

**DEVELOPMENT OF STRETCH OF RIVER MANDOVI, ZUARI
AND CUMBERJUA CANAL OF NATIONAL WATERWAYS IN THE
STATE OF GOA FOR INLAND NAVIGATION**



PROJECT REPORT



**INLAND WATERWAYS AUTHORITY OF INDIA
(Ministry of Shipping, Government of India)
A-13, Sector -1, Noida,
District Gautam Budh Nagar – 201301 (U.P.)**

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ABBREVIATIONS

CAGR	-	Compounded Annual Growth Rate
GBOA	-	Goa Barge Owners Association
GSDP	-	Gross State Domestic Product
IWAI	-	Inland Waterways Authority of India
IWT	-	Inland Water Transport
MOHP	-	Mechanical Ore Handling Plant
MPT	-	Mormugao Port Trust
NHWL	-	Navigational High Water Level
NW	-	National Waterway
RoM	-	Run of Ore Mine

1.1 GENERAL

Goa, a tiny emerald land on the west coast of India, the 25th State in the Union of States of India, Goa covers an area of 3702 square kilometers and comprises two Revenue district viz North Goa and South Goa. Goa, for the purpose of revenue administration is divided into district viz. North and South Goa with headquarters at Panaji and Margao respectively.

The major rivers flowing through the state are Mandovi, Zuari, Terekhol, Chapora and Betul. The other major rivers include the Tiracol, Chapora, Sal and the Talpona. Fig 1 shows the Index Map of Goa.



Fig. 1: Index Map of Goa

The Goa state economic survey 2014-15 has indicated that the Gross State Domestic Product (GSDP) of Goa at constant prices (2004-05) for the year 2013-14 (Provisional) is estimated at Rs. 30345 crore as against Rs. 28173 crore in the year 2012-13 thereby reflecting a growth of 7.71 percent. Compounded Annual Growth Rate (CAGR) of 7.5% during the period 1999-2000 to 2008-09 and 10.7% during the eleventh plan (2006-07 to 2010-11) has been registered. The contribution of mining and quarrying in Goa's state domestic product is quite considerable. Share of value addition from this sector in the state income at present is around 4%.

The iron ore industry contributes significantly to the exports, employment and foreign exchange earnings of Goa. Iron ore industry contributes a significant amount to the State and Central revenue in the form of taxes. The iron ore is shipped mostly from Mormugao Port and to some extent by Panaji port and mid-stream loading by Transhippers.

1.2 RIVERS OF GOA

There are nine major rivers in Goa flowing from East (Western Ghat) to West (Arabian Sea) except Sal River. Terekhol, Chapora, Baga, Mandovi, Zuari, Sal, Saleri, Talpona, Galgibag are the main nine rivers of Goa. Among these rivers Mandovi and Zuari drain 2553 Sq. Km, about 70% of the total geographical area of Goa. Out of nine rivers, six originate and flow exclusively within the state boundaries and do not have any interstate implications.

However, river Terekhol and Chapora originate in Maharashtra state while Mandovi originates in Karnataka. These rivers form an integral part of Goan life because of their portability, irrigation facilities, agriculture and coastal resources, transportation of mining ores, etc.

Goa's rivers are unique and are both tidal as well as rainfed. In Goa, during monsoon, water within the watershed areas is drained out through the major rivers to the sea. The rivers are influenced by the tidal influx upto the distance of 40 km inland towards upstream. Salinity factor in the river varies sharply during monsoon and non-monsoon seasons and so does the physico-chemical quality of water in wells along the riverbanks. Table 1.0 provides the details of river basins alongwith the basin area.

Table 1.0: River Basins of Goa

River Basin in Goa	Basin Area in Sq. Kms.
Terekhol	71
Chapora	255
Baga	50
Mandovi	1580
Zuari	973
Sal	301
Saleri	149
Talpona	233
Galgibag	90
Total	3702 Sq. Kms.

(Source: <http://goaenvi.nic.in/>)

THE MANDOVI – ZUARI ESTUARINE SYSTEM

The Mandovi and the Zuari are two estuaries located in Goa on the west coast of India and join the Arabian sea (Fig. 2). The main channels of these estuaries are each about 50 km long and they are connected by a narrow channel, the Cumberjua canal. At the upstream end, both estuaries receive freshwater from the rivers, which originate in the Western Ghat mountain ranges. A number of rivers / rivulets join the two estuaries.

The Mandovi is widest, approximately 4 km at the Aguada Bay. The Mapusa river joins the Mandovi at the upstream end of this stretch. Further upstream, Diwar Island, Approximately 11 km long, bifurcates the Mandovi into two channels. Before rejoining at the upstream end of the island, the two channels lead into an extensive network of narrow channels in a marshy area. The Cumberjua canal joins the Mandovi about 4 km upstream of the Diwar/Diwadi island. The 30 km stretch of the main channel of the Mandovi, from the eastern edge of the Diwar island to Ganjem, gets progressively narrower and shallower in the upstream direction. Rivers Dicholi, Valvat, Kudnem and Khandepar join the Mandovi along this stretch. Khandepar is the largest of the four rivers and is fed by the river Dudhsagar at its upstream end. During the dry season, in the main channel of the Mandovi, it is reported that the tidal influence is felt only till a little upstream of Ganjem. Further, upstream the channel bifurcates into the rivers Madei and Ragda. The Mapusa river, which joins the Mandovi at Penha de France, has at its upstream end the rivers Asnoda and Moide. The Mapusa river and its tributaries are joined by a large network of small rivulets, which often flow through marshy areas.

The Zuari estuary is larger than the Mandovi. The 10 km stretch upstream from the mouth of Zuari is approximately 5 km wide and 5 m deep. It is known as Mormugao Bay. At the upstream end of the Bay, the channel narrows to a width less than one km. The 30 km long channel from Cortalim to Sanvordem narrows progressively. It is less than 50 m wide at Sanvordem. The Kushavati river (also known as Paroda) joins the Zuari 4 km downstream at Sanvordem. The 10 km long stretch of the main channel from Sanvordem to Sanguem is also known as the Sanguem River. At Sanguem two rivers, Uguem and Guloli, join to form the Sanguem river. During the dry season, it is reported that the effect of tides is felt at Sanguem and possibly as far as 4 km upstream in the Uguem river and 1 km in the Guloli. In the Kushavati, the tidal influence appears to be present up to about 8 km upstream of the point where it joins the Zuari. During the wet season, the flow at Sanguem is dominated by river run-off.

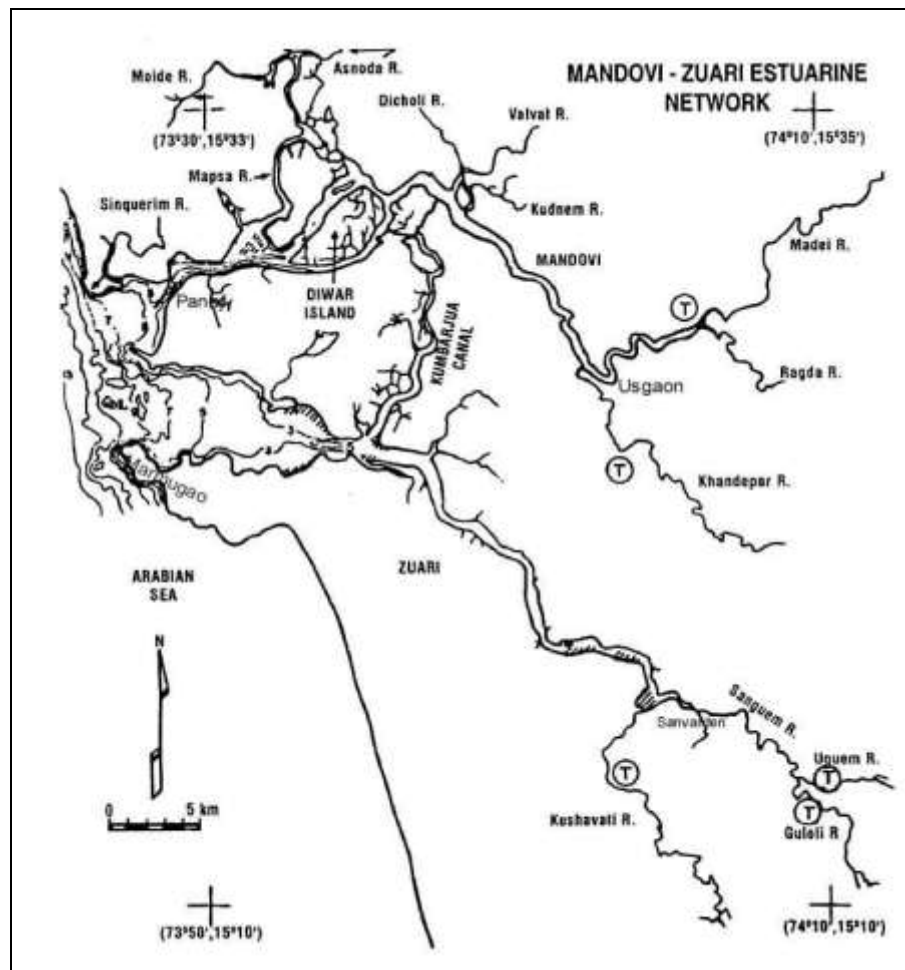


Fig. 2: Rivers Mandovi, Zuari and Cumberjua canal system in Goa

Morphology

Two rivers, the Mandovi and the Zuari, with their interconnecting Cumberjua canal, form an estuarine system in Goa waterway. The river discharges from the upland reaches during monsoon season from June to September bring about large changes in flow pattern and siltation when the estuary becomes fresh water dominated. During the pre-monsoon (dry) season, the water in the estuarine system is dominated by the sea water which is felt as far as 65 km upstream in both the rivers; but during the monsoon season it is reported that the sea water extends up to about 10 km upstream in the Mandovi and 12 km in the Zuari. The flow of the estuarine system is regulated by the entry of seawater with the incoming tide through Zuari which reaches Mandovi through the Cumberjua canal. The flow is reversed during the outgoing tide when the estuarine system is flushed.

Two shoals/sand bars occur permanently in Mandovi (Aguada Bay) close to a ramp-like inlet to the sea. This inlet poses no navigational problems for about 9 months during the dry season; but for a 3-month period during the monsoon, the waterway becomes hazardous and is closed to boat traffic. Heavy swell and intense wave activity lead to the transfer of sediments into the navigational inlet and the calm season brings the materials back to their original position with practically no overall change in the bathymetry of the bay.

The tidal variations, irregular coastal geometry, the presence of sand bars / shoals and the presence of navigational channels separated by shallow zones with deep pools make the flow quite complicated which lead to the estuarine system morphologically dynamic.

1.3 ROLE OF INLAND WATER TRANSPORT (IWT)

The state of Goa has about 555 kms. of Inland Waterways out of which only 255 kms. are navigable through the Rivers Mandovi, Zuari and their tributaries. Out of their total length the better part is being used by the mining and export Industry for transportation of Iron ore to the port of Mormugao and Panaji outer anchorage, from the loading points in the hinterlands. The proper harnessing of these waterways will provide quick and economical transportation facilities for both passengers and cargo traffic.

The Captain of Ports Department, Government of Goa is in-charge of all activities of Inland Waterways of Goa and shoulders the responsibility of developmental works of these Inland Waterways and Minor Ports of Goa, by way of periodical hydrographic surveys, dredging of rivers, maintenance of lighthouses and beacons, providing necessary navigational aids, imparting training to those desiring to build careers on Inland Vessels, providing landing facilities for both passenger boats and cargo vessels at jetties etc.

Functioning of all the activities in the Inland Waterways Transport Services are

carried out within the purview of the following acts:

- The Inland Vessels Act, 1917
- The Goa, Daman and Diu Barge Tax Act, 1973.
- The Goa, Daman and Diu Barge (Taxation of Goods) Act, 1985.
- The Goa, Daman and Diu Ports Rules 1983.
- The Indian Ports Act, 1908.

The Department also acts as Registering Authority at Panaji and Mormugao of mechanised and non-mechanised vessels such as Inland Cargo, Inland Fishing, Inland Passengers and Tourist Vessels.

Inland waterways have played an important role in the transportation of Iron ore and thereby the economy of the mining industry of Goa. Since the beginning of the commercial production of the minerals (mainly iron ore) in 1947, the river network of Mandovi, Zuari and Cumberjua canal in Goa have provided natural waterways and supported the promotion of iron ore industry with efficient means of transport.

1.4 NATIONAL WATERWAYS ACT, 2016

The Parliament of India has enacted the National Waterways Act, 2016 to make provisions for certain inland waterways and for the declaration of certain inland waterways to be national waterways. The Act provides for the regulation and development of the said waterways for the purposes of shipping and navigation. Under this Act, 111 waterways have been declared as National Waterways.

1.5 NATIONAL WATERWAYS IN GOA

The National Waterways Act, 2016 has declared six waterways in Goa as National Waterways (NWs) which are as follows:

- **Mandovi River (NW-68)** – from Bridge at Usgoan to confluence of Mandovi River with Arabian Sea at Reis Magos (**41 km**).
- **Zuari River (NW-111)** – from Sanvordem Bridge to Marmugao Port (**50 km**).
- **Chapora River (NW-25)** – from Bridge at State Highway No. 124 (1 km from Maneri village) to confluence of Chapora river with Arabian Sea at Morjim (**33 km**).
- **Cumberjua Canal (NW-27)** – from Confluence of Cumberjua and Zuari rivers near Cortalim ferry terminal to confluence of Cumberjua and Mandovi rivers near Sao Martias Vidhan Parishad (**17 km**).
- **Mapusa River (NW-71)** – from Bridge on National Highway – 17 at Mapusa to confluence point of Mapusa and Mandovi Rivers at Porvorim (**27 km**).
- **Sal River (NW-88)** – from Orlim Deusa Bridge to confluence with Arabian Sea at Mobor (**14 km**).

The development of these waterways shall be undertaken through various measures including dredging based on the recommendations in Feasibility studies/ Detailed Project Reports (DPRs).

1.6 MINING ACTIVITIES IN GOA – IRON ORE INDUSTRY

Goa, one of the smallest states of India, has witnessed a growth in iron ore production since 1970s and especially in the recent years. Iron ore mining is currently the major extractive industry and is concentrated along Goa coast where a mining belt extends 65 km from southeast to northwest spanning some 700 sq km. Goa is the only state in India where such iron ore mines are concentrated in such small lease areas. Many of the mines are having area of less than 100 hectares each.

The iron ore industry in the state of Goa is wholly dependent on exports. All the iron ore produced in Goa is exported to Japan, China, Korea, Taiwan and some European countries. The iron ore produced in Goa is less suitable for steel production. Goan iron ore is comparatively of low grade (Fe content ranges in between 50% to 62%) and hence does not justify for a steel plant based on it. Nevertheless, there is huge demand for Goan ore globally as it is often used as a product blend to make up for the optimal Silica and Alumina.

The state of Goa has been the biggest exporter of iron ore from India. Among all the ports of India, Goa has topped for exporting the maximum share of total exported iron ore of India in the recent years. In quantity terms share of Goa's export in India has been on an average around 40% during the last decade.

Considering the past trend of iron ore export from Goa and the present trend of world iron ore market scenario, it is estimated that a growth of 4% for iron ore exports shall prevail at least for next 15 years that is up to 2025. The projected iron ore exports for the years 2020 and 2025 would be about 78.65 and 95.69 million tons respectively with an average five yearly exports of 72.83 and 88.60 million tons for the period 2016-20 and 2021-25.

Goa uses the logistic advantage of inland water transportation to move iron ore to ports for exports. Goa has got a robust barge industry which includes more than 350 barges. The barge industry is the lifeline of the iron ore exports of Goa. It has virtually developed on its own without too much of government interference or support. The barge industry was developed by private operators for the last more than 50 years. The cost of transporting ores to ports by inland waterways works out to be a more efficient mode of transportation when compared to wagons and, thus provides cost competitiveness to exports of even low Fe content lumps and fines.

The tidal riverine system in Goa, comprising the Mandovi and Zuari rivers, the Cumberjua canal and the linkage with Mormugao and Panaji ports forms more than 90% of the commercially viable freight inland water movement in the country. Therefore, for transportation of iron-ore from mines to ports, the IWT mode provides the most effective and commercially attractive proposition.

1.7 MINING BELT OF GOA

The mining belt of Goa covers approximately 700 sq. km and is mostly concentrated in four talukas namely, Bicholim of North Goa district and Salcete, Sanguem and Quepem of South Goa district. Mining and associated activities have greatly affected the natural landscape in and around these areas, which is characterized by the presence of pits and waste rejects.

The mining belt of Goa is divided into three regions based on the concentration of the iron ore, namely, Northern, Central and Southern Zone. Usgao River is the dividing line for northern and central zone and Sanguem River between the central and southern zone. The maximum area under mining is in Sanguem Taluka followed by Bicholim, Sattari and Quepem.

1.8 MINING OPERATIONS IN GOA

Mining of iron ore in Goa is typically of open cast nature. The deposit recovered is of lower tenor and needs to undergo an elaborate process of beneficiation to render them marketable. The run of ore mine (ROM) needs to be either screened and thereafter in most cases, wet processed to get fines and lumps respectively. A typical iron ore open cast mine in Goa can be seen in Fig. 3.



Fig. 3: A typical open cast iron ore mine in Goa

1.9 IRON ORE MINING AREAS IN GOA

The location of iron ore mines in Goa is shown in Fig. 4. Based on the concentration, iron ore deposits can be broadly divided into 3 parts. Namely the Northern Zone, Central Zone and the Southern Zone with Usgao River would be the dividing line between north and south. The Northern Zone areas are more haematitic in nature and as one go down southwards, the Iron (Fe) contents drops and grades are of relatively lower tenor and the manganese (Mn) content increase. It may be envisaged that the north Goa deposits are relatively better surveyed. The south Goa deposits are still to be better assessed. There would be more potential areas of such reserves in the future. Typical iron ore mine areas along Zuari and Mandovi rivers can be seen in Figs 5 and 6.

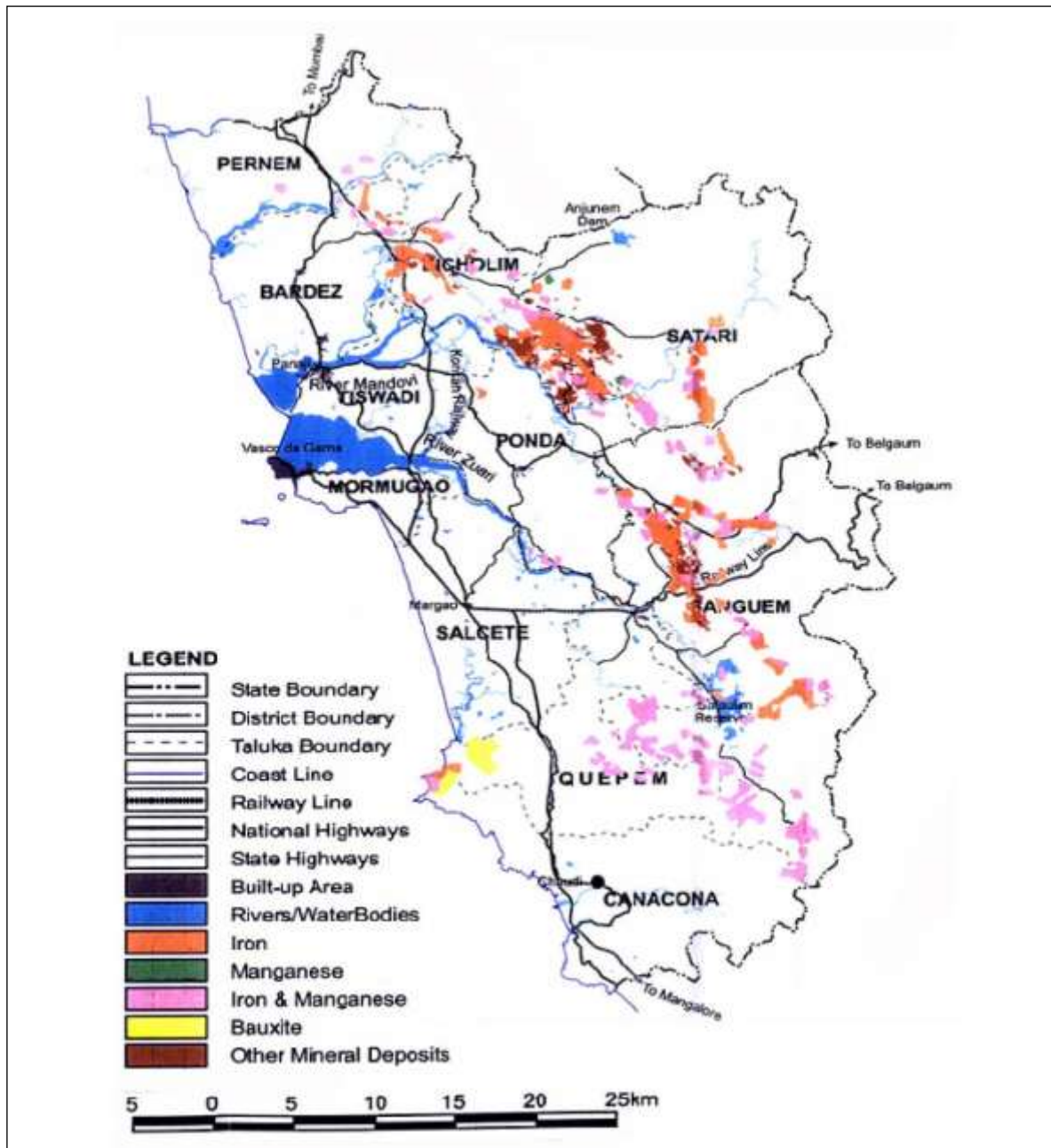


Fig 4: Location of iron ore mines in Goa



Fig. 5: Typical iron ore mines along Zuari river



Fig. 6: Typical iron ore mines along Mandovi river

2.0 EXISTING HANDLING FACILITIES

Mormugao Port

Mormugao Port, which is a major port, is an open type natural harbour. The harbour has been constructed on the leeward side of Mormugao Headland. It is protected with a breakwater, which affords protection from turbulent seas during the southwest monsoons. The port is served by both the major rivers of Goa viz. Mandovi and Zuari which are also interconnected by the Cumberjua canal. The port which mainly handles iron ore, has a wide range of facilities for pilotage, towage, lighterage, bunkering, warehousing, communication, mooring and anchorages for ships visiting the port. The port has conventional berths for handling different types of cargo. But it also has a special ore handling installation for handling iron ore, which forms about 90% of total exports from the port. The installation which has a capacity to handle 8000 tons of iron ore per hour, consists of a specialised berth and four finger jetties equipped with eight barge unloaders for unloading iron ore carrying barges. Ore unloaded by the unloaders can either be stocked on the stockpiles or can be diverted to the ship loaders for direct shipment. The system is provided with three stackers, two reclaimers and two ship loaders. The port has exported about 40 million tons of iron ore in the year 2009-10.

Mormugao Port is a natural harbour. It may be considered a mono Port, as 85% of the cargo handled is Iron Ore. Berth No. 9 is exclusively allocated for handling Iron Ore. It is a noteworthy fact that the Goan exporters are the major contributors to the flourishing of these ports.

Mormugao Port has a mechanical ore-handling complex. At present the limited draft at Berth No. 9, permits the loading of only Panama size vessels. However, the Cape size vessels can be up topped up to 200,000 tons ore more by transhippers (loading vessels), which are owned and maintained by the exporters. The transhippers thus play a complementary role in the port's operations and help raise Mormugao port to international standards.

Berth no 9 (Iron Ore)

The berth no. 9 of Mormugao Port is dedicated for the handling of iron ore with Mechanical Ore Handling Plant (MOHP). This berth is 357 m long and dredged to 14.1 m CD. The structure is of concrete cribs with R.C.C. decking. There are 6 cribs connected by RCC beams and decking. This berth was constructed in 1978. The iron ore handling berths of Mormugao Port are shown in Fig.7.

It can handle vessels up to LOA 335 m; Beam 50 m. The vessels are given a swell allowance of 0.5 m and under keel clearance of 1.2 m



Fig. 7: Iron ore handling facilities at Mormugao port

Mooring Dolphins

Apart from these berthing facilities there are three mooring dolphins in the port with a draft availability of 13.1 m CD. These mooring dolphins are used for accommodating iron ore vessels and loading them from the barges using ship's own gear.

The distance between two of the mooring dolphins is 380 m. Vessels of LOA up to 225 m and DWT 70,000 can be accommodated here.

The mooring dolphins are generally more in use during monsoon season while the MOHP and mid stream loading operations through transhippers are closed.

Mid Stream Loading / Transhippers

Apart from MOHP / Berth no 9 and mooring dolphins, iron ore is loaded in mid stream into larger ore carriers using Transhippers. Generally the larger vessels are loaded at Berth No 9 up to the permissible draft and then up topped in mid stream for the remaining part of cargo. However if Berth no 9 is not available, then the ore carriers are taken for primary loading in mid stream by transhippers.

Hence, the iron ore is the most important commodity for Mormugao Port Trust (MPT) and it is almost 99% of the total export cargo and all the iron ore comes to port by Inland Water Transport (IWT), an important role played by the Waterways of Goa.

Panaji Port

The Port of Panaji, which is a minor port, comes under the jurisdiction of Government of Goa. The port of Panaji is basically an anchorage port. This port is also accessible to main rivers of Goa. The port is located at the mouth of Mandovi river just upstream of Aguada bar. In the recent years, with increased demand for Goa iron, especially from China, activity of iron ore handling in this port has taken a quantum jump. In this port, iron ore is mostly handled in mid-stream either by ship's own gear or by transhippers.

Loading at this port is done with the help of transhippers. The congestion at Mormugao Port Trust is thereby reduced due to the introduction of Panaji Port. The loading capacity is approximately 25,000 tons per day. The iron ore handling berths of Panaji Port are shown in Fig.8.



Fig 8: Panaji Port – Iron ore handling facilities

River Ports

River ports are an essential part of the Goa mining industry as the ore from the mines is transported to the river jetty from where it is carried to the harbour for onward transfer to ships.

In early days when mining commenced in Goa on commercial lines during 1946-47, the ore was moved by rail or sometimes by truck up to the harbour. Since 1948, inland waterways are being utilized for iron ore transport from mines to the port. The earliest loading points were the river side plots where ore was manually loaded to the country crafts. A wooden plant resting on the craft and the natural river bank served as a jetty for loading iron ore. Later on, longer narrow platforms were built on using bamboos and wooden planks as decks. With the increase in demand for iron ore export, a number of exporters developed a number of such loading points with wooden jetties supported on wooden piles, all along the banks of Mandovi and Zuari waterways.

Over the years due to continuous demand for iron ore export, the wooden jetties were replaced by steel jetties which were more permanent. However, since these jetties were susceptible to corrosion, the steel jetties were later replaced by concrete jetties as permanent solution for ever increasing iron ore export demand. As exports grew steadily, further improvements took place in broadening of the jetties and even systems of mechanical loading with conveyor belt system were introduced.

There are more than 30 barge loading jetties located along the rivers in mining areas. Typical iron ore loading jetties along the banks of Zuari and Mandovi rivers can be seen in Figs 9 and 10.



Fig. 9: Typical iron ore loading jetty locations along the banks of river Zuari



Fig. 10: Typical iron ore loading jetty locations along the banks of river Mandovi

Barge Loading

Loading of barges is done at the jetty, after which the ore is carried to the sea going ships berthed / anchored at Mormugao / Panaji ports. The cargo is weighed prior to being loaded onto the barges. It is then loaded onto barges with the help of tipper trucks. The tipper truck reaches the edge of the jetty and directly load the barge placed down below in the river as shown in Fig.11. The jetties are generally with a barge-loading capacity of about 800 to 1000 tonnes per hour.

There are several agencies in Goa who can provide complete logistics support for bulk iron ore from storage to loading in to sea going vessel at Mormugao / Panaji port including barge transportation with full responsibility of complete shipment. Some agencies provide only barges and some agencies provide trucks, loading logistics as per the requirement.



Fig.11: Iron ore loading from truck to barge at Jetty

The jetties have a stacking capacity depending upon their shipment frequencies. Samples of ore for grading are drawn during the loading process. The private operators have their own stacking yards as shown in Fig. 12. The private operators also have their own barge loading facilities at their jetties. Besides there are several agencies who will provide facilities on hire basis.



Fig.12: Iron ore processing and staking yard on the banks of Mandovi river

2.1 BRIDGES ON GOA WATERWAYS

The details of bridges that come across the Goa waterways viz., Rivers Mandovi, Zuari and Cumberjua canal are provided in Table 2.0. The location of the important bridges is shown in Fig. 4.26. The horizontal and vertical clearances at these bridges are also indicated in the above table. The clearances are adequate to the proposed size of the vessel except two upstream end bridges. The dimensions of the proposed 3000 tons capacity barge are given above. The two nos. of bridges (refer Table 2.0) upstream of Mandovi as well as Zuari river each located near Usgaon and Sanvordem are old bridges and not meet the required clearance criteria however at present all barge loading jetties are situated downstream of these bridges. Since no barge loading has been carried out upstream of these bridges hence barge operations are not affected even though these bridges do not have sufficient horizontal and vertical clearances.

For cross-structures like bridges, the horizontal clearance between piers have been kept same as bottom width of the channel for river / canal to permit unhindered navigation. For existing bridges, one-way navigation at bridges may be considered without disturbing the structures.

For fixing vertical clearance, the calculation of Navigational High Water Level (NHWL) is an important factor so as to reduce the cost of cross-structures without causing unacceptable effect to the shipping operation. The IWAI / MOST as per Regulation 2006 (classification of waterways in India) have specified a clearance of 10.0 m for 1000 T / 2000 T vessel; 7 m for 500 T vessel and 5 m for 300 T vessel.

Since the Goa waterways are tidal, the water level fluctuates about 1.0 m up and down from the mean sea level and the mean tidal range from lowest to highest tide is about 2.1 m. Hence, in the present site conditions a vertical clearance of about 9.0 above the mean high water level / tide level can generally be considered. Hence, the vertical clearance is not adequate at the upstream of end bridges on Mandovi and Zuari rivers as per the standard guide lines. Since, the existing IWT terminals are located downstream of these bridges, these low level bridges may not come under the present navigation purview. However, the iron ore transport barges do not have high level decks and cabins and hence require low vertical clearance. Hence, the above standard guidelines for vertical clearance may not applicable in the present case or iron ore transport barges. Wherever, the horizontal clearance is less, it is recommended to fix rubber fenders at the piers of bridges for efficient impact absorption.

The requirement of vertical clearances of the bridges along the waterway routes were also discussed with Goa Barge Owners Association (GBOA). The suggested

vertical clearance of the bridges by GBOA is 9.3 m. Most of the bridges in the waterways meets the requirement except Mandovi bridge (old) near Panaji which has 9.0 m vertical clearance. Number of barges plying are of lower capacity except few barges which has higher capacity (more than 2500 tons) can pass during low tide. Similarly the Orago – Cumberjua has also vertical clearance of 9.0 m barges can pass by adopting similar approach as discussed above. However, it is suggested that the bridges constructed in future should have minimum vertical clearance 10.0 m and minimum horizontal clearance 100 m. The locations of bridges on waterways of Goa are shown in Fig.13 and typical bridge on Zuari river is shown in Fig.14.

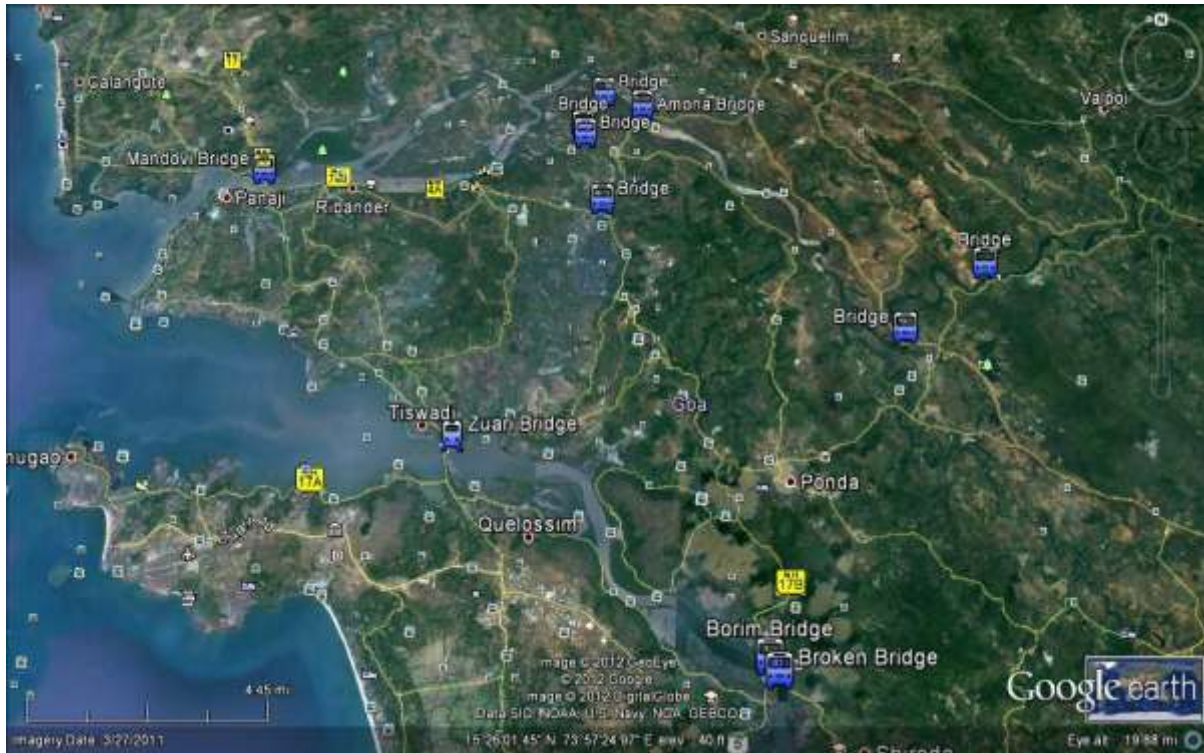


Fig.13: Bridges on Waterways of Goa



Fig 14: Typical Bridge on Zuari River

Table: 2.0 Details of bridges across Goa waterways

A - MANDOVI RIVER

S.NO.	NAME OF BRIDGE	CLEARANCES (IN METERS)		REMARKS
		HORIZONTAL	VERTICAL (from HFL/HTL)	
1	MANDOVI BRIDGE (OLD)	45	9.0	
2	MANDOVI BRIDGE (NEW)	45	9.5	
3	K.R.C.BRIDGE (DAUJIM)	124.2	12.9	
4	K.R.C.BRIDGE (NARVA)	53.5	10.15	* NOT IN THE MAIN WATERWAY ROUTE
5	AMONA - KHANDOLA BRIDGE	54	10	
6	AMBESHI - GANJEM	21	5.2	Bridge is beyond last

B - ZUARI RIVER

S.NO.	NAME OF BRIDGE	CLEARANCES (IN METERS)		REMARKS
		HORIZONTAL	VERTICAL (from HFL/HTL)	
1	ZUARI BRIDGE (CORTALIM)	105	13.7	
2	K.R.C. BRIDGE (CORTALIM)	124	14.2	
3	BORIM NEW BRIDGE (NEW)	85	13.7	
4	SANVORDEM STEEL BRIDGE	28.2	4.8	Bridge is beyond last loading point
5	SANVORDEM NEW BRIDGE	25	12	

C - CUMBERJUA CANAL

S.NO.	NAME OF BRIDGE	CLEARANCES (IN METERS)		REMARKS
		HORIZONTAL	VERTICAL (from HFL/HTL)	
1	BANASTARIM NEW BRIDGE	40	10.8	
2	GAUNDALI - CUMBERJUA	50	10.8	
3	ORGAO - CUMBERJUA	40	9	

2.2 DREDGING

In the proposed project, only maintenance dredging is envisaged. The navigational channels will be subject to resiltation due to several factors. In order to assess the quantity of maintenance dredging to clear the effect of such siltation with a fair degree of accuracy, hydrographic survey should be conducted at regular intervals for few years after completion of the capital dredging. However for purpose of basic estimates, the quantity has been estimated as 3.0 Mm³.

2.3 AIDS TO NAVIGATION

Aids to navigation are required to be provided to identify the fair way for safe navigation. These are various types of marks fixed on canal banks, floated on water and moored into the channel bed on both sides of the fairway to guide the master.

In open reaches of Mandovi, Zuari rivers (backwaters and river confluences), the marking of the navigational channel by floating buoys is most ideal considering the traffic potential on the waterway, permanent type of lighted buoys are recommended to facilitate round the clock navigation including night navigation.

The buoys are to be moored to the bed on either side of the fairway and also at the sea- river confluences of open reaches by means of anchor and chains. The anchor chains need to have sufficient length to facilitate their shortening/lengthening as required during low and high tide periods to suit the prevailing water level.

The permanent shore marks are required to be provided on the river banks wherever sharp bends exist so as to align the craft / barge in a straight line along the fairway. Sheets of adhesive scotchlite or luminous paint are required on the shore marks for night navigation.

The system and different type of navigation marks proposed are given as follows.

- Lateral Marks, to mark the left and right sides of the navigation route to be followed by navigator.
- Bifurcation Marks, to mark the middle grounds between the navigational channel, bifurcated channels and isolated dangers in the middle of the navigational channel.
- Shore Marks
 - Bank wise Marks, to indicate the channel at points where it approaches a bank.
 - Crossing Marks, to indicate crossings and alignment of the channel from one bank to another

- Marks of Prohibited Areas, to indicate no permission of entry.
- Sound Signal Marks, to indicate use of horning or other sound signals.
- Marks for Traffic Control, to control up bound or down bound vessels in one-way or sequential passage or to prohibit navigation.
- Marks on Bridges, to indicate the passage through bridges.
- Depth Indicator marks, to indicate shallow areas ahead in the navigational channel.
- Width Indicator marks, to indicate the narrow stretches ahead in the navigational channel.

The terms used as Left and Right shall respectively mean to the left and to the right of an observer facing downstream.

Traffic Lights

The Goa waterway comprising Mandovi river, Zuari river and Cumberjua canal is the busiest navigation route in India. About 400 barges of various sizes regularly play in the waterway for transportation of iron ore. On an average each barge makes 15 to 18 round trips in a month. It means daily about 200 barges move in the waterway between mining points and harbours (Mormugao and Panaji) for transportation of iron ore. Besides, the waterways are used for regular ferry services for transportation of passengers and accompanying cargo / luggage. The waterways are also extensively being used for recreation and water sports by tourists. Hence, for safety of the vessel and streamlining the traffic flow of iron ore barges and other vessels, it is essential to operate traffic signal lights at intersection points of the waterways similar to highway signal lights.

In current scenario, a traffic light is an important feature in traffic control. Not only does it provide an efficient means of controlling traffic flow, it also adds greatly to the safety of pilots and crew on the barges. Traffic signal lights improve waterway safety and reduce congestion by providing for the orderly and predictable movement of traffic through intersections. Traffic signals are electrically operated traffic control devices which alternately direct traffic to stop and to proceed. The primary function of any traffic signal is to assign right-of-way to conflicting movements of traffic at an intersection, and it does this by permitting conflicting streams of traffic to share the same intersection by means of time separation.

2.4 INLAND WATERWAYS AUTHORITY OF INDIA (IWAI)

The Inland Waterways Authority of India (IWAI), Ministry of Shipping, Government of India is primarily responsible for undertaking projects for development and maintenance of IWT infrastructure on national waterways.

As part of this initiative, IWAI has selected the following rivers/canal for development as National Waterways in the state of Goa:

- **Mandovi River (NW-68)** – from Bridge at Usgoan to confluence of Mandovi River with Arabian Sea at Reis Magos (**41 km**).
- **Zuari River (NW-111)** – from Sanvordem Bridge to Marmugao Port (**50 km**).
- **Cumberjua Canal (NW-27)** – from Confluence of Cumberjua and Zuari rivers near Cortalim ferry terminal to confluence of Cumberjua and Mandovi rivers near Sao Martias Vidhan Parishad (**17 km**).

2.5 PROJECT ACTIVITIES

IWAI is proposing to develop the waterways of rivers Mandovi (NW-68), Zuari (NW-111) and Cumberjua Canal (NW-27) as National Waterways in the state of Goa. For developing these waterways, IWAI is proposing to undertake the works of maintenance dredging and installation of navigational aids along the stretches of Mandovi, Zuari rivers and Cumberjua Canal for movement of barges and inland vessels. The dredged material generated from the maintenance dredging in these stretches is to be disposed of beyond the disposal area of Mormugao Port Trust (Lat 73° 44' to 73° 45' East and Long 15° 25'to 15° 26.2'North) towards sea side.

