respect to State statics are presented in Table below.

Table 9-8: Social Profile of the Project Area

Parameter	Kendrapara	Cuttack	Jagatsinghpur	Odisha State
Total Population as per 2011 Census	1440361	2624470	1136971	41974218
Total Male	717814	1352760	577865	21212136
Total Female	722547	1271710	559106	20762082
Sex Ratio (Females per 1000 Males)	1007	940	968	979

Population SC	309780 (21.5%)	498633 (19.0)	248152 (21.8)	7188463 (17.1%)
Population ST	9484 (0.7)	93745 (3.6)	7862 (0.7)	9590756 (22.8%)
Literacy Rate (%)	1089265 (85.2%)	2011469 (85.5)	889027 (86.6)	26742595 (72.9%)
Male Literacy Rate (%)	579970 (91.5)	1103033 (91.1)	481049 (92.4)	15089681 (81.6)
Female Literacy Rate (%)	509295 (79.0%)	908436 (79.6)	407978 (80.6)	11652914 (64.0%)
Total Workers	466890 (32.4%)	936365 (35.7)	403649 (35.5)	17541589 (41.8%)

Source: Census of India 2011

Livelihood of the project region is mostly dependent on agricultural activities. The work participation rate of the project districts ranges from 32.4% to 35.7% in respect to the State Work Participation Rate of 41.8%. Therefore, proposed development of waterways in the region is likely to increase the economy of the region by generation of employment in associated business facilities.

The project region presents good statistics in terms of literacy with rate varies from 85.2% to 86.6% against the state literacy rate of 72.9%.

9.16. Potential Environmental and Social Impacts of the Project

Proposed project is likely to change the prevailing environment condition of the project region. Considering some of the adverse impacts associated with project, these impacts have to be mitigated and mitigation measures need to be incorporated in the engineering design. Environmental mitigation measures represent the project's endeavour to reduce its environmental footprint to the minimum possible. These are conscious efforts from the project to reduce undesirable environmental impacts of the proposed activities and offset these to the degree practicable. Enhancement measures are project's efforts to gain acceptability in its area of influence. They reflect the pro-active approach of the project towards environmental management.

9.16.1. Impacts on Climate

Waterway is considered to be more environments friendly compared to other conventional source transport namely road or rail transport modes. However, slight change in the micro-climate of the area is expected due to Heat Island Effect near paved areas as likely to develop for loading and unloading point. However, Impact on the climate conditions from the proposed project will not be significant in long run as deforestation and / or removal of vegetation will be compensated by compensatory plantation to the tune of double the area denuded.

9.16.2. Impact on Air Quality

There will be rise in PM levels during the construction activities of loading-unloading point and strengthening of approach road, which shall again be within prescribed limit once the construction activities are over.

Dredging does not significantly affect the air quality, but operation of dredgers involves generation of emissions which may have effect on the air quality. However, the impact anticipated are localized and short term as it will be confined for the duration for which dredger will be operated and to the area where the dredger will be operated.

Barges also generate emissions, but this is far less as compared to road and rail for transportation of same quantity of cargo for the same distance. Thus, impacts on air quality are anticipated to be positive. As per analysis there is reduction in emission generation of all the pollutants.

9.16.3. Impact on Noise Levels

Impact on noise quality due to barge movement will be negligible and will be lesser when compared to road and railways generated noise for transportation of similar quantity of material. Intermittent noise of high level may be generated only when hooters are used as warning during navigation. No hooters sign shall be deployed near sensitive areas.

Dredging will be carried out within the navigation channel only, therefore, impacts of the dredging noise on the nearby settlements are likely to be insignificant. Noise generating activities should be carried out in daytime only.

9.16.4. Impact on Water Resources and Quality

Impact of river water quality is expected due to dredging and barging activities. Impacts of dredging on water quality are increase in turbidity; reduced light transmittance; reduced DO; changes in salinity, temperature, pH & concentration of nutrients and release of heavy metals/chemicals. Turbidity of water also increases substantially close to dredging point, but it reduces with distance and almost gets normal at a short distance from dredging point. Coarser sediments settle much faster and at shorter distance.

Dredging quantity may be reduced by effective study of river profiles. Sediment loss can be minimized by wise selection of dredger depending on strata and depth and use of Cutter Section Dredgers (CSDs).

Vessels generate garbage, oily waste, sewage, bilge water & ballast water which can affect the water quality of the river. Usage of anti-fouling paints may also impact the water quality as the paints may contain toxins. Settling of the dust of the material transported on river surface again can impact the river water quality. Ship accidents/collision may lead to spillage of the commodities transported including oil which may impact the water quality of the river.

Management of wastewater, oily waste, bilge water, noxious waste (if any), air emissions and garbage from vessels as per MARPOL can prevent the water quality pollution. All maintenance & repair works should be carried out at designated locations only. Only toxin-free paints should be used for anti-fouling purpose. Experienced crew should be hired to minimize the possibility of accidents.

9.16.5. Impact on Ecological Resources

Chandaka Dampara Wildlife Sanctuary and Nandankanan Zoological Park is about 10.0 km in the South from the starting point (Jobra barrage) of project river stretch. Indian elephant is the flagship species and indicative of the potential productivity of the habitat. Leopard is in the apex of biological pyramid. Chital, barking deer, mouse deer, wild pig, common langur, rhesus monkey, small Indian civet, common Indian mongoose, small Indian mongoose, ruddy mongoose, pangolin, sloth bear, ratel, Indian wolf and hyena are other mammals of the area. Chital or spotted deer are commonly encountered in groups of 3-7 on forest roads, forest openings, grass lands, foreshore of water bodies and even near guard camps. Wild dogs are occasionally seen.

9.16.5.1. Aquatic Ecology

The aquatic floral and faunal diversity comprises of Amphibians, Fish, phytoplankton, zooplankton, zoo-benthos including macro-invertebrates and higher vertebrates. Impacts due to maintenance dredging are impact on behavioral response & tissue injury of aquatic organism due to increased noise levels, blocking of fish gills due to increased sediments, intake of toxic pollutants by aquatic fauna as released during dredging.

Fishes and other aquatic mammals are subjected to threat of collision by vessel speeds causing injury and death. Smooth Coated Otter and Crocodile are rarely sighted species and prefers to rest on wetlands of riverbanks, noise impacts are anticipated negligible due to its fast attenuation.

Materials like coal, oil, building construction material, textiles, fertilizers etc. are proposed to be transported through the waterway. In case of accidents these materials can spill in the River and may pollute the water quality and may have significant impact on aquatic ecology.

9.16.5.2. Terrestrial Ecology

No major forest area is observed along the proposed waterways stretch. The riparian flora consists of commonly found trees, shrub and herb species. In absence of any dense forest alongside proposed waterway, no significant terrestrial fauna has been observed during field study. However, forest dept. record and I Bat Tool reflect the presence of Asian Elephant, Black Buck, Sloth Bear and Tiger in nearby forest areas. Study area has good biodiversity in terms of avi-fauna. Some of those species are near threatened or endangered like Eagle, Vulture, etc.

Dredging activities shall have very limited impact on avi-fauna and terrestrial ecology as dredging shall be confined within the impact zone (may be of 500 m or less) and duration of dredging only.

Development of the civil interventions may require clearing of the vegetation from the proposed site. However, most of civil intervention impact shall be limited in proposed terminal areas.

Positive impact on ecology is also anticipated due to development of peripheral green belt and avenue plantation. Green belt will provide excellent habitat to avifauna, insects, small animals like squirrels, lizards, chameleons etc. Tree survival rate will be monitored and will be maintained to minimum 75%. Proper after care will be done for the planned green belt and this has separate budgetary provision under the EMP.

9.16.6. Impact on Land

Land use along the proposed waterway is majorly agriculture land followed by settlement and some vegetation areas.

Impact due to maintenance dredging on land environment is anticipated only due to dredge disposal. Impact in terms of land and soil contamination is expected if the dredged material was found contaminated by pollution load of nearby areas.

Waste generated from barges if disposed of at the terminal facilities or nearby areas may also impact the soil quality. Thus, control measures should be taken to prevent any unauthorized waste/sewage dumping so as impact can be avoided.

Solid waste to be generated during the operation phase includes waste generated at terminal sites and waste generated in vessels which is to be received at terminal sites till the time vessel maintenance and repair facility is developed. The waste may include food waste, plastic, metal tins, papers, dredged sediments, STP sludge, e-waste and used oil from DG sets at terminal site and. These impacts could be significant and may persist for long periods if left unaddressed and unless mitigated. Hence, appropriate mitigation measures are warranted to minimize the impacts.

9.17. Environment Management and Monitoring Plan

The Environmental Management Action Plan is required to ensure sustainable implementation and operation of proposed waterway. Management plan has been drawn based onsite visit findings and assessment of project impact based on past experience. However, a detailed Environment Management shall be formulated during EIA Stage of the project.

9.17.1. Environment & Social Management Plan

Mitigation measures have been planned for identified adverse impacts. The project impacts and management plan suggested thereof are summarized in table below.

Table 9-9: Probable Impact and Mitigation Measures

Particulars	Stages	Potential Impacts	Mitigation Measures
Physiographic Environment			
Topography	Pre-construction & Construction	• Slight changes are expected due to proposed project • Impacts are marginal, but permanent	• Proper planning to keep the land reformation up to bare minimum
Land & Soil			
Contamination	Construction & Operation	• Disposal of dredged material • Disposal of barges waste	• Scientifically demarcated areas for disposal of contaminated waste
Induced Development	Preconstruction & Construction	• Insignificant change in the land use pattern	• Civil authorities to plan and guide any induced development using the prevailing regulatory framework
Water			
Impact on Water Resource	Design, Preconstruction, Construction & Operation	• Increase in turbidity; reduced light transmittance; reduced DO during dredging • Dumping or leakage of vessels generate garbage, oily waste, sewage, bilge water & ballast water • Usage of anti-fouling paints as the paints may contain toxins. • Ship accidents/collision may lead to spillage of the commodities transported including oil which may impact the	• Effective study of river profiles to reduce dredging quantity. • Wise selection of dredger depending on strata and depth and use of Cutter Section Dredgers (CSDs) • Management of wastewater, oily waste, bilge water, noxious waste (if any), air emissions and garbage from vessels as per MARPOL • All maintenance & repair works should be carried out at designated locations only.

Particulars	Stages	Potential Impacts	Mitigation Measures
		water quality of the river.	• Only toxin-free paints should be used for anti-fouling purpose. • Experienced crew should be hired to minimize the possibility of accidents.
Climate			
Temperature / Rainfall / Humidity	Preconstruction & Construction	• Heat Island Effect near paved areas • Slightly heat increases due to movement of ship and Cargo • Tree felling will have an impact of micro-climate of the area	• Compensatory afforestation of the trees to be cut as per Forest Dept. guidelines • With the proposed avenue plantation scheme, the microclimate of the project corridor will be smoothening
Air			
Dust generation	Preconstruction& Construction	• Removal of trees & vegetation, • Transportation of construction material	• Regular Sprinkling of Water • Fine materials to be completely covered, during transport and stocking. • Regular monitoring of particulate matter in Ambient Air
Gaseous pollutants	Preconstruction, Construction & Operation	• Vehicle operation for material transportation • Emission from dredgers • Barges emission	• Air pollution Norms will be enforced. • Only PUC certified vehicles and machineries shall be deployed • Labourers will be provided with mask. • Regular gaseous pollution monitoring in ambient air
Noise			

Particulars	Stages	Potential Impacts	Mitigation Measures
Dredging Activity	Construction	• Noise generation due to dredging activities	• Dredging activities should be limited for daytime near to settlement areas • Dredging should be limited for navigation channel only
Barges Operation	Operation	• Noise due movement of barges	• No hooters sign near sensitive and residential areas
Ecology			
Flora	Preconstruction, Construction	• Loss of vegetation cover • Felling of trees	• Felling of only unavoidable trees • Compensatory Afforestation as per Forest Dept. guidelines
Fauna	Preconstruction, Construction & Operation	• Impact on behavioural response & tissue injury of aquatic organism due to increased noise levels, • Blocking of fish gills due to increased sediments, • Fishes and other aquatic mammals' collision by vessel speeds causing injury and death. • Accidental spillage of materials like coal, oil, building construction material, textiles, fertilizers etc.	• Use of CSDs and proper planning of dredging activities should be carried out • Maintenance of speed to avoid any collision • Regular maintenance of barges
Social			
Socio Environment	Design, Preconstruction & Construction	• Disturbance due to noise generating activities	• Noise generating activities near to settlement areas shall

Particulars	Stages	Potential Impacts	Mitigation Measures
			be limited during daytime only • No hooter sign during operation phase

9.17.2. Implementation of EMP

The Environmental Officer of the Contractor should be available for the entire construction period of the project. The Environmental Officer shall be primarily responsible for compliance of EMP. The Environmental Specialist of the Monitoring Consultant who should ideally be deployed for the entire duration shall monitor the compliance of the EMP. However, prime responsibility of implementation lies with IWAI.

9.18. Applicable Legal and Regulatory Framework

The Government of India has formulated various policy guidelines; acts and regulations aimed at protection and enhancement of environmental resources. The following table surmises the existing legislations pertaining to the project, the various clearances required for the project and the status as on date. The summary of environment laws and their applicability is given in Table below

Table 9-10: Applicability Analysis of Indian Environment Regulatory Framework

S. No.	Law / Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
1	The Environmental (Protection) Act. 1986, and the Environmental (Protection) Rules, 1987-2002 (various amendments)	Umbrella Act. Protection and improvement of the environment. Establishes the standards for emission of noise in the atmosphere.	Yes	All environmental notifications, rules and schedules are issued under the act	MoEF&CC, State Dept. of Environment & Forest, CPCB and SPCB

S. No.	Law / Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
2	The EIA Notification, 14th September 2006 & subsequent amendments	Considered Not Applicable (EIA Notification 2006 does not classify terminals on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation should be reconfirmed from the concerned authority).	No	Considered Not Applicable (EIA Notification 2006 does not classify terminals on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation should be reconfirmed from the concerned authority).	MoEF&CC & SEIAA
3	The Water (Prevention and Control of Pollution) Act, 1974	Central and State Pollution Control Board to establish / enforce water quality and effluent standards, monitor water quality, prosecute offenders, and issue licenses for construction / operation of certain facilities.	Yes	Consent required for not polluting ground and surface water during construction and operation	State Pollution Control Board
4	The Air (Prevention and	Empowers OSPCB to set	Yes	Consent required for not	State Pollution Control Board

S. No.	Law / Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
	Control of Pollution) Act. 1981	and monitor air quality standards and to prosecute offenders, excluding vehicular air and noise emission.		polluting ground and surface water during construction and operation	
5	Noise Pollution (Regulation and Control) Act, 1990, 2010 and its subsequent amendments.	Standards for noise emission for various land uses	Yes	Construction including dredging and barge movement to conform to the prescribed standards	State Pollution Control Board
6	Forest (Conservation) Act, 1980 its subsequent amendments.	Conservation and diversion of forest areas. Diversion of forest land follows the process as laid by the Forest conservation Act.	Yes	If Need for Diversion of forest land is envisaged	State Forest Department, MoEF& CC
7	Coastal Regulatory Zone Notification, 2011 its subsequent amendments.	Protect and manage coastal areas	Yes	CRZ Clearance would be required.	MoEF& CC, State Department of Environment
8	Wildlife Protection Act, 1972 its subsequent amendments.	Protection of wildlife in sanctuaries and National Park	No	Chandaka Dampara Wildlife Sanctuary and Nandankanan	NBWL, SBWL & Chief Wildlife Warden

S. No.	Law / Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
				Zoological Park eco-sensitive Zone is found outside 10km radius from the project site.	
9	Ancient Monuments and Archaeological sites & remain Act 1958 its subsequent amendments.	To protect and conserve cultural and historical remains found.	No	No archaeological monuments found within the project vicinity	Archaeological Survey of India, State Dept. of Archaeology
10	The Motor Vehicle Act. 1988 its subsequent amendments.	Empowers State Transport Authority to enforce standards for vehicular pollution. From August 1997 the "Pollution Under Control Certificate is issued to reduce vehicular emissions	Yes	All vehicles used for construction will need to comply with the provisions of this act.	State Motor Vehicles Department
11	Public Liability and Insurance Act,1991	Protection to the general public from accidents due to hazardous materials	Yes	Hazardous materials like Bitumen shall be used for road construction	Ministry of Law and Justice
12	Hazardous and Other Wastes (Management, &	Protection to the general public against improper	Yes	Hazardous wastes shall be generated due to	State Pollution Control Board

S. No.	Law / Regulation / Guidelines	Relevance	Applicability (Yes / No)	Reason for Application	Implementing / Responsible Agency
	Transboundary Movement) Rules, 2016 and its subsequent amendments'	handling and disposal of hazardous wastes		activities like of maintenance and repair work on vehicles	
13	Construction and Demolition Waste Management Rules, 2016 and Solid Waste Management Rules 2016	Safe disposal of construction waste and municipal solid waste	Yes	Construction waste shall be generated due to the demolition of existing structures and municipal waste shall be generated from the construction worker camp	State pollution Control Board
14	Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996	Protection against chemical accident while handling any hazardous chemicals resulting	Yes	Handling of hazardous (flammable, toxic and explosive) chemicals during road construction	District & Local Crisis Group headed by the DM and SDM
15	The Building & Other Construction Workers (Regulation of Employment & Conditions of Service) BOCW Act, 1996	Employing Labour / workers	Yes	Employment of labours	District labour Commissioner

9.19. Need for Environmental Clearance

Considered Not Applicable (EIA Notification 2006 does not classify terminals on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation should be reconfirmed from the concerned authority).

9.20. Other Major Clearances / Approvals / Permits Applicable to the Project

- CRZ Clearance required,
- Tree felling permission. if tree cutting is any

9.21. Cost Implications

As per the scope of services for further environmental and social impact assessment (EIA & SIA) studies and requirement of obtaining all mandatory statutory clearances for the project approximately 1 to 1.5 year is adequate period for consultancy services (1 year for non-CRZ and 1.5 year for CRZ waterways) related to EIA & SIA studies. In this regard, the project authority may engage to QCI/NABET accredited EIA consultant for Category – A projects, who shall conduct rapid EIA & SIA studies and shall prepare a stand-alone EMMP (EMP & EMoP) for inclusion in the contractor bid documents. The generation of environmental baseline data at pre-construction stage along with environmental monitoring during construction and operation stages shall be carried out by the NABL/MoEF&CC approved laboratory to assess the project performance during entire project cycle.

9.21.1. Estimated Cost at Pre-Construction Stage

As, the statutory fee shall be paid by the project authority for obtaining all mandatory statutory clearances. The estimated environmental and social budget for EIA-EMP & SIA studies have been summarized below:

Table 9-11: Summarized estimated cost for Consultancy Services

Item No.	Component	Description	Unit	Quantity	Unit cost (INR)	Total cost (INR)	
						Detail Cost	Cost in Crores
1	**Environment Study Cost**						
1.1	*Detailed EIA	Detailed Environment Impact assessment study for Multilateral funding or MoEF & CC as the case may be	Nos.	1	20,00,000.00	20,00,000.00	0.200
1.2	*Wildlife Clearance / NOC	Requirement of Wildlife NOC / Clearance	Nos.	1	15,00,000.00	15,00,000.00	0.150

Item No.	Component	Description	Unit	Quantity	Unit cost (INR)	Total cost (INR)	
						Detail Cost	Cost in Crores
	Consultancy						
1.3	*Tree Felling Permission and Forest Clearance for revenue forest (If any)	Advisory services	Nos.	1	10,00,000.00	10,00,000.00	0.100
2	**MONITORING COST**						
2.1	Air	Sampling and monitoring ambient Air Quality and gaseous pollutants as per CPCB Standard Procedures at 2 locations on once in a month basis for 2 years	No. of Samples	48	10,000.00	4,80,000.00	0.048
2.2	Water Quality	Collection of grab samples of water quality at 2 locations 5 years (twice a year) in pre-& post monsoon seasons	No. of Samples	20	10,000.00	2,00,000.00	0.020
2.3	Noise	Monitoring Noise level near jetties at 2 locations on six monthly bases for 2 years	Nos.	8	5,000.00	40,000.00	0.004
2.4	Soil	Collection of grab samples of water quality at 2 locations 5 years (twice a year) in pre-& post monsoon seasons	No. of Samples	20	5,000.00	1,00,00.00	0.010
TOTAL COST						**53,20,000.00**	**0.532**
Contingency @ 5% on Total Environmental Cost						**2,66,000.10**	**0.026**
GRAND TOTAL						**55,86,000.00**	**0.558**

❖ *- based on past experience and may vary at the time of commencement based on Consulting Scope and Quality

10. INSTITUTIONAL REQUIREMENTS

10.1. Organizational Set up / Establishment

The organizational set is aimed at enabling effective implementation of decisions and proper monitoring of progress with correction of shortfalls and clearing bottlenecks. Facilitating co-ordination and co-operation between the various stake holders for easy interfacing of the institution is ensures by the organizational set up. Operations of the inland waterway terminals and transportation will be managed by following three departments:

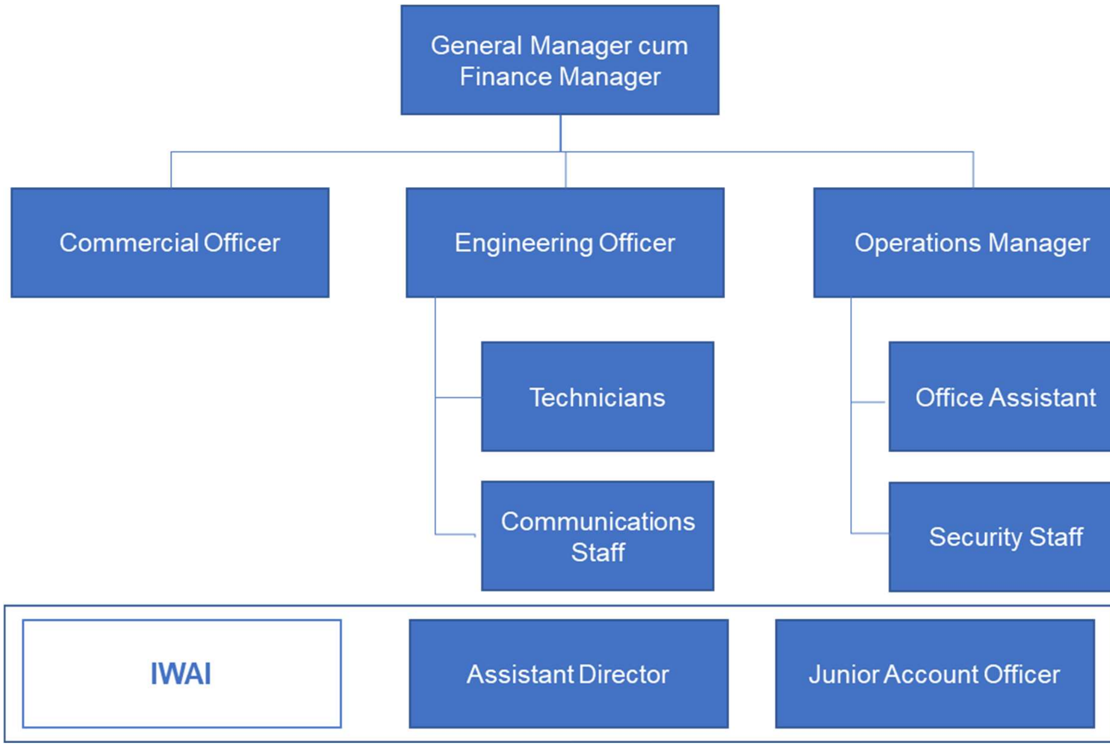
- Administration/Finance
- Operations
- Engineering/Maintenance

Due to the smaller size of project, Feedback has refrained from an extensive organization setup. However, we have endeavored to account for adequate support staff for the smooth operations of the project. It has been found that Govt. of India promulgated direction under section 111 of the Major Port Trusts Act 1963 to the selected Major Port Trusts for allocations of National Waterways (NWs) for undertaking the development of the National Waterways through release of grants by the IWAI. The Major Port Trusts are to be the implementing agency for development of the National Waterways. As per the above directions of Govt. of India, the River Mahanadi – luna (NW-64) has been allocated to the Paradip Port Trusts for development.

Since, the River Mahanadi – Luna (NW-64) has been allocated to Paradip Port Trust for development, the IWAI's manpower requirement for maintenance under the present scenario shall be an Officer at the level of Assistant Director (T.) and Junior Account Officer may be posted at Head Quarter, Noida and Bhubaneswar to monitor the various development and operations works undertaken by the Paradip Port Trusts for development of various National Waterways allocated and also monitoring the utilization of fund.

Proposed organizational set up for the waterway operation is shown in the following Figure10.1. The hierarchical designations that can be used may be drawn from the IWAI / Paradip Port Trust organization structure and worked out accordingly.

Figure 10.1: Organizational chart



10.2. Manpower Requirement

Major assumptions made in the calculation of the of the manpower are:

- The terminal operates only in the daytime and ~180 days per annum with 8hrs working time per day.
- Only one terminalis proposed along the waterway – at Cuttack.
- Vessels are operated by private parties.

The organizational set up would be headed by a general manager and his responsibility is to perform regular administration and management activities of the organization. General manger would be supported by three departments and the manpower proposed for each department is given in Tables 10.1, 10.2 and 10.3 below:

Table 10-1: Manpower Requirement for Administration/Finance Department

Employee	Responsibilities	Nos.
Commercial Manager	Undertake negotiations with Customers & Large industrial Clients Review, Do negotiations, Prepare Contracts, Review and extension of contracts, investigate ways to improve profitability and analyze markets for business opportunities, such as expansion, mergers or acquisitions	1
Accountant	Prepare asset, liability and capital account entries by compiling and analyzing account information - Summarize current financial status by collecting information, preparing balance sheet, profit and loss statement, and other reports	1
Office Assistant cum Typist	Maintain spreadsheets and databases - Maintain filing; Recordkeeping - Staff support	2

Table 10-2: Manpower Requirement for Operations Department

Employee	Responsibilities	Nos.
Operation Manager	Makes sure an organization is running as well as it possibly can, with a smooth efficient service that meets the expectations and needs of customers and clients. Schedule work hours and shifts, provide reports and activity updates to management, supervising the functioning of communication systems. oversees activities at a terminal - maintenance of safety and security within the terminal, taking care of the functioning of the DGPS station and other communication systems.	1
Security officer	Responsible for the passengers and terminal premise	3

Table 10-3: Manpower Requirement for Engineering/Maintenance Department

Employee	Responsibilities	Nos.

Engineering/Maintenance Manager	Develop maintenance procedures and ensure implementation - carry out inspections of the facilities to identify and resolve issues. Ensures and monitors the proper functioning of communication systems	1
Electrician	Inspect electrical components and Identify problems - repair or replace wiring, equipment, or fixtures	1
Mechanic	Inspect machines, engines etc. and run diagnostic tests to discover functionality issues - conduct repairs aiming for maximum reliability	1
Communication Engineer (refer to Chapter 8)	To oversee operations of RIS system and communication equipment installed at Cuttack and other Base stations	1
Communication Operators (refer to Chapter 8)	Operate RIS Systems, maintain effective communication for safe and efficient waterway operations	9

10.3. Training Requirement / Capacity Building

Since the manpower will be deployed by the Paradip Port Trust for maintenance and development of the River Mahanadi – Luna (NW-64), the training of personnel shall not be required at the terminals.

The employees of each department must be capable doing the work assigned to them. Also, each department are required to provide necessary trainings for the employees if needed like terminal operation, ticketing operation, repair &maintenance, operation of communication systems, etc.

10.4. Infrastructure

10.4.1. Immovable

A building premise is required to house the staffs and their activities for the efficient running of the organizational set up. It is proposed to house the heads of the department in IWAI regional office and the subordinate staffs can be housed in the terminal building proposed at Cuttack.

10.4.2. Movable

Movable infrastructures like inspection vessels, etc., are proposed to be hired as and when required.

10.5. Cost Implications

As per the assumptions and criteria mentioned in the previous sections, an overview of the operating staff structure and costing is highlighted in the Table 10.4 below. Annual costs are projected at approximately Rs. 93,80,000 per annum.

Table 10-4: Costing of Staff Structure

Labour	Nos.	Wage per annum per position (Rs.)
General Manager cum Finance Manager	1	12,00,000.00
Assistant Director (IWAI)	1	10,00,000.00
Commercial Manager	1	8,00,000.00
Operational Manager	1	8,00,000.00
Engineering Head	1	6,00,000.00
Accounts Officer	1	3,60,000.00
Office Assistant	1	2,40,000.00
Security officer	3	2,40,000.00
Electrician	1	2,40,000.00
Mechanic	1	2,40,000.00
Communication Engineer	1	4,80,000.00
Communication Operators	9	3,00,000.00
Total		**93,80,000.00**

11. PROJECT COSTING

11.1. General

The cost estimates for the project are extremely important as its entire viability and implementation depends on the project cost. In this section, the cost estimate for the proposed inland waterway project is provided based on the preliminary design of various components constituting the terminal infrastructure.

Inland Waterway Transportation system cost is built upon the cost of development, operation and maintenance of following subsystems:

i. Fairway
ii. Terminal (berth + terminal building +storage)
iii. Vessel
iv. Utility shifting
v. Auxiliary items
vi. Landscaping
vii. Mechanical equipment

The costing of each subsystem development is worked out and presented in the following sections.

11.2. Basis of Costing

The estimate of capital costs has been worked out based on the project components as detailed in the previous sections and the schematic drawings enclosed as Vol. II. Detailed bill of quantities is worked out and the total project cost is derived from the following schedule of rates:

- Delhi schedule of Rates 2014 by CPWD
- Standard Data Book 2014 by Ministry of Road Transportation and Highways

Other aspects considered in the project costing are:

i. Rates for works that are not available in above standards were taken from the budgetary quotes or discussion with suppliers

ii. Resources in terms of experienced skilled labour, material and equipment are available locally
iii. The whole project takes one and half year of construction. Inflation of the rates during the construction period is not considered.
iv. A provision of 5% for contingencies has also been made to arrive at the total project cost to account any unforeseen items.
v. Cost index of 1 is taken.

The different options considered for costing are:

a.) Option 1: No navigation during summer.
b.) Option 2: Navigation during summer with construction of barrage and associated weirs.

The detailed cost estimate of different items is enclosed as Annexure II.

11.3. Development Cost

Development cost includes the cost of consultancy services like supervision, quality assurance and project management. Pre-project expenses have been taken at 2% of the capital cost of the project, which includes cost incurred for obtaining clearances. Provision for engineering consultancy and project management has been made at 5% of the capital cost.

11.4. Capital Expenditure

While estimating the capital cost of the project, the development activities mentioned below are considered and expecting that the works can be completed within period of two years including a 6-month time for obtaining clearances for the project.

- **Fairway development** – Includes dredging, river training and bank protection works.
- **Terminal infrastructure development** – Includes construction of a terminal with one high-level jetty and another low-level jetty at Jagatpur village in the Cuttack District; provision for open and closed storage; buildingto house administrative, operational, security and passenger amenity blocks.

- **Utility shifting**- Modifying and adjusting the location of utilities like existing road through the terminal premises, water supply line, electricity cables, etc.
- **Auxiliary items**- Including firefighting, safety gadgets, public security services, fuel pump, water supply, workshop facilities, communication facility, lighting, internal road network establishment, etc.
- **Mechanical equipment**- Weighing bridge, cranes, payloaders, etc.
- **Land scaping**- Pathway, horticulture development, lawn, etc.
- **Aids to navigation-** Ranges and marker buoys to enable safe navigation.
- **Navigation and communication systems** - Communication equipment like DGPS, VHF radio, etc. Details of Navigation and communication systems has been provided in Chapter 8.

Table 11-1:Summary of Capital Expenditure for Proposed Option 1

Sl. No.	Description	Minimum cost incurred (Rs.)
1	Berthing structure	₹ 6,97,28,251.30
2	Terminal building	₹ 30,62,287.00
3	Storage	₹ 1,67,03,347.59
4	Fairway development (including aids to navigation)	₹ 1,62,36,93,867.24
5	Utility shifting	₹ 50,00,000.00
6	Auxiliary items	₹ 2,55,00,000.00
7	Mechanical equipment	₹ 2,05,00,000.00
8	Land scaping	₹ 5,00,000.00
9	Navigation and communication	₹ 10,84,80,000.00
10	Modification to existing crossing bridges	₹ 75,00,00,000.00
	Total (Cr.)	**₹ 263.66**

Table 11-2: Capital investment requirement for different options

Option	Cost (Cr.)
1	263.66
2	854.86

11.5. Operational and Maintenance Expenditure

The annual operational and maintenance expenditure on the different components of the project is ascertained taking in to account the life of component, repair and maintenance requirements, wages of personnel and cost of consumables. Theological assessment of this expenditure is possible with the maintenance schedule for each structure and equipment, personnel strength fixed and requirement of consumables, etc., but even then, the estimation cannot be precise because of the unpredictable breakdown necessitating considerable expenditure on repairs and replacement. One of the practical approaches in the situation is to fix the annual expenditure as a percentage of the capital cost of the project. This percentage is judged based on the past performance of similar structures and equipment functioning and comments from experts or suppliers.

11.5.1.1. Operation Cost

The operational cost of the waterway includes the following:

- Manpower - Manpower such as engineers, supervisors, accountants, drivers, security officers and other technical, communication and administrative personal are required. The same is presented in Section 10.1 Organizational Setup/Establishment.

11.5.2. Maintenance Cost

In the initial stages the maintenance of Inland Waterways System is to be handled by the SPV through the construction agency for a period specified in the tender document. Afterward operations and maintenance shall be handled through the combination of in-house capacity building & outsourcing.

It has been observed that there will be requirement of dredging and channel marking which are to be executed annually to maintain the navigable depth throughout the year. It is assumed that 5% of the dredging cost is required for maintenance each year. The need for maintenance of civil infrastructure is less noticeable than in the case of mechanical equipment or electrical supply breakdowns where the need for maintenance is obvious.

The percentage for the various items of the project adopted is as follows:

i. Dredging -5 %
ii. Bank maintenance – 1 %
iii. Auxiliary items – 1%
iv. Civil works – 1% (on land); 2% (in water-front)
v. Mechanical equipment- 5%
vi. Aids to navigation – 2%

The annual operational and maintenance cost of the project is as shown in the following Table 11.3.

Table 11-3: Summary of Operation and Maintenance Expenditure

Sl. No.	Description	Percentage of capex	Amount
I	**Fairway**		
1	Dredging	5	₹ 5,46,36,233.50
2	Bank maintenance	1	₹ 1,34,000.00
3	River training	5	₹ 2,12,52,650.00
4	Auxiliary items	1	₹ 2,55,000.00
5	Aids to navigation	2	₹ 60,000.00
II	**Terminals**		
1	Terminal operations (salary of staffs)	Chapter 10	₹ 93,80,000.00 PA
2	Terminal building maintenance	1	₹ 30,622.87
3	Mechanical equipment	5	₹ 10,25,000.00
4	Landscaping	1	₹ 5,000.00
5	Navigation and communication	5	₹ 54,24,000.00
6	Berthing structure	2	₹ 13,94,565.03
7	Storage area	1	₹1,67,033.48

11.6. Phasing of Expenditure

The proposal for the project is made with provisions for minimum facilities required in an inland cargo terminal. Hence it is proposed to have the **proposal completed in a**

single phase. Future development plan cannot be predicted with confidence now as the exact projection of traffic is difficult at this stage.

12. IMPLEMENTATION SCHEDULE

12.1. Time Frame

Targeting timely completion of the project, planning of various modules is done with an accomplishable implementation schedule based on experience with similar projects and standard completion rates of different tasks. The timeframes have been estimated based on assumed construction methodology. The EPC contractor may choose a different construction methodology depending on their capability and understanding and this may lead to slight changes in the schedule presented below. Also, it is to be noted that delays in project implementation due to environmental factors, financial closure, construction delays etc., have not been factored in the implementation schedule.

The development can be divided into pre-construction and construction activities. Various activities identified under pre-construction are:

i. Clearance from various authorities
ii. Preparation of tender document
iii. Tender process

Given the requirement of procuring appropriate environment clearances and conducting the entire tender process (preparation of documents, pre-bid queries, contract awarding, work order signing etc.), it is assumed that above mentioned activities would require about **one year** after Government's approval.

Various activities identified under construction are:

12.1.1. Dredging:

Dredging is the major activity in the development of the channel, which is critical. In this implementation schedule, it is assumed that the whole of the dredging will be carried out in as a single contract and can be completed within 6 months after commencing work.

12.1.2. Bank protection works:

As part of river training works, bank protection works is found mandatory at identified locations including terminal locations. The construction of the same can be started in the initial stage and assumed that can be completed within three months.

12.1.3. Construction of terminal structures:

Construction of terminals is an important stage in the development of waterway projects. In Mahanadi & Luna waterway development project, it is assumed the construction of berthing structure can be completed within one and half year and the same for terminal building will took three months.

12.1.4. Procurement of vessels and navigation aids:

The procurement of vessels and navigation aids can be so planned that the same and construction of floating terminals are completed simultaneously.

12.1.5. Commissioning:

After completion of whole work with in one and half years, the waterway will be ready for commissioning by concerned authorities. The bar chart for implementation schedule is prepared and presented in following Figure 12.1.

12.2. Phasing

It is planned that the development of waterway system will take place in a single phase. It includes all development works including fairway development and terminal infrastructure development. A total of 18 months is required for the whole project.

Figure 12.1: Implementation Schedule of the Project

		Months																		
Sl No	Item	6 Months	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	All clearances including land acquisition and utility shifting																			
1	Dredging of entire channel: 3 dredgers of grab type working simultaneosly at the rate of 300 cum / hr, working for 15 hours a day and 15 days per month																			
2	Construction of terminal building at Cuttack																			
2.1	Site clearing and construction of foundation																			
2.2	Superstructure wor, electrification and water connection																			
3	Construction of berthing structure																			
3.1	High level jetty																			
3.1.1	Pile foundation																			
3.1.2	Superstructure																			
3.1.2.1	Pre-Cast																			
3.1.2.2	Cast in situ																			
3.1.3	Procurement of fixture like fenders and bollards for both jetties																			
3.1.4	Electrification and plumbing works																			
3.2	Low level jetty																			
3.2.1	Pile foundation																			
3.2.2	Superstructure																			
3.2.2.1	Pre-Cast																			
3.2.2.2	Cast in situ																			
3.2.3	Electrification and plumbing works																			
4	Construction of ware house																			
4.1	Site clearance and construction of foudation																			
4.2	Construction of superstructure																			
4.3	Fabricatinon of roof truss																			
4.4	Procurement and fabrication of shutters for doors																			
4.5	Fixing fabricated elements																			
4.6	Electrification and plumbing																			
5	Procurement of auxillary items as, safety gadgets, firefighting systems, communication systems, aids to navigation etc																			
6	Fairway development working for 15 hours a day and 25 days a month																			
6.1	River training and modification of crossing bridges																			
6.2	Embankment protection near the terminal location																			
6.3	Installation aids to navigation																			
7	Terminal area development																			
7.1	Internal road connectivity																			
7.2	Installation of other amenities as fire fighting, safet gadges, fresh water supply lines, STP, communication system etc																			
7.3	Landscaping																			
8	Selection and arranging of private operators for vessel operation																			
9	Commissioning																			

12.3. Suggested Implementation Mechanism

To develop the project and to manage the common infrastructure facilities, it is necessary to establish an independent institutional framework under the IWAI, the implementing agency. This shall be in the form of Special Purpose Vehicle (SPV). SPV shall be the agency for service delivery, operation and maintenance of the Project. The option of SPV owned by the Government entities is best suited for the Mahanadi & Luna inland waterway development and operation. However, private entities may hold some equity in the SPV, but less controlling stake. Thus, for all practical purpose, the SPV would be a Government entity. In the construction phase of the proposed project IWAI shall be the main implementing agency. IWAI shall create a focused SPV manned by the qualified & experienced professional & multi-disciplinary technical team dedicated to the planning and management of the project. The process of awarding the contract shall be on tender or deposit basis. SPV shall invite, process and award the tenders. As and when necessary the SPV shall invite the offer from government construction agencies on limited tender or deposit basis. An apex coordination committee shall be formed to co-ordinate between the departments related to the project and issue guidelines to the SPV for execution of the works. A policy framework and operating manual containing detailed system and structure of execution shall be prepared for effective control and delivery of the services.

The entire construction (including dredging) is proposed to be through EPC contracts. The maintenance of Inland Waterways system is to be handled by the SPV through the construction agency for a period specified in the tender document. Afterward O&M shall be handled through the combination of in-house capacity building & outsourcing. The revenue connected with these activities will also be collected by the SPV in the shape of tariff & user charges. SPV will also have to be provided with the necessary power for building byelaws for efficient functioning of Inland Waterways System.

It is recommended that the SPV have full right to fix its own tariff, based on the market realities. SPV should involve the private sector participation in as many as possible with a view to achieve higher efficiency with participation in the construction, operation and maintenance (after a suitable time lag).

12.3.1. Options for Private Sector Participation

The options for private sector participation can be ranged along a spectrum. At one end are those in which the government retains full responsibility for ownership, operations, maintenance, capital investment, financing, and commercial risk – at the other, those on which the private sector takes on much of these responsibilities.

The private participation can take one of the following forms:

- Service contract
- Management contract
- Lease
- Concession

Service contracts secure private sector assistance for performing specific tasks – operations and maintenance of channel, vessels etc. their main benefit is that they take advantage of private sector expertise for technical tasks or open these tasks to competition. Service contracts are the best a cost-effective way to meet technical needs for a project that is already well managed.

Management contracts transfer responsibility for the operations and maintenance of government owned business to the private sector. It ranges from paying a private firm a fixed fee for performing managerial tasks to sophisticated management contracts with incentives for efficiency, by defining performance targets and basing remuneration at least in part of their fulfillment. Management contracts leave all responsibility for investment with the government. Management contracts are likely to be useful where main objective is to rapidly enhance a private sector player's technical capacity and its efficiency in performing specific tasks, or to prepare for greater private involvement.

Under a lease agreement a private firm leases the assets from the government and takes on the responsibility for operating and maintaining them. Leases leave the responsibility for financing and planning investments with the government. So, if major new investments are needed, the government must raise the finance and coordinate its investment program with the operator's operational and commercial program.

Leases are most appropriate where there is scope for big gains in operating efficiency but only limited need or scope for new investments.

A concession gives the partner responsibility not only for the operational and maintenance of a project's asset but also for investments. Asset ownership remains with the government, however, and full use rights to all the assets, including those create by the private partner, revert to the government when the contract/concession ends-usually after 25 to 30 years there are several variants of concession viz. Build Own Operate(BOD), Build Operate Transfer (BOT), Build Own Operate and Transfer(BOOT), etc.

The proposed project implementation structure for the proposed Mahanadi & Luna Inland Waterway project is outlined below

- ***IWAI owns the project with no involvement of private sector participant. All capital and maintenance works shall be implemented through contracting system prevalent in the IWAI.***

13. ECONOMIC AND FINANCIAL ANALYSIS

This chapter analyses the viability of the project from financial and economic perspectives. Only the ~100km stretch of NW-64 has been considered for the analysis. While financial analysis focuses on the project specific expenditures and revenues accounting for time value of money, economic analysis focusses more on larger socio-economic impact of the project in quantifiable terms.

13.1. Revenue

As mentioned in traffic, analysis, two traffic scenarios have been covered – (a) Moderate (b) Aggressive, based on traffic diver and forecasted growth rates. Further different revenue assumptions have been taken in both scenarios as indicated below:

- **Moderate Scenario: Current tariff structure (as per IWAI guidelines rates); lower traffic growth projections**
- **Aggressive Scenario: Proposed tariff structure (as per proposed revised tariffs); higher traffic growth projections**
- **Aggressive Scenario + Tourism Activities:** Revenues from waterway related tourist activities has been included in the form of per customers charges. Tourist footfall of 75,000 tourists increasing at 6% p.a. has been considered.

Moderate Scenario: Current Tariff Structure

This scenario assumes that the guidelines tariffs published by IWAI for Indian waterways would be applicable. However, it should be noted that the tariffs are significantly outdated, being published in 2011. Hence, in absence of any revised tariffs, existing tariffs have been considered for Moderate Scenario. The growth rate for traffic is assumed to be 4% p.a. till 2025 after which a steady state growth rate of 5% p.a. is taken in moderate scenario

Table 13.1: Traffic Projections for Moderate Scenario

	2019	2020	2021	2022	2023	2024	2030	2050
Divertible Traffic Potential	0.06	0.07	0.07	0.07	0.07	0.08	0.10	0.27
Potential Achieved	40%	80%	100%	100%	100%	100%	100%	100%
Divertible Traffic	0.02	0.04	0.05	0.05	0.06	0.06	0.08	0.20

Aggressive Scenario: Proposed Tariff Structure

Transportation through waterways enjoys significant cost benefits as compared to road or rail transport. This significant cost differential drives possibility of escalation of key tariffs as listed below:

- Fairway charges – since the waterway involves significantly high dredging, increasing the fairway charges would significantly help in recovering the capital expenses in dredging and sustaining the recurring maintenance expenses.
- Terminal charge – While it is recommended to exclude investment in equipment / machinery at the terminal, still the terminal charges can be escalated for provision of multi-modal connectivity (both highway and railways), logistic operators and various facilities.
- Storage charge – High storage charges are desirable as it not only forces faster clearance of cargo from the yards but also increases terminal operator revenues.

While tariff escalation is warranted due to price inflation and high capital costs (in this case), the waterway tariffs should remain cost effective as compared to other modes. Further reduction in barge operator charges can be expected once the waterway is fully operational due to improved capacity utilization, turn-around time and traffic. Hence the waterway would not only be the most cost-effective transport mode but also ensure appreciable returns for barge operators.

In addition, revenue share from private terminal operator have also been considered in both the scenarios:

- End-user Charge: INR 200 / ton (considering operating cost of ~INR 1.1/ton/km and operating margin of ~INR 1.1/ton/km and waterway stretch of ~100 km)
- Revenue Share to IWAI: INR 20 / ton (*10% of end-user charge - as explained in Section 4.7.1*)

The growth rate for traffic is assumed to be 4% p.a. till 2025 after which a steady state growth rate of 8% p.a. is taken in aggressive scenario. The growth rate for tourist traffic is taken as 6% p.a.

Table 13.2: Traffic Projections for Aggressive Scenario

	2019	2020	2021	2022	2023	2024	2030	2050
Divertible Traffic Potential	0.35	0.36	0.38	0.39	0.41	0.42	0.64	3.00
Potential Achieved	40%	80%	100 %	100 %	100 %	100 %	100 %	100%
Divertible Traffic	0.10	0.22	0.28	0.29	0.30	0.32	0.48	2.25

Table 13.3: Tourist Traffic Projections for Aggressive Scenario

	201 8	2019	2020	2021	2022	2023	2024	2030	2050
Tourist Inflows		26,0 00	45,00 0	81,00 0	1,01,0 00	1,07,0 00	1,13,0 00	1,60,0 00	5,14,0 00

13.1.1. Moderate Scenario (Current Tariff Structure)

For estimating the revenues, the tariff structure provided by Inland Waterways Authority of India has been used. The tariff structure is divided into the following heads.

Waterway Usage Charges: These charges are levied on the cargo vessel on a per km basis for using the Indian waterways. These charges are mainly utilized towards recovery of dredging costs.

- Cargo vessel movement: 0.02 per GRT per km
  (Total length of waterway from Cuttack to Paradip is 100 km)

Vessel Related Charges: These charges are dependent on the type and size of the vessel measured in the maximum amount of tonnage (for dry bulk vessels) or in Gross Tonnage (GT) of the vessel. As mentioned earlier, vessel / barge of 1,000 DWT / 600 GRT capacity has been considered for analysis.

- Berth Hire – INR 1,000 per vessel for 24 hours or part thereof
- Towage – INR 600 per vessel per hour (1 hour of towage operation has been assumer per barge)
- Pilotage – INR 750 per day or part thereof per pilot

Cargo Charges: These mainly include cargo handling / wharf age charges. The charges are dependent upon the type of cargo being handled at the port.

- Dry Cargo Terminal Handling – INR 1 per tonne

Storage Charges: A grace period is usually provided for clearance of cargo from storage yard at the terminal. The quantum of charges depends upon the type of cargo (bulk, bagged bulk, liquid, container) and type of storage space (open, closed, hard stand). Considering the target cargo in subject stretch, storage charges for hard charges provided under the tariff structure are shown in the following table. Further the cargo breakup as per storage days has also been assumed. It is expected that majority of the cargo would be cleared within 7 days. The storage costs have been increased exponentially to ensure low turnaround time for the storage of the cargo.

Table 13.4: Storage Charges

Storage Period	INR per tonne per day	% Cargo Breakup
0-3 days	0.0	40%
3-7 days	0.0	25%
7-21 days	2.0	30%
22-35 days	4.0	5%
>35 days	16.0	0%

In addition to above, miscellaneous charges amounting to 5% of total revenues have been considered.

As mentioned earlier, barges would also utilize facilities at Paradip Port for cargo handling. IWAI / Project SPV can enter into a long-term agreement with the Port Authority for securing subsidized rates. These costs would however be passed on to the end-customers and would not contribute to any IWAI / Project SPV margins. Based on the above considerations, the revenues projections are shown below.

Table 13.5: Moderate Scenario (IWAI Tariffs) - Revenue Projections[25]

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Waterway Usage Charges	-	-	0.01	0.02	0.03	0.03	0.04	0.04	0.08	1.03
Vessel Related Charges	-	-	0.01	0.03	0.04	0.05	0.05	0.06	0.12	1.51
Berthing	-	-	0.01	0.01	0.02	0.02	0.02	0.02	0.05	0.64
Towage	-	-	0.00	0.01	0.01	0.01	0.01	0.01	0.03	0.39
Pilotage	-	-	0.00	0.01	0.01	0.01	0.02	0.02	0.04	0.48
Cargo Related Terminal Charges	-	-	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.26
Storage Charges	-	-	0.01	0.03	0.04	0.04	0.05	0.05	0.11	1.39
Revenue Share	-	-	0.04	0.10	0.14	0.16	0.18	0.20	0.42	5.15
Miscellaneous Charges	-	-	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.29
Total Revenues	-	-	0.08	0.19	0.26	0.29	0.33	0.37	0.78	9.63

[25]Revenue escalation considered at 7% p.a.

13.1.2. Aggressive Scenario (Proposed Tariff Structure)

As discussed previously, the following revised tariffs are proposed:

- Waterway Usage Charges: 0.1 per GRT per km
- Cargo related Charges: INR 5 per tonne (for dry bulk)

Revised storage charges are shown below:

Table 13.6: Aggressive Scenario - Revised Storage Charges

Storage Period	INR per tonne per day
0-3 days	0.0
3-7 days	2.0
7-21 days	4.0
22-35 days	16.0
>35 days	32.0

The remaining charges and revenue assumptions have assumed to be same as Moderate Scenario. The following table shows revenue projections considering the revised tariff.

Table 13.7: Aggressive Scenario (Escalated Traffic) - Projected Revenues[26]

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Waterway Usage Charges	-	-	0.24	0.55	0.77	0.86	0.97	1.08	2.63	57.13
Vessel Related Charges	-	-	0.07	0.16	0.22	0.25	0.28	0.32	0.77	16.78
Berthing	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.14
Towage	-	-	0.02	0.04	0.06	0.06	0.07	0.08	0.20	4.28
Pilotage	-	-	0.02	0.05	0.07	0.08	0.09	0.10	0.25	5.36
Cargo Related	-	-	0.06	0.14	0.19	0.21	0.24	0.27	0.66	14.28

[26]Revenue escalation considered at 7% p.a.

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Terminal Charges										
Storage Charges	-	-	0.17	0.39	0.54	0.61	0.69	0.77	1.87	40.56
Revenue Share	-	-	0.24	0.55	0.77	0.86	0.97	1.08	2.63	57.13
Miscellaneous Charges	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.28
Total Revenues	-	-	0.82	1.84	2.59	2.91	3.26	3.67	8.89	193.17

13.1.3. Aggressive Scenario (Proposed Tariff Structure) + Tourism Activities

As discussed previously, additional tourism revenues have been considered in this scenario. Per tourist revenue of INR 75 has been considered. Considering an average boat size of 10 people, total charge of ~INR 750 can be recovered per boat. These charges are in line with charges proposed for Baitarani waterway, where INR 8,000 – 10,000 are charged per boat (15-20 PAX)

The remaining charges and revenue assumptions have assumed to be same as Aggressive Scenario. The following table shows revenue projections considering the revised tariff.

Table 13.8: Aggressive Scenario (Escalated Traffic) - Projected Revenues[27]

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Waterway Usage Charges	-	-	0.24	0.55	0.77	0.86	0.97	1.08	2.63	57.13
Vessel Related Charges	-	-	0.07	0.16	0.22	0.25	0.28	0.32	0.77	16.78
Berthing	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.14
Towage	-	-	0.02	0.04	0.06	0.06	0.07	0.08	0.20	4.28
Pilotage	-	-	0.02	0.05	0.07	0.08	0.09	0.10	0.25	5.36
Cargo Related Terminal Charges	-	-	0.06	0.14	0.19	0.21	0.24	0.27	0.66	14.28
Storage Charges	-	-	0.17	0.39	0.54	0.61	0.69	0.77	1.87	40.56
Revenue Share	-	-	0.24	0.55	0.77	0.86	0.97	1.08	2.63	57.13
Miscellaneous Charges	-	-	0.03	0.07	0.10	0.11	0.12	0.14	0.33	7.28
Add. Tourism Revenues	**-**	**-**	0.25	0.46	0.89	1.20	1.38	1.57	**3.52**	**52.78**
Total Revenues	**-**	**-**	1.07	2.30	3.48	4.11	4.64	5.24	**12.42**	**245.95**

13.2. Financial Analysis

The financial feasibility of the project has been determined in form of Net Present Value (NPV) of pre-tax cash flows projected up to 2050. Following sub-sections detail the assumptions, O&M costs, revenues estimated for the project.

[27] Revenue escalation considered at 7% p.a.

13.2.1. Financial Assumptions

The following general assumptions have been considered:

- Capital Costs escalation: 5% p.a.
- Operational Expenditure escalation: 5% p.a.
- Interest Rate:9% p.a.
- Cost of Equity: 16%
- Discount Rate (WACC): 10%

13.2.2. Capital Expenditure

The capital expenditure breakup has been covered in Project costing chapter. As mentioned earlier, two options have been considered (a) with summer navigability (b) without summer navigability. The Financial Analysis has been evaluated only for the first option (with summer navigability) due to high CAPEX in the second option.

The main cost components include:

- **Capital Dredging**: Dredging requires investment depending on vessel classes. Both these investments represent unusually high cost when compared on a per km basis with other waterways. This is because of the high level of siltation occurring in Mahanadi river and lack of sufficient water flow all throughout the year.
- **Barrages, weirs (for summer navigability)**: Because of the low level of water in the subject waterway, significant investment would be required in barrages and weirs to provide sufficient water for navigability during summer months. Such structures are projected to require **INR 500+ Cr** of investment.

13.2.3. Operations & Maintenance Expenditure

As mentioned in the Project Costing chapter, O&M expenses comprises mainly of manpower and various maintenance charges (dredging, bank, navigation aids, terminal. The total OPEX in Option 1 is ~INR 9 Crore. OPEX escalation at 5% p.a. (7% p.a. for manpower) has been considered.

Table 13.9: Option 1 –O&M Projections

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2050
Dredging	-	-	6.02	6.32	6.64	6.97	7.32	7.69	10.30	27.34
Bank maintenance	-	-	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.07
River Training			2.34	2.46	2.58	2.71	2.85	2.99	4.01	10.64
Auxiliary items			0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.13
Aids to navigation			0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06
Terminal operations (salary of staffs)			1.03	1.09	1.14	1.20	1.26	1.32	1.77	4.69
Terminal building maintenance	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
Mechanical equipment			0.11	0.12	0.12	0.13	0.14	0.14	0.19	0.51
Landscaping	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Navigation and communication	-	-	0.60	0.63	0.66	0.69	0.73	0.76	1.02	2.71
Berthing structure	-	-	0.15	0.16	0.17	0.18	0.19	0.20	0.26	0.70
Storage area	-	-	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.08
Total OPEX	**-**	**-**	10.34	10.86	11.40	11.97	12.57	13.20	17.68	46.94

13.2.4. Net Cashflows

Moderate Scenario (Current Tariff Structure)

The pre-tax cash flows for Moderate Scenario are shown in the following table.

Table 13.10: Project Cashflows – Moderate Scenario

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Revenues	-	-	0.1	0.2	0.3	0.3	0.3	0.4	0.8	2.7	9.6
Less: CAPEX	263.7	-	-	-	-	-	-	-	-	-	-
Less: O&M Costs	-	-	10.3	10.9	11.4	12.0	12.6	13.2	17.7	28.8	46.9
Pre-Tax Cash Flows	-263.7	-	-10.3	-10.7	-11.1	-11.7	-12.2	-12.8	-16.9	-26.1	-37.3

The above cash flows yield **NPV of INR -364.95 Cr**. This makes the project highly unviable as per the current assumptions. Very low traffic potential, low tariffs and high capital costs account for financial infeasibility of the project.

Aggressive *Scenario (Proposed Tariff Structure)*

The pre-tax cash flows for the Aggressive Scenario are shown in the following table. Only the revenues vary as compared with Moderate Scenario with capex and operational costs remaining the same.

Table 13.11: Project Cashflows – Aggressive Scenario

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Revenues	-	-	0.8	1.8	2.6	2.9	3.3	3.7	8.9	41.4	193.2
Less: CAPEX	263.7	-	-	-	-	-	-	-	-	-	-
Less: O&M Costs	-	-	10.3	10.9	11.4	12.0	12.6	13.2	17.7	28.8	46.9
Pre-Tax Cash Flows	-263.7	-	-9.5	-9.0	-8.8	-9.1	-9.3	-9.5	-8.8	12.6	146.2

The above cash flows yield **NPV of INR (-259.49) Cr and an IRR of 2.09%.**

Aggressive Scenario + Tourism Activities

The pre-tax cash flows for this scenario are shown in the following table. Only the additional revenues for tourism activities are added with other revenues, CAPEX and OPEX same as Aggressive Scenario.

Table 13.12: Project Cashflows – Aggressive Scenario + Tourism Activities

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Revenues	-	0.1	1.1	2.3	3.5	4.1	4.6	5.2	12.4	55.1	246.0
Less: CAPEX	263.7	-	-	-	-	-	-	-	-	-	-
Less: O&M Costs	-	-	10.3	10.9	11.4	12.0	12.6	13.2	17.7	28.8	46.9
Pre-Tax Cash Flows	-263.7	0.1	-9.3	-8.6	-7.9	-7.9	-7.9	-8.0	-5.3	26.3	199.0

The above cash flows yield **NPV of INR (- 221.91) Cr and IRR of 4.07% p.a**.

13.2.5. Conclusion

The project remains unviable with NPV of INR (- 365) Crore to INR (-222) Crore under different scenarios. **However, the project can be executed with government support / funding. IRR of ~2% and ~4% can be observed in Aggressive Scenario and with additional tourism revenues respectively.**

Additional traffic is required on the stretch to make it financially profitable. Based upon further analysis of the traffic, it is determined that the project would break even (NPV = 0) at traffic of **1 MTPA** for Option 1 (Class VII in initial stretch, Class III till Cuttack, no summer navigability) with escalated IWAI tariffs. The high capex requirement for the river is a major factor in its viability in the absence of any major traffic drivers.

Hence based on the traffic study conducted in the catchment area and technical analysis of the river, it can be concluded that while the river does not possess sufficient traffic to make it economically viable, it does have potential for serving both cargo traffic and support tourism activities with governmental assistance. Further, the waterway can be supplanted by introduction of mega / large industrial projects in the catchment area. As indicated in the traffic analysis chapter, while projects such as Petroleum, Chemical and Petrochemical Investment Region (PCPIR), Smart Industrial Port City (SIPC), possible industrial plants of TATA and Jindal might be coming up in catchment area, it is presently unclear that how much respective traffic, if any, can be diverted onto the waterway. Moreover, industries at the port (ex IFFCO) would be interested in using coastal shipping and waterways for domestic movement of cargo. The waterway can also be developed as a tourist destination to further augment returns.

13.3. Economic Analysis

Inland waterways as a means of transportation has been harnessed worldwide in the face of expanding economies as it is considered as a preferred alternative due to its various direct and indirect benefits as mentioned in this section.

13.3.1. Direct Benefits

13.3.1.1. Employment Generation

Employment occurs both during the construction and operation phases of the transport infrastructure. Inland waterways perform several non-transport related functions that can be easily considered as benefits of economic assessment. Its use to move goods and services was found to fuel the economic growth and rural development of the local communities especially where it is the only means of transport available. It would boost the economy of nearby districts by promoting all facets of agro and other businesses such as crop production, fishery, production of basic materials, processing of timber products etc.

13.3.1.2. Creation of Business Opportunity

Due to the proposed project, the local economy can be promoted through income from barge / boat hires, mooring and licensing fee, canoeing, and other recreational activities for further tourism development.

13.3.1.3. Vessel Operating Cost

Comparing the vessel operation cost of the three most common modes of cargo transfer, inland waterways turns out to be the cheapest mode of transport. Transport by road costs INR 2.58 per tonne-km and transport by rail costs INR 1.41 per tonne-km.[28] The cost for inland waterways is considerably cheaper at INR 1.06 per tonne-km.[29]

13.3.1.4. Environmental and Social Benefits

13.3.1.4.1. Carbon Saving

Estimating transport-related carbon savings depends on calculating the difference in emissions between the type of transport that is offset or equivalent vehicles that are offset.

Tyndall Centre for Climate Change Research has estimated that freight transport produces one-third of carbon emissions of road transport. Road freight transport produces 0.08 tons CO_2 per thousand tonne-km. The carbon emission through waterway transportation is 0.02 tons per thousand tonne-km. The saving in this regard is 0.06 tons of carbon per thousand tonne-km because 1 liter of fuel moves 24 tonne-km by road and 85 tonne-km by rail as compared to 105 tonne-km by waterways.[30]

The shadow price of carbon is used to estimate the value of carbon saving in many government projects. The methodology is based on a damage cost approach and provides values for a tonne of carbon in any given year and requires the costs to be inflated annual to account for increased damages over time. The benefits of carbon savings arising from renewable energy production should be valued at the market price of carbon. The carbon shadow price value of damages on society at large due

28http://pib.nic.in/newsite/mbErel.aspx?relid=117695

29http://pib.nic.in/newsite/mbErel.aspx?relid=1176335

30http://pib.nic.in/newsite/mbErel.aspx?relid=117695 to emissions is 20$ / tonne. Reduction in carbon emission is a direct factor for damages on society which can be calculated based on this price.

13.3.1.4.2. Air / Noise pollution

Some of the most pervasive and intrusive sources of noise and air pollution are transportation systems. Air pollution comes from a wide variety of man-made and natural sources, with fossil fuel combustion as the largest contributor. Air pollution caused by transportation includes pollutants directly emitted by engines as well as secondary pollutants formed by chemical reactions. Road traffic is, by far, the greatest source of air emissions.

Water transport, conversely, causes far less air pollution than trucking, and less or comparable amounts, than rail. Cumulatively, it has a relatively minor effect on air quality, consumes much less energy (and thus, produces less air pollution) per tonne-km of freight carried than either rail or truck. For the most part, waterway operations are conducted away from population centres, which reduces the impact of its exhaust emissions. Little data exists on noise levels of barge operations, mainly because they are not considered a problem. Towboats operate well away from shore, with the sound of their engines muffled below the water line, and any noise levels are hardly audible beyond the immediate area of the town.

13.3.2. Indirect Benefits

13.3.2.1. Traffic Congestion Solution

The steady increase in highway traffic has outstripped any increase in infrastructure capacity, resulting in delays, safety problems, and congestion which costs the nation in crores annually. Other impacts of traffic congestion include accidents, increased energy consumption, environmental damage, increased commuting times, and greater social tension. Water transport is currently underutilized and optimizing the modal shift would reduce congestion problems in the country.

13.3.2.2. Economic Boost

Inland waterways can generate an economic benefit in the form of property premiums beyond the average rent or sale of residential and commercial property. The available studies show that proximity to waterway has effect of price of property. There is an average 8-20% increase in value of land and properties around waterways. There has been significant increase of property prices around NW1 and NW2[31]. The actual economic benefit is location specific and depends on the existing property prices and rental rates in the area.

13.3.2.3. Operational Safety

Transporting cargo safely is an important measure of environmental responsibility, and water transport has the fewest number of accidents, fatalities, and injuries as compared to road or rail. Shallow-draft water transportation has definite advantages over competitive modes. It generally involves less urban exposure than either road or rail, operates on a system that has few crossing junctures, and is relatively remote from population centres – all factors that reduce both the number and impact of waterway incidents. Truck and rail tank car spills occur more often than barge spills. Barges, because of their much larger capacity, require far fewer units than either road or rail to move an equivalent amount of cargo, and so the chance of a spill is less likely.

Also, design features of barges such as double-hulls and navigational aids help reduce accident frequency. Any hazardous liquid material shipped by water requires a

31http://www.indianchamber.org/wp-content/uploads/2015/06/Sector-Update-Logistics.pdf comprehensive list of safeguards and controls that govern the design and construction of vessels and equipment, and personnel manning qualifications.

13.3.2.4. Land Usage and Social Impact

The impact of rail lines passing through urban areas, and trucking operations occurring near high-density population areas, can become a disturbing element to an otherwise reasonably calm environment in settled areas. By contrast, water transport has little impact on densely populated areas since shallow-draft vessels operate in mid-river, well away from shore, and because of the large tonnage moved at one time, tow passages are infrequent.

Since most of the right-of-way for water transport is provided by nature, navigation is less likely than other transport forms to compete with non-transportation uses for land area, an important consideration in urban locations. Extensive land area can be taken up by new highways and railroad corridors, but apart from a few connections and waterside terminals, waterways pre-empt very little land.

13.4. Socio Economic Returns

The following socio-economic impact is envisaged by the development of the waterways.

- Operation Efficiency (cost savings) – INR 1.44 per ton-km
- Job Creation during Construction – 1000 jobs per $ 100 Mn (INR 700 Cr)
    - Total Project Investment: ~INR 260 Cr
    - Job Creation: ~400
    - Economic Impact: ~INR 18 Cr
- Job Creation during Operations – 50 jobs per MTPA traffic

The Economic cash flows for the project is shown below for the different scenarios:

OPEX same as Aggressive Scenario.

Table 13.13: Economic Cashflows – Moderate Scenario (Current Tariff Structure)

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Financial Cash Flows	-263.7	-	-10.3	-10.7	-11.1	-11.7	-12.2	-12.8	-32.8	-26.1	-37.3
Economic Impact											
Operational Efficiency	-	-	0.3	0.6	0.7	0.8	0.8	0.8	1.1	1.8	2.9
Job Creation	9.0	9.0	-	-	0.0	0.1	0.1	0.1	0.2	0.5	1.3
Economic Cash Flows	**-254.7**	**9.0**	**-10.0**	**-10.1**	**-10.4**	**-10.8**	**-11.3**	**-11.9**	**-16.0**	**-23.8**	**-33.1**

There is not IRR calculatable for this scenario

Table 14.14: Economic Cashflows – Aggressive Scenario (Proposed Tariff Structure)

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Financial Cash Flows	-263.7	-	-9.5	-9.0	-8.8	-9.1	-9.3	-9.5	-8.8	12.6	146.2
Economic Impact											
Operational Efficiency	-	-	1.5	3.1	4.1	4.2	4.4	4.6	7.0	15.0	32.5
Job Creation	9.0	9.0	-	-	0.2	0.4	0.5	0.6	1.1	3.9	13.8
Economic Cash Flows	**-254.7**	**9.0**	**-8.0**	**-5.9**	**-4.6**	**-4.5**	**-4.4**	**-4.4**	**-5.5**	**31.6**	**192.5**

The above cash flows yield **an EIRR of 4.99%.**

Table 15.15:: Economic Cashflows – Aggressive Scenario + Tourism Activities

Values in INR Cr	2017	2018	2019	2020	2021	2022	2023	2024	2030	2040	2050
Financial Cash Flows	-263.7	0.1	-9.3	-8.6	-7.9	-7.9	-7.9	-8.0	-5.3	26.3	199.0
Economic Impact											
Operational Efficiency	-	-	1.5	3.1	4.1	4.2	4.4	4.6	7.0	15.0	32.5
Job Creation	9.0	9.0	-	-	0.2	0.4	0.5	0.6	1.1	3.9	13.8
Economic Cash Flows	**-254.7**	**9.1**	**-7.8**	**-5.4**	**-3.7**	**-3.3**	**-3.0**	**-2.8**	**-3.7**	**45.2**	**245.3**

The above cash flows yield **an EIRR of 6.42% p.a**.

Comparison of the three Scenarios is as below:

Table 16.16:: Project FIRR & EIRR

Scenario	FIRR	EIRR
Moderate Scenario	-	-
Aggressive Scenario	2.09%	4.99%
Aggressive Scenario + Tourism Activities	4.07%	6.42%

14. CONCLUSIONS AND RECOMMENDATIONS

From study of Mahanadi river via Luna for the development of navigation channel, it can be concluded that:

- The stretch under study is 100 km up to downstream of Jobra barrage, of which up to 43km alone is under the influence of tide. The rest of the river is susceptible to drying during summer. No major hindrance to navigation in the stretch like barrages, dams, etc., is noted. The vertical and horizontal clearances of bridge crossing structures deviate from the clearance criteria for the specified class III, but the horizontal clearance criteria can be managed by some soft measures as one-way traffic, however, to meet vertical clearance criteria, the central spans are to be modified.
- It is evident that the waterway has only limited traffic potential at present due to lack of industrial development and small stretch (~100 km) considered. But the traffic can be expected to increase in future with upcoming Industrial developments such as PCPIR, riverine port, relaxation on mining restrictions and overall prevalence of waterway transport etc. etc.
- Building a terminal at 43 km chainage, where the river has tidal influence, is not viable due to lack of traffic. All the cargo traffic is concentrated nearby Cuttack and transporting cargo by road till 43 km Chainage and thereafter using waterway till Paradip, is not economically viable for freighters. Moreover, the proposed terminal location at Karilopatna (Chainage 43) has poor road access, further adding to the cost. The total cost of waterway infrastructure development (terminal, fairway, navigation equipment, roads etc.) till Chainage 43 km is ~INR 260 Crore.
- The river requires training at few stretches, the channel needs dredging to maintain the depth of 1.7m corresponding to Class III waterway features, embankments near the terminal requires immediate protection owing to vessel wakes. In all, the waterway can be used during fair weather season only between July and December when the river has water.
- The expected traffic potential is through diversion from other modes. Cuttack being an industrial area with a major seaport at Paradip, it can be assumed that

about 0.14 to 0.30 MMTPA of cargo can be diverted to the new waterway. Also, passenger ferry services can also be entertained.

- The waterway is also characterised by a large IFFCO plant at ~3 km chainage (very close to river mouth at Paradip). The plant is desirous of building a captive waterway terminal for transporting fertilizers. Moreover, the state has cleared development of a riverine port at Akhadasali village under Mahakalapada block in Kendrapada district on PPP. The port would handle Panamax vessels, with proposed channel width of 14-16 m. Thus, the initial ~7 km of waterway (till Chainage 7 km) is proposed to be developed as Class VII waterway to enable developments at IFFCO and Riverine Port.
- The region is flood prone hence the terminal structure should be of that type which can accommodate the water level fluctuations. Considering the dry bulk cargo, it is proposed to have one high-level and a low-level jetty at Jagatpur village, near Cuttack.
- Vessels/ barges of up to 500 DWT seems sufficient for the present traffic.
- It is proposed to have DGPS station and RIS network (including VHF and AIS) for the safe managing of the vessels along with facilities for receiving weather forecasts from IMD or other similar organizations.
- The river is already having ferry service and the proposed terminal is beyond 10km lateral distance from the sea mouth, hence environmental clearance is not required.
- The cost for developing the river as Class III with terminal at Cuttack is around Rs. 263.7 crore, with no navigation during summer.
- It is proposed to complete the work within a period of 18 months, including 6-month time to obtain all clearances.
- It is observed that EPC mode of implementation is suitable for this kind of works.
- Based on the socio-economic analysis, the project remains unviable due to low financial returns.

14.1. Recommendation:

The projects seem unviable from socio-economic analysis, this being a green field project and a public infrastructural project, it may be considered to develop the river as Class III waterway. No navigation during summer is recommended, because to have hydraulic structures like barrages to aid all weather navigation, investment escalates highly and that cannot be justified by the present traffic potential.

With the IFFCO plant setting up a waterway terminal (Chainage 3 km) for fertilizer transport and riverine port coming up at Akhadasali village (Chainage 7 km), the initial 7 km of waterway can be developed as Class VII waterway in Phase 1 of the project. It should however be noted that the port development would require intensive fairway development (~14m depth requirement, wide channel requirement), which would be taken up separately by the riverine port developer, and therefore Feedback has not considered any cost for the same. This section of waterway also connects to NW-5 confluence. Being situated at sea mouth, and without any terminal investment (in IFFCO and riverine port), IWAI's investment requirement would be restricted to navigational aids, communication & navigation equipment (~INR 5 Crore).

15. TEMPLATES

15.1. Environmental & Social Screening Template

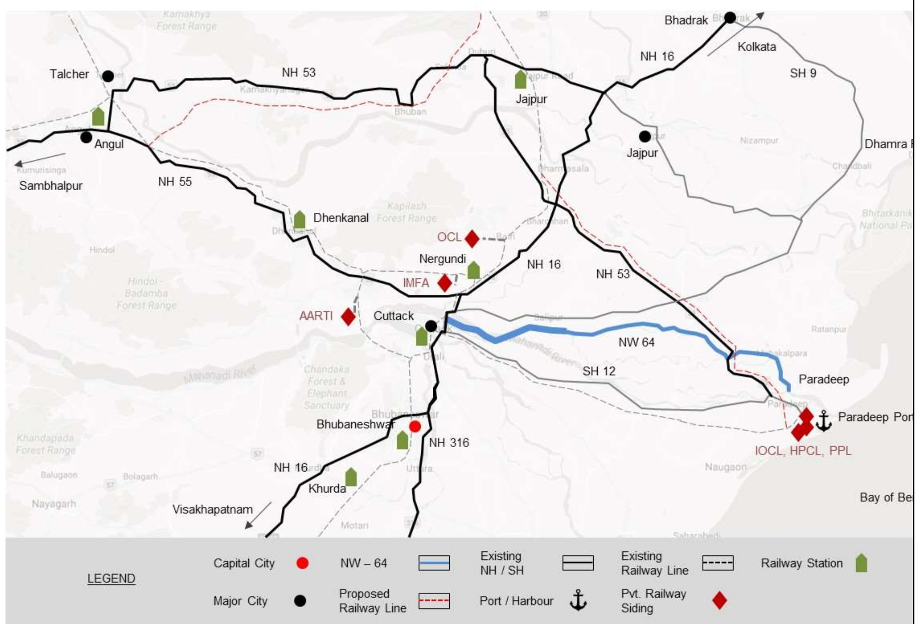
Screening Question	Yes	No	Details / Remarks
1. Is the project located in whole or part in / near any of the following Environmentally Sensitive Area? If yes, please provide the name and distance from the project site.			
a) National Park		No	
b) Wildlife/ Bird Sanctuary		No	
c) Tiger or Elephant Reserve		No	
d) Biosphere Reserve		No	
e) Reserved / Protected Forest		No	
f) Wetland		No	
g) Important Bird Areas		No	
h) Mangroves Areas	Yes		Near Paradip Estuary
i) Estuary with Mangroves	Yes		Paradip Estuary
j) Areas used by protected, important or sensitive species of fauna for breeding, nesting, foraging, resting, over wintering, migration		No	
k) World Heritage Sites		No	
l) Archaeological monuments/ sites (under ASI's Central / State list)		No	
2. Is the project located in whole or part in / near any Critically Polluted Areas identified by CPCB?		No	
3. Is, there any defence installations near the project site?		No	

4. Whether there is any Government Order/ Policy relevant / relating to the site?		No	
5. Is the project involved clearance of existing land, vegetation, and buildings?		No	
6. Is the project involved dredging?	Yes		As and When required Maintenance dredging will be carry out along the project waterways
7. Is the project area susceptible to natural hazard (*earthquakes, subsidence, erosion, flooding, cyclone or extreme or adverse climatic conditions*)	Yes		Cyclone and flood are very common in the project area.
8. Is the project located in whole or part within the Coastal Regulation Zone?	Yes		CRZ-II and CRZ-III is applicable for the proposed project
9. Is the project involving any demolition of existing structure?		No	
. Is the project activity requires acquisition of private land?		No	
. Is the proposed project activity result in loss of direct livelihood / employment?		No	
. Is the proposed project activity affect schedule tribe/ caste communities?		No	

S. N.	Result of Screening Exercise	(Yes / No)
1.	Environment Impact Assessment is Required	Yes
2.	CRZ Clearance is Required	Yes
3.	Environmental Clearance is Required	No (Considered Not Applicable (EIA Notification 2006 does not classify terminals on river or dredging in the river as a project requiring environmental clearance. The applicability of this legislation should be reconfirmed from the concerned authority).
4.	Forest Clearance is required	Yes (Diversion of forest land if any)
5.	Wildlife Clearance is required	No
6.	NOC from SPCB is required	Yes
7.	Social Impact Assessment is Required	Yes
8.	Abbreviated RAP is required	Yes
9.	Full RAP is required	No
10.	Any other clearance is required	Tree cutting permission from the forest department for construction of Jetty

15.2. Traffic Template

The Catchment baseline	• Limited by presence of NW-5 north of the waterway • Defined by terminals at Cuttack and port at Paradip • Includes industries in proximity of Cuttack (~30km radius) and Paradip (nearby Port)

	• Population: Cuttack (8 lakh), Paradip (70,000), some villages along the waterway with < 3,000 population each • Road Connectivity: NH-16 (connects Kolkata, Chennai), NH-53 (connects Angul, Jajpur, Paradip), NH-316 (connects Puri), SH-12 (connects Paradip Port) • Rail Connectivity: Well developed network at Cuttack (major transit point) and Paradip Port 

Item	Guidance
The Navigation baseline	• No terminal currently at Cuttack; Paradip port has well developed infrastructure & facilities • No current movement of industrial traffic along waterway • Negligible current passenger traffic due to lack of any settlements along the waterway • Minor tourist traffic currently– limited to Satkosia Tiger Reserve (outside catchment) and Dhabaleswar temple • No current Ro-Ro traffics • Tidal influence stretches till Chainage 43 km.

	• No major structural navigability constraints - vertical and horizontal clearances of bridge crossing structures deviate slightly from the clearance criteria for the specified class III. • Limited water availability: Limited only to monsoon season and subsequent months (5-6 months in year). For rest of the year, the river would be having limited water once the current leakage in Jobra Barrage is addressed.

The Market baseline	• Cuttack
	  ○ Main industries- OCL India, Aarti Steels, Sri Hardev Steel, Biraja steel and power, T.S. Alloys Limited, IMFA, Choudwar
	  ○ Major commodities - Iron & Steel, Cement, Sponge Iron, Ferro Chrome, Coal & Coke, Iron Ore, Gypsum
	• Paradip
	  ○ Main industries - IFFCO Fertilizers, Paradip Carbons, Paradip Phosphates, Essar Steels
	  ○ Major commodities - Fertilizers (raw material), Sponge Iron, Fertilizers Steel Pellets, Chemical, Marine Products, Coal &Coke
	• Relevant commodities for waterway movement including the following:
	  ○ Gypsum (0.15 MTPA): Transported from fertilizer plants at Paradip to OCL plant and brick kilns in Cuttack
	  ○ Ferro Chrome (0.10 MTPA): Transported from IMFA and TS Alloys to Paradip Port for export
	  ○ Coal / Coke (0.35 MTPA): Imported at Paradip port and transported to iron and steel plants nearby Cuttack

Forecasting years	Moderate Scenario
	• Divertible Traffic
	  ○ Rail (8%), Road (40%)
	  ○ Current modal distribution: 3.2 MTPA by rail, 2.8 MTPA by road

	• Traffic
	  ○ Commodities (Traffic): Gypsum (0.05 MTPA); Ferro chrome (0.04 MTPA), Coal (0.05 MTPA)
	  ○ Total Traffic (MTPA): 0.03 (2019), 0.06 (2020), 0.11 (2030), 0.19 (2040), 0.30 (2050)
	Aggressive Scenario
	• Divertible Traffic
	  ○ Rail (24%), Road (79%)
	  ○ Current modal distribution: 3.2 MTPA by rail, 2.8 MTPA by road
	• Traffic
	  ○ Commodities (Traffic): Gypsum (0.05 MTPA); Ferro chrome (0.04 MTPA), Coal (0.05 MTPA)
	  ○ Total Traffic (MTPA): 0.06 (2019), 0.13 (2020), 0.29 (2030), 0.62 (2040), 1.34 (2050)

Presentation of forecasts	• Initial commodity growth of 4% p.a. – based upon lack of clarity on macro-parameters (mining) and limited pipeline capacity • Higher commodity growth in long run due to restored mining operations, upcoming industrial development at Paradip, government promotion, evolution of technology, establishment of waterway transportation concept • Steady state commodity growth of 5% p.a. in Moderate Scenario • Steady state commodity growth of 8% p.a. in Aggressive Scenario
Market success factors	• Cost savings of waterway vis-à-vis road and rail transport – *100 km stretch of waterway allows to accumulate enough transport savings to offset higher handling charges; waterway savings are higher for road transport than rail* • Presence of private sidings with industries – *low divertiblity in this case*

	• Last mile connectivity from IWT terminals – *currently the industries are in close proximity of IWT terminals with well-developed last mile connectivity* • Minimal number of barges –2 barges by 2030 for moderate scenario and 5 barges by 2030 for aggressive scenario • Volume of cargo moving in the catchment – *only coal/coke, gypsum and limestone have enough volumes to consider consolidation for waterway movement*
Forecasting Methodology	• Included seasonality factor of waterway: Navigability limited to rainy months; actual divertible traffic considered only as 30% of projected divertible traffic (traffic value indicated above include the seasonality factor) • Included phasing of traffic-build up on waterway (40% of potential traffic inyear 1, 80% in year 2, 100% in year 3 and thereafter)
Alternative forecasts	•

15.3. Project Costing Template

Cost type	Cost categories	Components to be itemized
Capital costs	Waterway Infrastructure	• Land, compensation and resettlement: Rs. 10,28,29,197.24 • Dredging: Rs. 1,09,27,24,670.00 • River training: Rs.42,51,40,000.00 • Embankment protection: Rs.1,34,00,000.00 • Channel marking: Rs. 30,00,000.00 • Modification of crossing bridges: Rs. 65,00,000.00
	Terminal Infrastructure	• Fixed infrastructure: ✓ High and low-level jetty: Rs. 6,97,28,251.30 • Buildings ✓ Terminal building: Rs.30,62,287.00 ✓ Storage building: Rs. 1,67,03,347.59 • Mechanical equipment: Rs. 2,05,00,000.00 • Auxiliary items: Rs. 2,55,00,000.00 • Utility shifting: Rs. 50,00,000.00 • Landscaping: Rs. 5,00,000.00 • Navigation and Communication: Rs. 10,84,80,000
Operation and maintenance (O & M) costs	Waterways	Maintenance dredging: 5%: Rs 5,46,36,233.50 • Markings and nav.-aids: 2%: Rs. 60,000.00 • Bank maintenance: 1%: Rs. 1,34,000.00
	Terminals	• Terminal operations: Rs. 93,80,000.00 PA • Terminal building: 1%: Rs. 30,622.87 • Storage: Rs. 1,67,033.48 • Mechanical equipment: Rs. 10,25,000.00

		• Auxiliary items: Rs. 2,55,000.00 • Landscaping: Rs. 5,000.00 • Navigation and Communication: Rs. 54,24,000
	Vessel: (NB vessel operating costs/tons-km fall sharply with larger capacity vessel, when there is sufficient traffic to utilize them)	It is to be suffered by the private operator. Rs. 15,00,000.00 per vessel.
Recurrent costs	Periodic major capital costs that may occur over life of assets	Except maintenance cost, no recurrent cost is noted for the period till 2050.
Price levels	-	
Value engineering		
Cost verification	-	

15.4. Financial Evaluation Template

Consultants shall adhere to the following standard approaches in estimating financial internal rate of return (FIRR) and payback period.

Item	Requirements
Objective	• Same financial and economic assumptions considered between waterway stitches
Financial evaluation approach	• Navigation infrastructure – rates as per prevalent market rates • Terminal operations – rates considered at IWAI guideline rates • Barging operators – Considered to be operated by private operators
Disaggregation	• Cash streams not segregated by sector due to high dredging costs and low IWAI charges thus rendering it grossly unviable • Barge operations excluded
Transfers between Subsectors	• Disaggregation not considered
Incremental barging operations	• Incremental costs and incremental revenue considered
Cash flows in real terms	• Current prices considered along with relevant escalation rates to arrive at the realistic cash flows • Revenue inflation rates are higher than costs thus improving project returns with further years
Evaluation period	• Evaluation done till 2050
FIRR and payback period	• Cumulative flows are never positive
Ramp-up period	• Considered
Commentary on FIRR	• Considered

Risks to financial outturn	• Considered
Checking and Replicability	• Considered

15.5. Economic Evaluation Template

Consultants shall adhere to the following standard approaches in estimating economic internal rate of return (EIRR)	
Item	**Requirements**
Objective	• Considered
Economic evaluation approach	Economic evaluation of each river upgrading project may include: • Capital and O & M costs considered • Savings in transport costs between IWT and rail and/or road transport considered • Barge operating costs are based upon navigation facilities • Savings in road/rail accident costs considered • Saving in carbon emissions considered
Standard values	• Considered as per guildelines
Other benefits	• Considered
Cash flows in real terms	• Considered
Resource cost adjustments	• Considered

Evaluation period	• Evaluation done till 2050
EIRR	• Considered
Checking and Replicability	• Considered