DEVELOPMENT OF MANDOVI RIVER, ZUARI RIVER AND CUMBERJUA CANAL IN GOA

FOR

SHIPPING AND NAVIGATION

FINAL REPORT

CONTENTS
Volume –I (Main Report)

CONTENTS (Contd)

Volume –II (Thalweg Survey Drawings)

EXECUTIVE SUMMARY

Preamble

The global iron ore market is in a boom particularly during the last decade with emergence of Chinese industrial demand. China emerged as the largest producer of steel and consequently became the largest consumer of iron ore. China alone needs more than 650 million tons of imported iron ore in 2010 to feed its ever growing steel industry. Iron ore is the world's second-largest commodity market by value after crude oil. Japan and European Union import close to about 150 million tons annually, while South Korea imports about a third of it. Total global imports were 940.7 million tons in 2009. China imported a little over 66% of the global import of iron ore in 2009. India is 4th largest producing country and 3rd largest exporting country next to Australia and Brazil. India had produced 217 million ton production and 117 million ton exports in 2009-10. China is the largest recipient of Indian exports of Iron ore. In 2009-10 Goa exported a record 53.24 million tons of Iron ore out of country's total exports of about 117 million tons which is almost 50% of total exports. Besides China the other importers of Goa's iron ore are Japan, Italy, Pakistan, Dubai, Turkey, UAE, Kenya Netherlands, Belgium, Qatar, Saudi Arabia, Rumania, South Korea, Kuwait and Oman.

Contribution of Iron ore Industry

The 'Mining and Quarrying' industry in Goa has witnessed phenomenal growth in the last few years in response to world market demand. The exports of Iron ore from Goa are being organized by the Goa Mineral Ore Exporters' Association (GMOEA). The iron ore is shipped mostly from Mormugao port and to some extent by Panaji port and mid stream loading by Transhippers. 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. In the year 2008-09, Central government collected over Rs 1,600 crores from corporate tax, Rs 250 crores exports duty from Goa's mining and quarrying industry. In the same year, the industry paid a total tax of Rs. 500 crore to the State government in terms of Royalty paid at 10% ad volerem tax plus barge tax, road tax and road infrastructural cess. Royalty paid to state government is around Rs 250 per ton.

The Goa state economic survey 2009-10 has indicated that the Gross State Domestic Product (GSDP) of Goa at constant prices has registered a compound annual growth rate of 7.5% during the period 1999-2000 to 2008-09 and 10.7% during the eleventh plan (2006-07 to 2010-11). The contribution of mining and quarrying in Goa's state domestic product is quite considerable. Mining was an important economic activity at the time of liberation contributing about 17% of the State income. Share of value addition from this sector in the state income at present is around 4%. The iron ore mining and export has registered an annual growth of 4.7% in 2008-09 in terms of GSDP at constant prices. The Goa government receives approximately Rs. 300 crores annually as royalty from the mines, besides taxes and excise duty of Central Government.

Role of Inland Water Transport – Barge Industry

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 net work of Mandovi, Zuari and Cumberjua canal in Goa have provided natural waterway and supported the promotion of iron ore industry with efficient means of transport.

The Goa has a robust barge industry. The barge industry is the lifeline of 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 60 years or so. The cost of transporting ores to ports by inland waterways works out to be a more efficient mode of transportation when compared to wagons / trucks and, thus provides cost competitiveness to exports of even low Fe content lumps and fines.

Presently there are about 400 barges of total capacity approx. 6, 75,000 tons plying in Goan waters for the transport of the iron ore from the mines. All these barges in total make about 31,500 trips per annum to transport the iron ore to Mormugao and Panaji ports from the mines. These barges carried a total of about 53 million tons of iron ore to Mormugao Port and nearby Panjim port in 2009-10. The average capacity of the barge fleet in 2009-10 is about 1685 tons. The number of trips has been worked out on the basis of 53 million tons iron ore divided by average capacity of 1685 tons. The economy afforded by this mode of transport has made the Goan iron ore competitive in the international market.

Traffic Study – Iron Ore Export

Goa has been the biggest exporter of iron ore from India. Among all the ports of India, Goa has been 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. Goa exports iron ore originated from Goa itself and also sourced from Karnataka state. Goa has exported 53.24 million tons of iron ore in the year 2009-10. The compound annual growth rate for Goan iron ore export during the last decade (2001-02 to 2009-10) is about 11%. However, the growth of iron ore export depends upon the volatile international market particularly China, the largest consumer of Iron ore.

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% of iron ore export will prevail at least for next 15 years that is up to 2025. The projected iron ore exports for the years 2015, 2020 and 2025 would be about 64.65, 78.65 and 95.69 million tons respectively with an average five yearly exports of 59.86, 72.83 and 88.60 million tons for the period 2011-15, 2016-20 and 2021-25 in that order.

With the ever increasing Goan iron ore demand in the world market and the role being played by the barge industry in transportation of iron, there is a need to develop the Goa waterways not only to sustain in the present waterway transport but also to improve and more economize the system.

Waterway Development

Thalweg surveys have been carried out in the Goa waterways viz., Mandovi river, Zuari river and Cumberjua canal during January, 2011. The figure showing thalweg survey route is presented below. The thalweg surveys have revealed that the least available depths in the Mandovi river in the upstream reach near Usgaon bridge are around 1.2 to 1.5 m below the Chart Datum (CD) and in the remaining reach the depths are around 2 to 2.5 m below CD with intermittent deep pools of around 10 to 15 m. In the Zuari river also the least available depths in the upstream reach near Sanvarden bridge are less of the order of around 1.2 to 1.5 m below CD and in the remaining reach the depths are around 2.5 m with intermittent deep pools of around 8 to 12 m. The Cumberjua canal is narrow with meandering bends. Its mouth with Mandovi River is choked with silt and hence the depths recorded are around 0.3 to 0.6 m only. In the remaining reach though the canal is narrow, the depths are around 3 to 4 m. Sea water influence is there in the above navigable reaches of the waterways. The tidal range at the mouth is about 2 m which reduces to around 0.5 m in the upstream reaches Mandovi and Zuari rivers near Usgaon bridge and Sanvarden bridge respectively. At present higher draft vessel (more than 2000 tons) negotiate the shallow areas during high tide period.

The depths recorded during the recent thalweg survey (2011) have been compared with the detailed hydrographic surveys carried out by Panaji Port during 2001 - 2003. It is generally found that there is a considerable siltation of the navigational occurred during the intervening period from 2001 to 2011. The dredging quantities have been estimated to deepen the channel for smooth navigation. It is estimated that about 6.5 million m^3 of material is required to dredged out to maintain a navigation channel of 67.5 m bottom width with a depth of 4.0 m below CD for uninterrupted navigation of 3000 tons barges round the clock. In addition to deepening of the waterways to increase the draft of the vessel, there are certain waterway developmental works such as provision of aids to navigation, channel marking, night navigation facilities, traffic signal lights, bank protection works, parking bay for waiting barges have been suggested to improve navigation conditions to meet the ever increasing barge operations in the waterways. The capital cost for waterway developmental works work out to Rs. 310.0 crores. Summary of the estimated cost for the developmental works waterways wise tabulated below

Fig.: Thalweg route of Mandovi, Zuari and Cumbarjua canal in Goa

Capital cost for Development of Waterways in Goa					
S.No.	**Description**	**Quantity**	**Unit**	**Rate (Rs.)**	**Capital cost Amount (Rs)**
A	***MANDOVI RIVER***				
1	Capital Dredging	1.20 Million	Cum	400	48.5 Crores
2	Aids to Navigation		As detailed in Chapter 4	As detailed in Chapter 4	3.5 Crores
	TOTAL of A			Total	52 Crores
B.	***ZUARI RIVER***				
1	Capital Dredging	2.65 Million	Cum	400	106 Crores
2	Aids to Navigation			As detailed in Chapter 4	6 Crores
	TOTAL of B				112 Crores
C	***CUMBERJUA CANAL***				
1	Capital Dredging	2638001	Cum	400	106 Crores
2	Bank Protection Works			As detailed in Chapter 4	15.25 Crores
3	Aids to Navigation			As detailed in Chapter 4	2 Crores
4	Land Acquisition	33.975	Hectare	1500000	5.25 Crores
5	Cost of Mooring Dolphins	25	Nos	5000000	12.5 Crores
	Total of C				141 Crores
D	Manpower cost		LS		4 Crores
E	Cost for vessel tracking system		LS		1 Crores
		GRAND TOTAL			**310 Crores**

Model Studies

The model studies have been carried out to study the influence of Aguada bar on navigation. The studies have revealed that the formation of sand bars at the mouth of the Aguada bay is due the sediment transport mechanism which in turn depends upon the near shore dynamics such as wave activity, tidal propagation, currents and circulation. Aguada bay is open to swells from the prevailing south west, west and north west approaches of wave directions of the Arabian sea. Shallow water waves transporting sediments, in part from headlands erosion and in part from offshore sources, would tend to deposit at the mouth. The waves are responsible for the formation of bars. The waves approach accompanied by the silt laden waters would block the mouth of the estuary. Further the model studies have also indicated that the circular motion due to flood and ebb flows at the mouth which influences the formation of the shoals and bars. The fresh water out flow in the monsoon season had a flushing and scouring effect due to strong current in the narrow Aguada bar area but during the lean season the channel return to its original depth that is, becomes shallow. The deposition occurs at the bar is due to the abrupt reduction in the velocity (competency of the flow) of the ebbing waters of the estuary as they enter the bay (constriction near the head of the bay) and this process is particularly during monsoon season. However, counteracting this process during the monsoon is the intensification of wave activity (steep short period waves become prominent) which results in the net removal of material from the bay/bar. This process leads to extensive loss of material from the bar during the monsoon and build up during the fair weather season. However, the strong flood and ebb velocities maintain the channel between the two shoals.

Looking at the present conditions prevailing in the Bay during the recent surveys carried out by RITES and in the light of the history behind the bar, it would appear that, so far as these shoals and the navigational channel are concerned, not much has changed over a few centuries. That the shoals/bars have neither grown significantly in size nor have they disappeared completely suggest that a kind of balance exists between the supply and depletion of sediment which maintain the shoals/bars controlled by the interaction of tides, waves, river runoff, etc. Further, it is only during monsoon that this region poses navigational problems due strong swell and rough sea while during the fair weather season the situation becomes normal and the navigational channel remains relatively deep and well marked between the shoals. The naturally available channel is adequate for the movement of iron ore barges of maximum capacity 3000 DWT. Since the formation of shoal and natural opening of the channel prevail naturally, the economical solution to the problem exists by resorting to dredging. Though the dredging will be required to carry out to deepen and widen the navigation channel between the bars (Aguada bar in the south and Reis Magos bar in the north), the area gets silt up to its original depth in due course due to the peculiar phenomena as explained. Hence, it is recommended that the dredging to be carried out on SOS basis as and when the situation is warranted.

Barge Economics

Perhaps, the inland water transport system in Goa is the first and foremost IWT system in the world which has replaced the other two competitive modes viz., road and rail on commercial and operational aspects. The barge economic study has indicated that there is an operational surplus for all sizes of barges plying in the Goa waterways. The success behind the economic viability of the barge industry in Goa is perfect planning and better interface of transportation of iron ore from the mines till loading into sea vessel for export to international market. There are various sizes of barges are in operation right from 750 tons to 2500 tons in Goa waterways for transport of iron ore. The barge economic study carried out has revealed that the age old low carrying capacity barges (750 and 1000 tons) are less efficient and less commercially viable when compared to higher capacity barges (> 2000 tons). Hence, it is proposed to introduce 3000 tons capacity barges by improving navigation channel to better economize the system. To introduce higher capacity barges and also to improve the existing water transport system, there is a need to develop the waterway.

Project Appraisal

The project appraisal has been carried out for the proposed waterway development. In the project appraisal, it is considered that after deepening of the navigation channel and implementation of other waterway development works, a barge of 3000 tons capacity can be introduced in the future, while the existing barges will continue to ply. However, the old barges after completion of their economic life will be replaced with 3000 tons barges in future. The proposed waterway development project will also enhance the operational efficiency of existing 2000 tons and above barges by improving their turnaround time since these barges have to wait for high tide to negotiate shallow regions of the waterway.

As per the traffic projections, the demand for iron ore export through Goan waterways is estimated as 95 million tons by 2025. The present waterway system that permits to 2000 to 2500 DWT vessels during high tide and with existing navigational aids will not be able to meet the future iron ore export demand. The proposal to deepen the navigational channel up to 4 m below CD with an investment of Rs 310 crores will not only increase the present throughput but also meet the future export demand of iron ore. Presently 2500 DWT vessel can make 150 numbers of trips per annum which will be increased by 187 trips per annum due to proposed waterway development works. The cost incurred by the iron ore barge as per the existing scenario is around Rs. 62.29 per ton per entire lead. After implementation of waterway development works, the transportation cost of existing 2500 DWT barge will be reduced to Rs. 53.67 and the transportation cost of proposed 3000 DWT barge will be Rs. 46.87. Hence there is an increase in savings of transportation cost by Rs. 8.62 for presently plying 2500 DWT barges and the savings in transportation cost for the proposed barges (3000 DWT) will be Rs. 15.41 per ton per trip.

The Financial Internal Rate of Return (FIRR) for an investment of Rs 310 crores works out to 3.6% without charging anything from the user. However, if the investor / implementing agency charges additional Rs. 7 per ton per trip, the FIRR will be 12.39 % and EIRR will be around 17.70% during the project appraisal period of 15 years. After 15 years, once the waterway will be completely utilized by higher capacity barges of 3000 DWT, the savings on cost and the financial returns will be further enhanced.

With the proposed online vessel tracking system and introduction of other navigational aids, the safety of the vessels will be ensured besides the economic and financial benefits.

Conclusions and Recommendations

Considering the Goan iron ore industry’s contribution to state as well as nation’s economy, the consultants recommend to take up the proposed waterway development project to increase the vessel capacity to 3000 tons and other associated waterway development works. The proposed project will yield additional benefits to the existing system as discussed above and in turn improve overall efficiency of the inland water transport system and its contribution to the iron ore industry.

CHAPTER - 1

INTRODUCTION

1.1 BACKGROUND

After a series of discussion Inland Waterways Authority of India (IWAI), state Government of Goa,Goa Barge Owner Association (GBOA) and Goa Mineral Ore Exporter Association (GMOEA) IWAI decided to prepare a DPR for development of the Goa waterways comprising of Mandovi River, Zuari River and Cumberjua canal for shipping and navigation to make them more efficient and to increase their commercial potential and capacity (Fig. 1.1). 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.

Goa, one of the smallest states of India, has witnessed a growth in iron ore production since 1970s and especially in the last 5 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 an iron ore mines are concentrated in such a small lease areas. Many of the mines are having area of less than 100 hectares each.

The Goa iron ore industry 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.

Goa uses the logistic advantage of inland water transportation to move iron ore to ports for exports. The Goa has got a robust barging 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 or so. 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 iron ore mining industry in Goa is important for Goan economy. It has direct and indirect contributions of the sector. The direct one is taken to indicate, inter alia, the contribution of the constituent iron ore-mining firms to the economy in the form of output, employment, taxes, and foreign exchange etc. The indirect impact, on the other hand, records the gains made by the other sectors of the economy that have linkages with the iron ore mining.

1.2 SCOPE OF WORK

Detailed scope of work / Terms of Reference (TOR) for the DPR study as given in tender document and amendments made during the pre-bid meeting are as follows:

- Collect and study/ analyze the hydrographic survey charts prepared by Captain of Ports Deptt, Govt of Goa for River Mandovi (Usgaon to sea mouth), River Zuari (Sanvardan to sea mouth) and entire Camberjua canal. Conduct Thalweg survey (longitudinal hydrographic survey along deepest channel) to verify the hydrographic survey charts collected from Government of Goa

- Collect and study/ analyze the available data/ reports regarding water level, depth, velocity, discharge, cross section, bed and bank material, hydrographic, topographic data etc. of Mandovi river, Zuari river and Camberjua canal from various sources like Central Water Commission (CWC), concerned departments of Govt. of Goa, National Remote Sensing Agency, Survey of India, Marmugao Port Trust, Central Water and Power Research Station (CWPRS), National Hydrographic Office (NHO), etc. and also identify the missing data to be collected in the field.

- Study the existing barge operation scenario in these rivers/canal and the problems being faced by the barge operators during their operation.

- Suggest suitable channel dimension to accommodate self propelled cargo vessels of about 3000 tonnes capacity.

- Study/ identify the vulnerable stretches/ recurring shoals/ navigational impediments and other difficult areas with respect to navigation and suggest suitable remedial measures such as dredging, disposal of dredged spoil, bank protection and any other measures to overcome such impediments.

- Study the Aguada Sand bar and the effects of dredging thereon based on suitable mathematical modeling.

  Select tentative location and carryout preliminary topographic surveys for:

- River training /bank protection works particularly for those stretches where either the channel is narrow and needs to be widened by dredging or where it is anticipated that the banks can erode due to continuous movement of barges.

- The preliminary topographic survey mean spot levels connected with a bench mark to depict general features of the area and it’s Reduced Level.

- The main identified cargo is iron ore. However, identify the types and O-D of other cargoes, if any, and make traffic projections (including that of iron ore) for a time horizon of 5, 10 & 15 years.

- Study the specification of various types of cargo vessels plying at present and suggest better suitable type of cargo vessels, if so required, for the cargo as assessed under the above item. Workout the details of the type of vessels their number and cost.

- Study the morphological, hydrological, hydrographical conditions, and operation and maintenance requirements of the subject waterways to identify works in sufficient details that are required in respect of:

    - River conservancy including river training, bank protection, dredging etc. needed for shipping and navigation.

    - Navigational aids and communication facilities.

    - Locks, bridges, New/ improvements with reference to horizontal and vertical clearances.

    - Other infrastructural facilities such as repair facilities, channel patrol, security, enforcement of rules and regulations, pilotage, issue of navigational notices, navigation charts, warnings, rescue and salvage, pollution control measures etc.

- Avoiding adverse interference of shipping and navigations on other users of water (like irrigation, power, drinking water, fisheries, recreation etc.).

- Prepare preliminary engineering designs, drawings and estimates for the optimum structures of river training and bank protection measures and navigational aids to develop and maintain a navigable channel for the waterway system.

- For preliminary engineering designs, the data about soil characteristics shall be collected from the local sources based on the structures constructed nearby. In addition, wherever required, consultant may obtain soil data through trial pits/plate load test etc and preliminary designs shall be based thereon. In case of critical structures, consultant can suggest that detailed soil investigation including borehole tests etc and detailed design may be done before actual execution of the work.

- Study should suggest the requirement of waiting dolphins in the Cumburjua canal and give preliminary design, drawing and cost thereof.

- The road and rail bridges and foot bridges crossing the navigation routes shall be studied with respect to horizontal and vertical clearances and recommendation made on measures required to permit uninterrupted navigation. In this regard, IWAI (classification of inland waterways in India) Regulations 2006 shall also be studied.

- Prepare cost estimates for various possible alternatives for the entire proposed infrastructure, handling, and other allied facilities. While comparing the different alternatives, the cost and economy factors shall also be evaluated. The most suitable alternative recommended shall have detailed costing for all the components of the project.

- Assess the environmental impacts due to these development works and suggest suitable environmental management plan (EMP) to mitigate the adverse impacts, if any, including its cost.

  Only rapid EIA/EMP study is envisaged for which one season data shall be sufficient. However, all necessary information should be given in the report to enable IWAI/Government of Goa to approach concerned authorities for getting environmental clearance for undertaking the works proposed in the DPR.

- Prepare a realistic construction schedule for the whole project indicating the priority of different component of the project. The phasing of expenditure is also to be worked out.

- Recommend the necessary organizational structure and manpower required for execution of the project.

- Workout the transport cost for cargo, commodity wise per ton km between origin and destination of traffic as at present and also project the transport cost using IWT along with the cost benefit analysis.

- Study the existing freight and tariff structure and recommend a suitable freight structure together with its basis and subsidies, if any, that may be necessary in the initial years. Also tariff rates for using waterway, terminal and other infrastructural facilities.

- Identify individual projects/ activities that can be taken up under private sector participation/ BOT/JV basis.

- (A) Workout Economic Internal Rate of Return (EIRR) considering the employment generation, carbon credit earned, fuel saving, saving in noise pollution and accidents, saving in repair and maintenance of roads, saving in land acquisition etc. for the projected traffic potentials by IWT mode.

- (B) Financial internal rate of return (FIRR) may be worked out for the following option:

  - (a) For the Govt. (based on user charges proposed to levy by the Govt. from the operator for use of waterway, terminal etc).

- (b) For the operators considering rate he can charge for transportation of the goods by barges and the user charge he shall pay to the Govt.

- Prepare the DPR covering all the above items and submit 15 copies.

Fig. 1.1 : Index Map of Goa

CHAPTER – 2

TRAFFIC SURVEY – IRON ORE EXPORT

2.1 INDIAN IRON ORE INDUSTRY

India is one of the largest exporters of Iron ore in the world. It caters to both the domestic industry as well as export markets and hence functions as resource industry as well as feeder industry where the captive mines of the steel plant operate as the feeder sources.

2.1.1 Iron Ore Reserves

India's iron ore reserves are estimated at about 22 billion tons out of which 10.43 billion tons of hematite and 10.68 billion tons of magnetite. This figure may be on the lower side as 'Probable and Indicated" categories remain to be further explored. According to the Indian Bureau of Mines, more than 50% of the hematite ore is of medium to high grade having ferric content of more than 62%. High Grade Hematite constitutes around 14% of the total iron ore reserves.

The hematite reserves are located largely in Eastern/ Central India - Jharkhand, Orissa, and Chhattisgarh. Magnetite ore is largely confined to Karnataka in south India. Some hematite deposits are also found in Goa. Iron ore reserves in India are shown in Fig. 2.1.

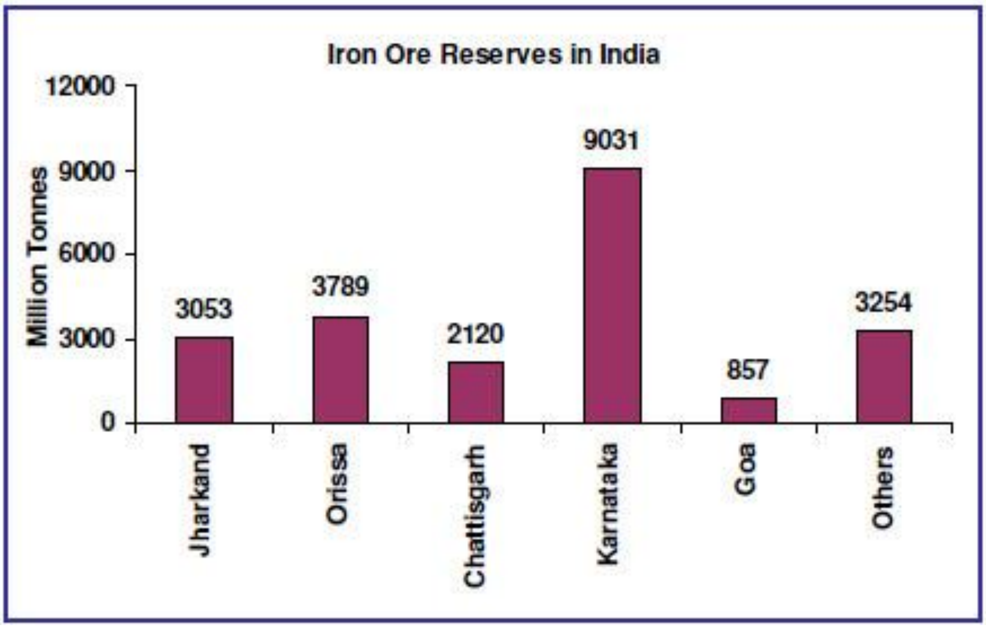


Fig. 2.1: Iron Ore reserves in India (Source: Indian Bureau of Mines)

Resources:

India produces 9.13 per cent of the global iron ore output. In terms of pure iron in it, India’s share is 10.86 per cent as in 2005. Therefore, there is no immediate concern about iron ore resources turning out to be a constraint to the growth of the steel industry as per ICRIER study.

It is interesting to note that the iron ore resources in total have increased from 17.564 billion tonnes in 1980 to 25.249 billion tonnes over the period 1980-2005 despite continuous extraction for domestic consumption and exports**.** While the average annual iron ore production during 1980-2005 was 66 million tonnes, the total resources increased by an average of 307 million tonnes per year.

However, reserves, defined as economically mineable portion of the total resources, are only at 7 billion tonnes in the case of haematite ores and 0.207 billion tonnes for magnetite. A large chunk of the proven deposits did not find place in the reserves category on environmental considerations. Of the total reserves, 18.6per cent belong to the high grade category (65per cent Fe and above), 50.6per cent to the medium grade (62-65 per cent) and 28.4 per cent to the low grade (62 per cent and lower). The remaining 2.4 per cent have not been classified.

As per the tenth five year plan working group committee’s projection, the expected requirements of various grades/ specifications of iron ore are estimated to be 122 million tonnes and 156 million tonnes during 2006-07 and 2011-12, respectively. However, as per National Steel Policy 2005, in order to support steel production of 110 million tonnes by 2019-20, the requirement of iron ore is placed at 190 million tonnes. Thus the projected domestic demand of iron ore will be 190 million tonnes; similarly, exports have been estimated to be around 100 million tonnes by 2019-20. The total demand of iron ore will be around 290 million tonnes by 2019-20. It is expected that the additional demand will be met through capacity augmentation from Bellary-Hospet sector, opening up of deposit no. 1, 4, 11B & 13 of Bailadila and capacity expansion of existing Bailadila group of mines, capacity enhancement of SAIL mines, new mines by M/s Rio Tinto in eastern sector, opening up of new deposits like Chiria, Thakurani, Taldih, Rowghat, Ramandurg, Kumarswamy etc.

2.1.2 Iron Ore Production and Export

Iron ore demand has been rapidly increasing across the globe especially during the last few years. . India has significant reserves of iron ore and has emerged a major exporter taking advantage of the burgeoning Chinese demand. The high levels of exports attained in the past few years and there is a possibility of the same growing further which led to the domestic steel industry expanding rapidly. The deepening supply constraints have led to the phenomenal increases in its price across the globe. There is a serious thought process is going on whether iron ore should be conserved for the domestic steel industry through active policy intervention, or, whether the market forces be allowed to play freely for optimum allocation of resources between domestic use and exports. At the same time, the government as well as the industry recognizes the urgency for reforms in the mineral industry to draw investment and modern technology into it to raise output to generate employment and create wealth in the society. To this end the Indian Council for Research on International Economic Relations (ICRIER) had carried out a detailed study on Mineral Policy issues in the context of export and domestic use of iron ore in India (Dr. A.S. Firoz, 2008).

Orissa, Chhattisgarh, Karnataka, Jharkhand and Goa are the major iron ore producing states in India (Fig. 2.2). The iron ore quality varies in production according to its Fe content based grade with 83.7 per cent of the total production having Fe content of 62 per cent and above. The share of lumps in total iron ore production has been about 40 per cent with the rest being accounted for by fines and concentrates. The share of lumps in total iron ore varies across the states depending on the quality of the deposits, operating practices followed and the commercial judgment of the miners.

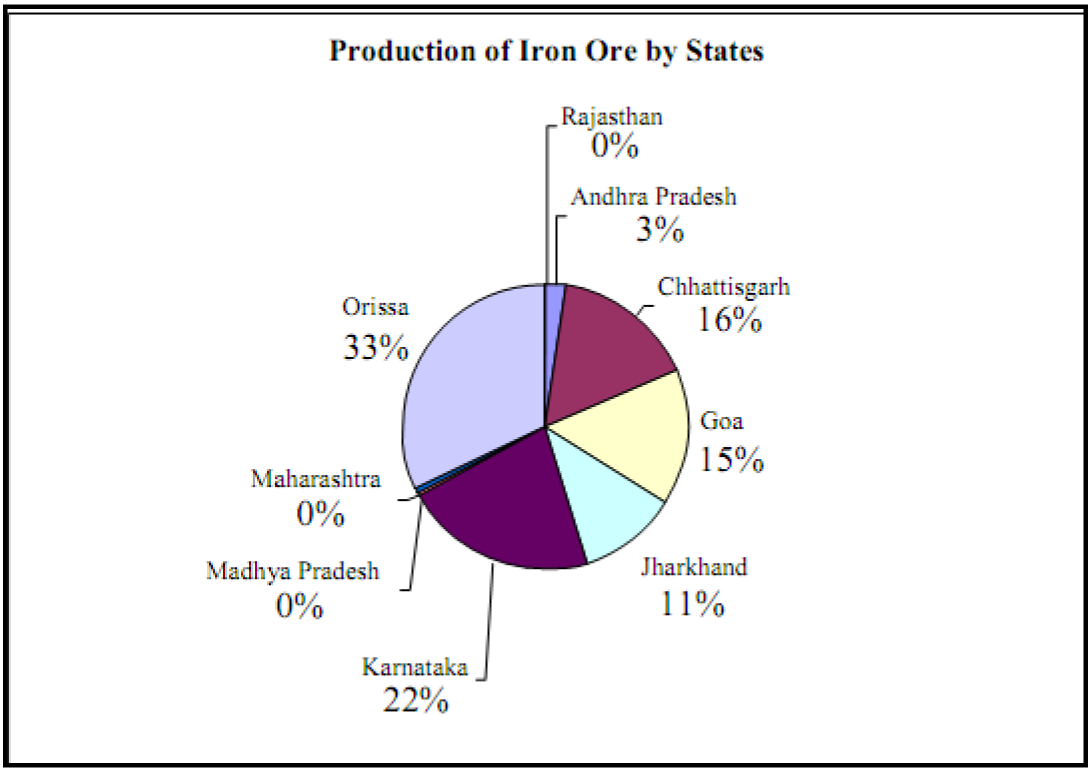


Fig. 2.2: Production of iron ore by various States.

There are about 500 mines, half of which are operational. These mines are held by about 80 companies. High-grade ores with 62-65 percent iron are produced mainly in the east and south. Low-grade ores with 50-60 percent iron are produced in the west and south. The largest mining firm is state-run National Mineral Development Corporation (NMDC), which produces about 29 million tonnes annually, mostly for local sales. The steel industry is a big domestic user of iron ore. Many steel companies have captive mines.

India is the fifth largest producer of iron ore in the world with production at 226 million tonnes in 2009-10. Production growth has been continuous and has largely been driven by export opportunities.

India's iron ore exports in the 2009-10 fiscal year was at 117 million tones, up 3.8 percent from previous year. India is the world's third-biggest supplier of iron ore after Australia and Brazil. China is India's biggest buyer, with its proximity helping it secure ores with low freight costs. The largest exporter is Sesa Goa, a unit of London-listed Vedanta Resources. Other large producers and exporters are Essel Mining, Rungta Mines, V.M. Salgaocar, MSPL and Chowgule. About 80 per cent of the ores exported are fines. China accounts for more than 80 per cent of the total iron ore exports from India. Most of the iron ore is sold on the global spot market.

The cost of mining iron ore ranges from $8 to $16 per tonne. Miners in Goa, on the west coast, have lower costs as mines are located near the port and use low cost IWT barges for transportation and so avoid road and rail charges. Otherwise, the rail transportation to the port can be as high as $30 per ton. Indian prices generally follow the global market, dominated by Australian and Brazilian miners, with China buying on spot basis for its low-grade ore needs.

2.2 HISTORY OF IRON ORE TRADE FROM GOA

Even though the occurrence of mineral ores of iron and manganese were known from early times, in Goa, little attention was paid to their study / exploration till the beginning of the 20th century. The first detailed study was however by German Geologists commissioned by the Portuguese Government to produce a geological map. However, no other sustained effort was carried out through systematic studies in exploration of minerals.

Planned geological studies commenced only after 1961 after the integration of Goa with rest of India. Geological mapping, accompanied by regional assessment of mineral deposits were undertaken by the Geological Survey of India from 1962-1968 (Kalavampara Glenn J, 2009). Studies were also undertaken for assessment of iron, manganese, clay and bauxite deposits (GMOEA, 1988).

Prior to World War II, Japan had imported around 100,000 tons from Goa, building the initial contacts with the Japanese steel mills with Goan miners, thus, slowly cementing relationships. In the initial years of mining in Goa, there used to be more demand for manganese based ores as well as lumpy iron ores. From early records, the initial mines to operate in Goa were that of manganese ores from South Goa in 1940’s. Iron ores were thereafter sought for and were supplied chiefly from North Goa mines (Bicholim Taluka), which lead to many mining concessions being obtained and mines commencing operations in Bicholim – Pale sector.

The Iron ore exports commenced in the late 1940’s with around 40,000 tons of iron ore exported through Goa’s Port. The exports witnessed a remarkable jump to about an average of 10 million tons in 1970s and have been rising consistently since then (Fig. 2.3).

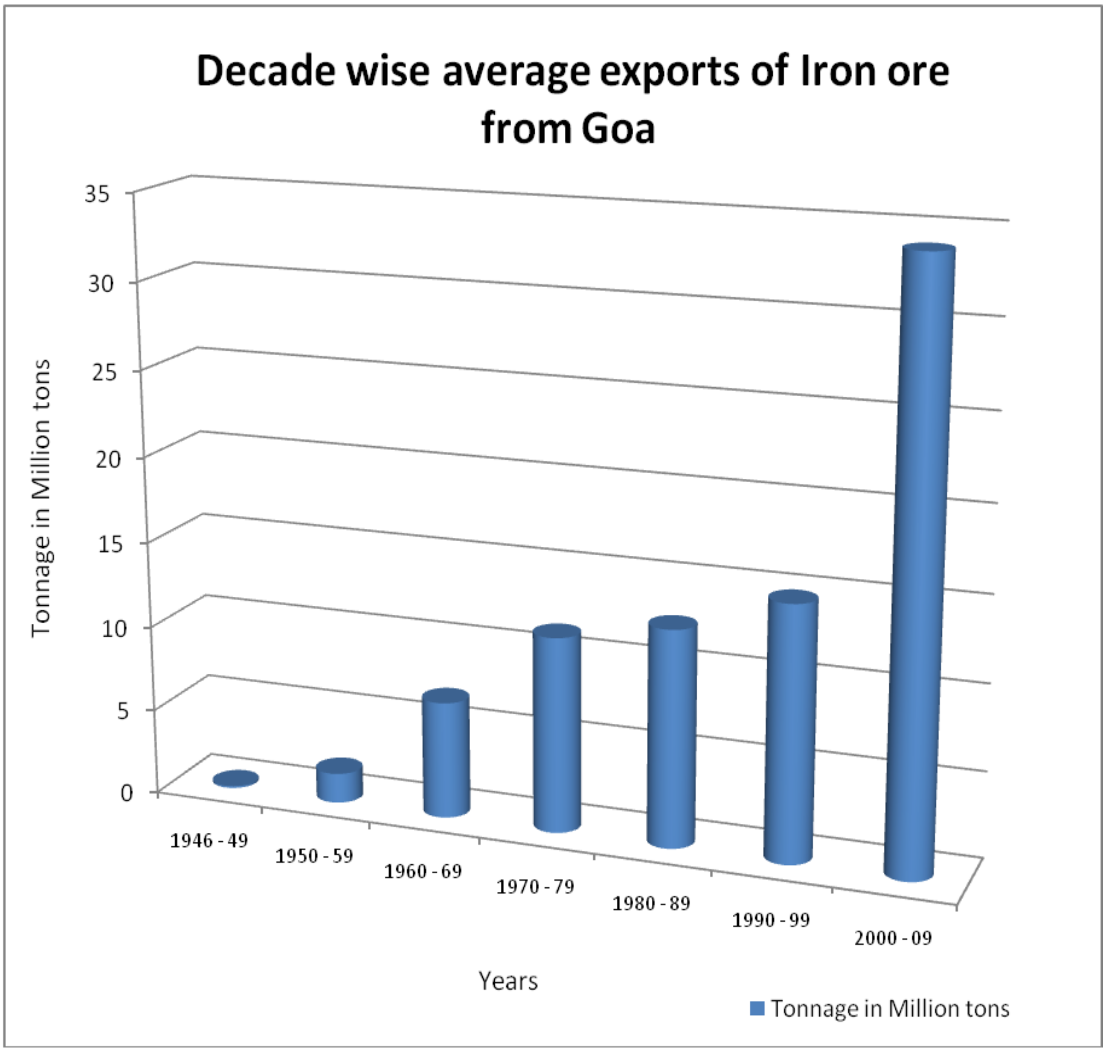


Fig.2.3: Decade wise average exports of iron ore from Goa

The initial mining operations were mostly through manually. The initial mode of carriage of ores from the mines to the loading jetties was by bullock carts, and later ores were carried across by canoes within the port limits where midstream operations were carried out. In course of time, transportation through trucks commenced and bigger canoes evolved in the early 1950’s. The first barge was imported by M/S Chowgule and Co. in the mid 1950’s which had a capacity of 100 tons. Mechanized trucks also replaced traditional movements from roads to jetties.

Thereafter, mining in Goa in the late 1950’s and early 1960’s operations were more semi mechanized and use of motor driven vehicles replaced existing slow means of transportation and even to an extent sizing of ores commenced.

Presently, the Mining Industry in Goa is fairly mechanized. Apart from moving towards beneficiation of ores, the logistic chain also has gone a considerable change. Barges up to 2500 tons are presently used in the inland waters of Goa.

Dumpers of higher capacities of 25-35 tons are introduced for more effective workings within mining leases.

Sea going ships size for export of ore too have increased from handymax (35,000 to 59,000 DWT) to panamax (60,000 to 80,000 DWT) and even to capsize (> 80,000 DWT) to meet to such requirements. In operations of low value bulk minerals economies of scale of operations particularly transportation means is a universal trend that any competing company needs to match to such international pressures in order to survive.

2.3 SOURCES OF IRON ORE FOR EXPORT FROM GOA

Goa has traditionally been 100% export oriented as far as iron ore is concerned. Since Goa has access to ports of discharge it also provides avenues where in ores from neighbouring states as Karnataka also route their exports from Goa. The ore coming from outside Goa generally uses the rail network up to Curchorem – Sanvordem junction and other private rail terminals before as Costi. Although there appear some recent moves to take a part of the ore to the Mormugao port, this will take some time. The rest of the non goan ore is unloaded at Tinnneighat (Karnataka) and finds its way into the state through road network coming from Anmod-Mollem.

2.3.1 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.

2.3.2 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) ore extracted 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. 2.4.

Fig. 2.4: A typical open cast iron ore mine in Goa

2.3.3 Reserves of iron ore

While assessments of determining reserves are constantly on, technological improvements as well as lower of threshold values are bound to augment further reserves. However, as per the current data as available with the Indian Bureau of Mines, the reserves of the major minerals in Goa are as under.

Iron ore:

Tentatively the total estimated in situ reserves as per the Indian Bureau of Mines (as on 1/4/2005) are of the order of 926 million tons (714 million tons haematite and 214 million tons magnetite)

Manganese ore:

The ores are generally poor in grade with manganese content varying from 30-45% Mn. All deposits of economic significance are confined to the southern part of Goa. The estimated in situ reserves as IBM (as on 1/4/2005) are of the order of 19 million tons.

Bauxite:

Bauxite deposits in Goa are chiefly demarcated into 3 categories:

1. North Goa Deposits
2. Central Goa Deposits and
3. South Goa Deposits

The estimated in situ reserves as per IBM (as on 1/4/2005) are of the order of 50.3 million tons.

Limestone:

Occurrence of limestone has also been recorded in the NE corner of Goa in Satari Taluka. The limestone extends over a strike length of 20 km having an average thickness of the limestone zone with intercalations of about 50 m. The strike is roughly NW-SE in the eastern sector which changes to nearly E-W in the western part.

The total estimated reserves of all grades are of the order of around 80 million tons.

In regard to bulk ores, especially iron, it must be also borne in mind that additional reserves could be of lower tenor, which would render the process of beneficiation necessary in order to meet the ore to the requirement of buyers. Improvement in technology coupled with incentives to market such low grade ores would result in additional reserves and therefore life to the industry in Goa. Further with the reduction of threshold values of ores, it is expected that reserves will increase significantly.

Karnataka

GSI estimate of iron ore resources in Karnataka is only up to 40 meters depth whereas the proved depth persistence in Bellary-Hospet is upto 200 meters and as such the reserves may prove to be to the tune of 3000 million tonnes. As per Sesa surveys, the total iron ore resource in Karnataka are to the tune of 9488 million tons. The increase in production has been due to demand from China which resulted in opening up of closed mines in Chitradurga-Thumkur in Karnataka and Redi area in Maharashtra, optimum utilization of production capacities in Bellary-Hospet, Eastern sector and Goa.

2.3.4 Mining leases granted in Goa

In the post war scenario, mining concessions were granted to private entrepreneurs to mine the mineral. In order to maintain administrative control, the area of the concessions was limited to a maximum of 100 hectares each. During the time of grant, 806 concessions were granted. This comprised of almost 578 sq km of (about 16%) of the total geographical area of Goa. Prior to the liberation of the territory, the grant of mining leases was regulated under the Portuguese colonial mining laws. Mining rights were in the nature of mining concessions which were for unlimited period. After liberation the grant of the mining leases is regulated under the Mines and Minerals Act 1957. In the year 1987, the earlier held concessions were abolished and converted in leases.

Presently, about 454 leases exist. Considering the total leases would occupy about 335 sq km or around 9% of the total geographical area of the state. In the recent past, due to a surge in demand for iron ore, the State Government have also received numerous requests for new mining leases in the State.

Nevertheless, without prejudice, out of these existing leases, i.e., 454, presently only around 100 are under active mining operations, in short, not more than 2.5% of the total geographical area is under mining leases, apart from roads, plants, stockpiles and barge loading areas.

2.3.5 Location of the iron ore mining areas in Goa

On the basis of the existing 454 concessions / leases, the locations of iron ore mines in the state of Goa are provided in Table 2.1.

Table 2.1: Mining locations of iron ore in Goa

Sl.No.	Area / Taluka	Total Area (in Sq. Km)	Mining area (in Sq. Km)
1	Tiswadi	166.12	0.70
2	Bardez	264.80	3.37
3	Pernem	242.00	3.80
4	Bicholim	236.33	51.31
5	Sattari	512.84	42.55
6	Ponda	252.28	6.80
7	Sanguem	886.60	184.38
8	Quepem	437.31	36.88
9	Canacona	347.36	6.30
10	Mormugao	78.31	0.00
11	Salcete	277.19	0.40
	Total		335.62

(Source: Kalavampara Glenn J, 2009; A synopsis of Mining Operations in Goa, compiled from Department of Mines and Geology)

Chiefly Sanguem, Bicholim and Sattari are the important talukas / areas where the mineral wealth of Goa exists. The location of iron ore mines in Goa is shown in Fig. 2.5. 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 2.6 and 2.7.

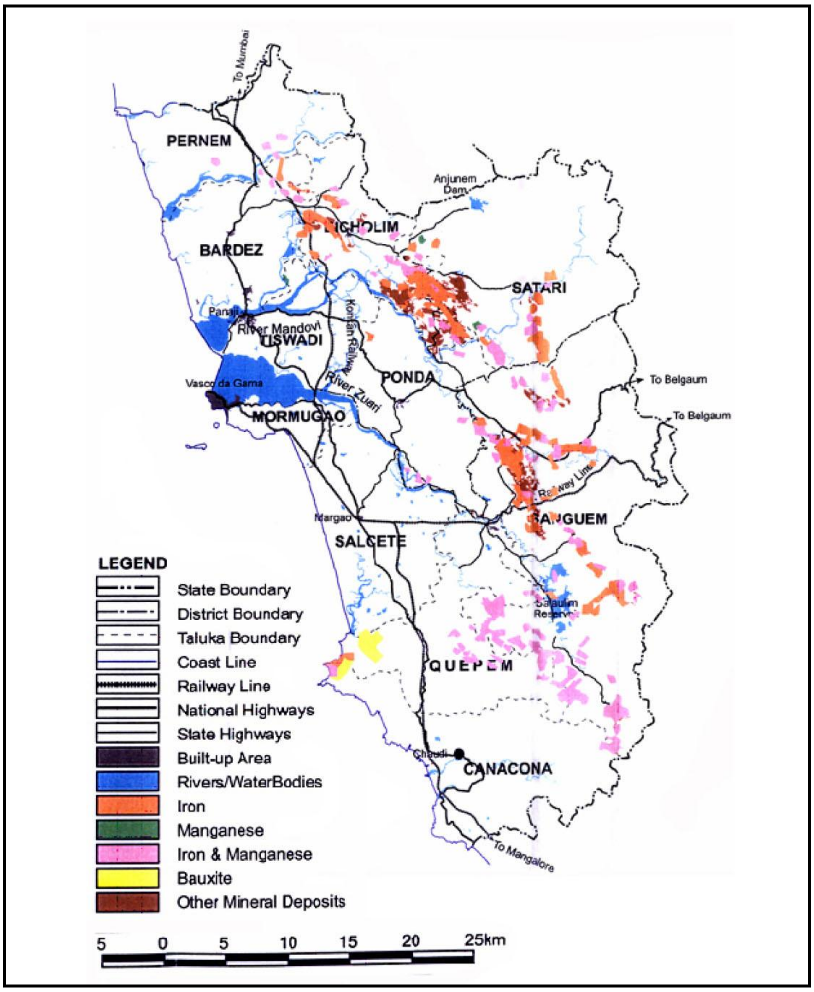


Fig. 2.5: Location of Iron ore mines in Goa

Fig. 2.6: Typical iron ore mines along Zuari river

Fig. 2.7: Typical iron ore mines along Mandovi river

2.4 ADMINISTRATION OF MINING ACTIVITY: HISTORICAL PERSPECTIVE

After the commencement of the mining industry in the district in 1905, need was felt to organize the respective services regarding mining. On April 18, 1906, the then Director of Land Survey was given an additional charge as the Mining Engineer. The Portuguese Colonial Mining Laws came to be enforced by the Decree dated September 20, 1906. The administrative service in connection with the mining activity was centralised by the General Administration Department and a separate mining Section was established on December 17, 1907 to look after this work. Subsequently, the Mining Section was separated from the General Administration Department and was attached to the Land Survey Department. The Director of Public Works Department was appointed as the head of the mining section. Later on, on November 2, 1935, the Minister Section came to be attached to the Public Works Department and it continue to be so till the creation of the Directorate of Economic Services in July 1957 of which the Land Survey Department and the Department of Mines became the wings. However, the Land Survey Department, the Mines Department and the Industries Department functioned under the Public Works Department upto the end of the year 1958.

The Department of Mines was created to look after the sub-soil and its resources in mineral ore of any type, the quarrying of mineral ore and the execution of the Mining Legislation. Under Notification dated September 17, 1962, the Director of Economic Services was inter alia delegated with the following powers:

(1) Collecting mining taxes under Portuguese Colonial Mining Laws (2) Granting licenses for quarrying, construction, rubber and stones subject to the approval of the Port Officer in case the quarrying was done within any Port area. (3) Ordering refund of deposits from mining concessions and land grants. (4) Issuing certificates of inspection of mines. (5) Signing visit books of mines. (6) Approving the selection of the members of the Committee entrusted with the survey of the mining area demarcated for exploration of a mine. Under gazette notifications, dated September 30, 1963, the provision of the Mines Act, 1952, the Mines and Minerals (Regulations and Development) Act, 1957, the Mineral Concession Rules, 1960, and the Mines Rules, 1955, as modified by the Goa Daman and Diu (Laws) Regulation, 1962, came into force in Goa with effect from October 1, 1969. However under the same notification it was declared that Section 16 of the Mines and Minerals (Regulation and Development) Act 1957 was not at that time applicable to Goa. This Section 16 was later on extended to Goa with effect from January 13, 1966.

The provisions of the Mines Act 1952 are enforced by the Directorate General of Mines Safety, Government of India. The Mines Act 1952 provides to amend and consolidate the law relating to the regulations of labour and safety in mines. So, after October 1, 1963, the Mines Department which was hitherto also concerned with the enforcement of the provisions for safety and health of workmen employed in Mines, was left with the following functions:

(1) grant of concessions under Mineral Concession Rules, 1960; (2) collection of

mining taxes including royalty in mineral ore; (3) issue of essential certificate for the import of mining machinery; (4) authorization for sale/transport/ export of mineral ore; (5) issues of licenses for storage of explosives; (6) enforcement of those provisions of the Portuguese Colonial Mining Laws, which were not covered by the Mines Act, 1952 and the Mines and Minerals (Regulations and Development) Act 1957; (7) grant of licenses for quarrying stones in Government land; (8) collection of statistics on production of mineral ore in different mines in Goa. (9) To provide necessary information to the government on the matters connected with mines and minerals in Goa. (10) To attend to public inquiries relating to mines and minerals.

It may be pointed out that the mining industry in the district has developed under the control and guidance of the Mines Department. Even though prospecting of iron ore and manganese was started in Goa as early as in 1905, it was only in 1941 that a sample consignment of 1,000 tons of iron was made to Belgium. Regular export of iron ore was started only in the year 1947 and most of the iron ore was exported to Japan. The speedy development if mining industry in the district was also due to the grant of concessions and due to low taxation on minerals and also nominal import duty on mining machinery. Fixed tax has also been levied on the mineral concessions governed under the Portuguese mining laws. This tax has been to the tune of Rs 4,00,000.00 every year up to 1966. The controller of mining leases has modified some of these concession w.e.f January 1, 1966. After notification of a mining concession, the first tax will not be levied and the leases are liable to pay dead rent from January 1, 1966.

2.5 EXPORTS OF MINERALS

Goa has traditionally been 100% export oriented traffic as far as iron ore is concerned. Since Goa has access to ports of discharge it also provides avenues where in ores from neighbouring states as Karnataka also route their exports from Goa. The ore coming from outside Goa generally uses the rail network up to Curchorem – Savordem junction and other private rail terminals before as Costi. Although there appear some recent moves to take a part of the ore to the Mormugao port, this will take some time. The rest of the non Goan ore is unloaded at Tenneighat (Karnataka) and finds its way in to the state through road network coming from Anmod – Mollem.

At the Mormugao port, ores are either loaded into mother vessels through the mechanical ore handling plant at berth number 9 or through transhipers. Transhipers are often used to up top (compliment loading of) larger vessels. Midstream loading using vessels own grabs are also being carried out. In close vicinity, some transhipers also operate in the Panjim port limits.

The exports of iron ore, manganese ore, bauxite and other minerals using Inland Water Transport barges in Mandovi, Zuari and Cumberjua canals system in Goa from 2003-04 to 2009-10 are presented in table 2.2.

Table 2.2: Exports of mineral ores from Goa

TYPE OF ORE	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10
GOAN IRON ORE	22095993	23149003	25443972	30893953	33263229	38037723	45686900
PALLETS		159030	93952		171200	37500	
TOTAL GOAN IRON ORE	22,095,993	23,308,033	25,537,924	30,893,953	33,434,429	38,075,223	45,686,900
NON GOAN IRON ORE	8442447	9237207	10733726	9642721	6117626	7513548	7445102
PALLETS	186200	42931					
TOTAL NON GOAN IRON ORE	8,628,647	9,280,138	10,733,726	9,642,721	6,117,626	7,513,548	7,445,102
TOTAL EXPORTS IRON ORE GROUP	30,724,640	32,588,171	36,271,650	40,536,674	39,552,055	45,588,771	53,132,002
MANGANESE ORE GROUPS	49050	19786					
BAUXITE					127403	341190	105276
TOTAL MINERALS	30,773,690	32,607,957	36,271,650	40,536,674	39,679,458	45,929,961	53,237,278
GOAN IRON ORE PRODUCTION	23,727,937	21,705,667	25,440,925	30,738,191	31,327,805	32,720,536	41,038,392

From the table it can be seen that the Goa based iron ore exports have been increased progressively from 22.10 million tons in 2003-04 to 45.69 million tons in 2009-10, an increase of 23.59 million tons over a period of 7 years. The exports of non Goan minerals through Goa waterways fluctuate year to year and are of the order of 6.12 million tons to 10.73 million tons. The total exports of minerals, both Goa based and non-Goa based minerals have been however progressively increased from 30.77 million tons in 2003-04 to 53.24 million tons in 2009-10. It means that there is an increase of exports of 22.47 million tons over a period of 7 years. The average annual growth of exports is about 3.21 million tons.
The Compound Annual Growth Rate (CAGR) for total mineral exports (Goan + Non Goan) from 2003-04 to 2009-2010 (last 7 years) is 8.14%. The CAGR for only Goan iron ore exports from 2003-04 to 2009-10 is 10.93%.

In total exports, the percentage of Goa based iron ore exports has increased over the years. From 2004-05 to 2006-07 the average non-Goa based iron ore exports through Goa waterways was accounted for about 27%, and Goa based iron ore exports were about 73%. During the last three years (2007-08 to 2009-10), the

Goa based iron ore exports constitutes about 85% and non-Goa based iron ore exports through Goa waterways contributes about 15% of the total exports.

The Goa based iron ore production has been progressively increased from 21.71 million tons in 2004-05 to 41.04 million tons in 2009-10. There is an increase of production of Goa based minerals of the order of 19.33 million tons in 6 years period with an average annual production of 3.22 million tons. The production versus exports of Goa based minerals are shown in Fig.2.8. Though the quantum of production of Goan iron ore production is at par with exports, the quantum of exports in general exceeds the production quantities since the exports through Goan waterways include the non Goan based ores.

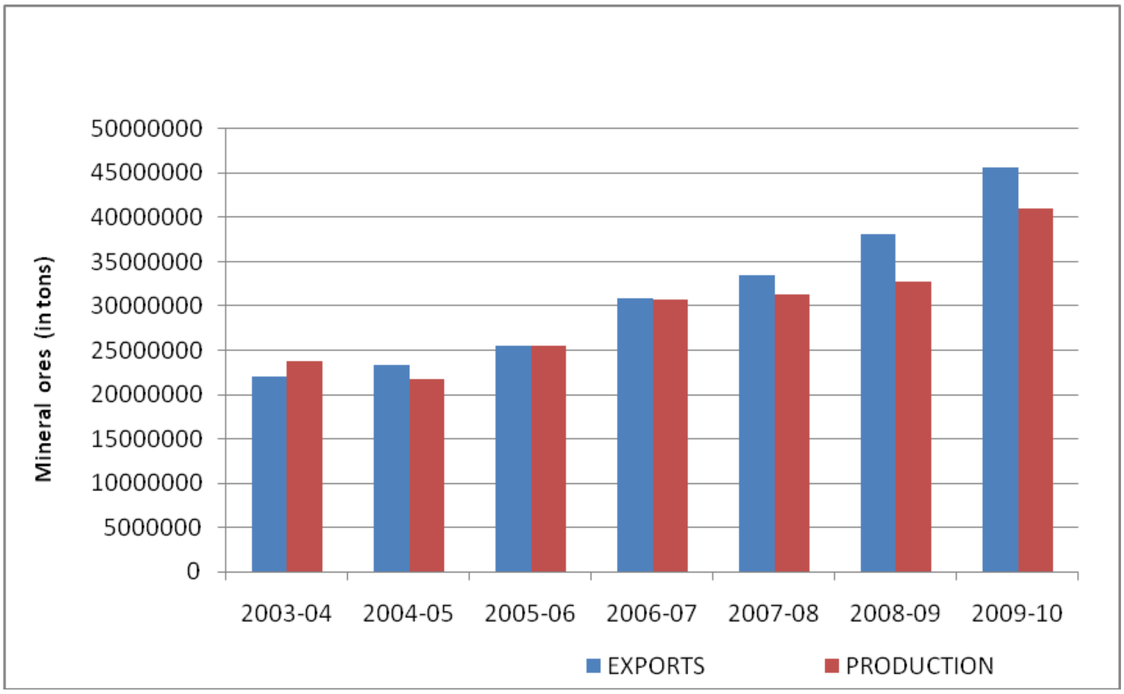


Fig 2.8 : Goan iron ore exports vs production

Goan iron ore exports for the last 16 years from 1994-95 to 2009-10 with classification of iron ore are presented in Table 2.3. The Goan iron ore exports from 1994-95 to 2009-10 and total Goan and Non Goan ore exports from 2003-04 to 2009-10 are shown in Fig. 2.9. To a large extent the classification of Goan ores is predominantly fines. While the Goan iron ore exports in 1994-95 were of the order of 14.75 million tons, the exports in 2009-10 were 45.7 million tons, i.e., an increase of about 31 million tons over a period of 16 years which means an average annual increase of exports of about 13.2%. The percentage increase of Goan iron ore exports from year to year, the annual growth rate, during the last decade is shown in Fig. 2.10. There was a quantum jump in percentage increase of exports of the order of 24% in 2002-03; 21% in 2006-07 and 20% in 2009-10 when compared to their respective previous years. The percentage increase of annual exports is minimum of about 4% during 2001-02 and maximum of 24% during the following year. The CAGR of Goan iron ore exports from 1994-95 to

2009-10 is 7.32%. The CAGR for Goan iron ore exports during the last decade (2001-02 to 2009-10) is 11.01%.

Table 2.3: Goan Iron Ore Exports with Classification (Tons)

FISCAL YEAR	LUMPS	FINES	TOTAL (1+2)	PALLETS	ROM	G.TOTAL
	1	2	3	4	5	6
1994-95	2822611	11883598	14706209	47683		14,753,892
1995-96	3362596	11130688	14493284	290629		14,783,913
1996-97	3514954	10621921	14136875	339622		14,476,497
1997-98	3664683	14408779	18073462	368469		18,441,931
1998-99	3233668	12126420	15360088	80553		15,440,641
1999-00	3148206	11958409	15106615	32700		15,139,315
2000-01	3331432	12741179	16072611			16,072,611
2001-02	3062170	13581720	16643890	54620		16,698,510
2002-03*	3104508	17482941	20587449	101918		20,689,367
2003-04	4112230	17983763	22095993			22,095,993
2004-05	3806980	19342023	23149003	159030		23,308,033
2005-06	4436990	21006982	25443972	93952		25,537,924
2006-07	6207702	24686251	30893953			30,893,953
2007-08	5855461	27407768	33263229	171200		33,434,429
2008-09	5755992	31990991	37746983	37500	290740	38,075,223
2009-10	8038052	37648848	45686900			45,686,900

* Exports during 2002-03 includes 1,729,219 tons of non Goan ore blended with Goan ore

About 80 per cent of the ores exported are fines. China accounts for more than 80 per cent of the total iron ore exports. Most of the iron ore is sold on the global spot market.

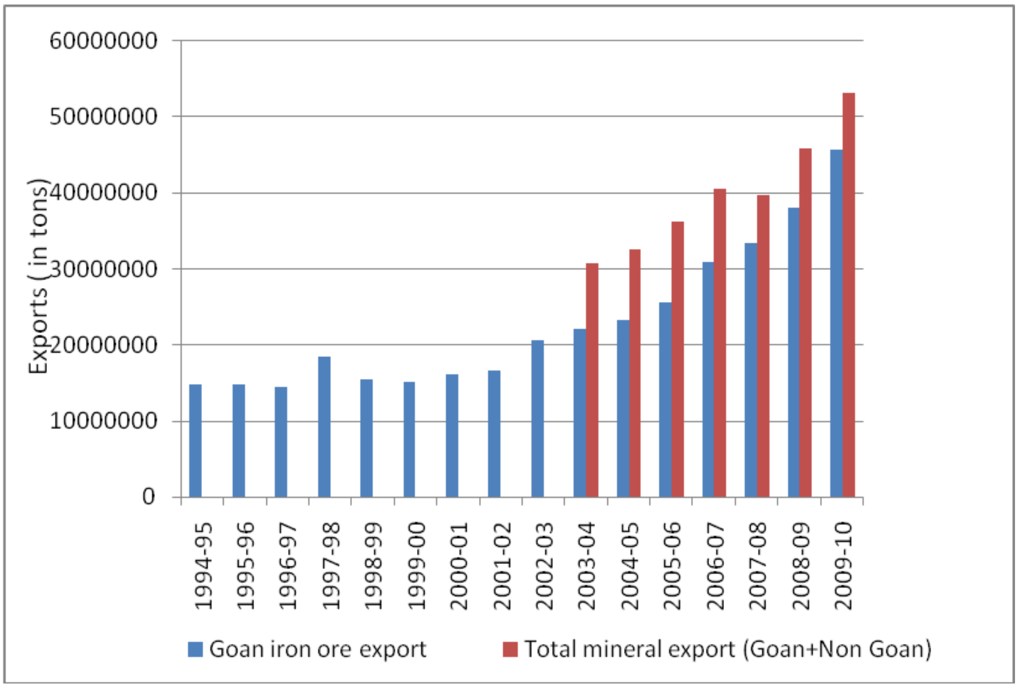


Fig. 2.9 : Exports of Goan and Non Goan ore

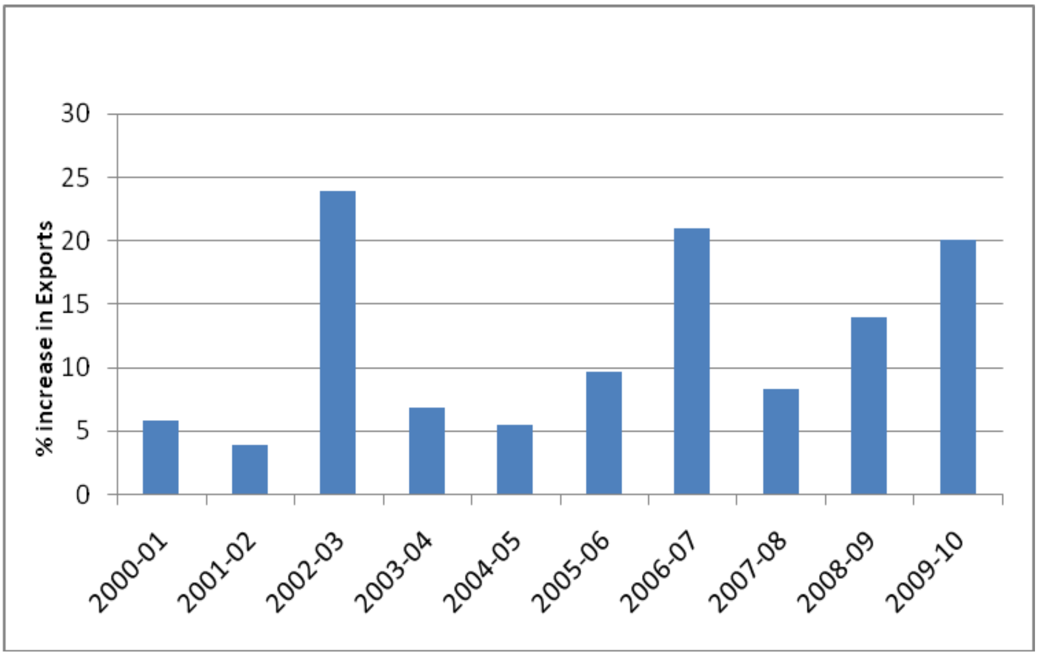


Fig.2.10 : Annual growth rate of Goan iron ore exports

For the financial year 2002-2003, of the total 22.42 million tons of iron ore exported from Goan ports, exports to Japan alone accounted for 45%, China accounted for 38% of the exports, South Korea accounted for 4%, Europe for 10%, while other Asian countries accounted for the remaining 3%.

The situation changed since February 2004, when Chinese demand started picking up and the iron ore industry started getting additional outlet. The prices zoomed and spot market boomed. The steel industry panicked not because it would not get iron ore (which was in surplus) but because they have now to match their price with export price. Till then the mining companies would often visit the steel mills and plead for their product (iron ore) at a price which will be dictated by them (steel mills) and payments made sporadically at leisurely intervals. Now the steel mills would have to come to the mining companies for iron ore and pay the price dictated by market conditions.

2.5.1 Shipper wise goan iron ore exports

The shipper wise Goan iron ore exports during 2009-10 are presented in Annexure – 2.1 whereas the exports of non Goan iron ore through Goa are furnished in Annexure – 2.2. During 2009-10, the exports of Goan iron ore was of 45,686,900 tons, whereas the exports of non Goan iron ore through Goa were 7,445,102 tons and the total exports were 53,132,002 tons. It means the exports of Goan iron ore is constituted about 86% and non Goan iron ore is only 14%. As many as 58 exporters are involved for transportation and export of ore. The earlier shipper wise records of Goan iron ore exports from 2004-05 to 2008-09 are provided in Annexure – 2.3. Based on the past records, there are about 81 exporters are there in this business of iron ore export. All are private operators. The major exporters of Goan iron ore are M/S SESA GOA LIMITED. The only public sector operator is M/S Minerals and Metals Trading Corporation (MMTC). However, the exports of MMTC are only of the order of about 0.1 to 0.6 million tons per annum. On the other hand the exports of M/S SESA Goa Ltd alone are of the order of 4 to 10 million tons per annum.

Shipper and destination wise exports of goan iron ore during 2009-2010 are presented in Annexure – 2.4 whereas non goan iron ore details are in Annexure – 2.5.

A brief about the major players of iron ore export through Goa is furnished below:

SESA Goa Ltd

The mining operations of Sesa Goa Ltd are carried out in the States of Goa, Karnataka and Orissa in India. Iron ore from mines at Karnataka is exported through ports of Goa, Mangalore and Krishnapatnam while iron ore from mines in Orissa is mainly exported through ports of Haldia and Paradeep. Iron ore from mines in Goa is exported through port of Goa. As of 31 March 2010, Sesa owns or has the rights to reserves and resources consisting of 353 million tonnes of iron ore at an average grade of 58.0%. The establishments of Sesa Goa can be seen in Fig. 2.11.
It acquired VS Dempo & Co. Private Limited (VSD) now Sesa Resources Limited in June 2009, which in turn, also holds 100% equity shares of Dempo Mining Corporation Private Limited now Sesa Mining Corporation Limited and 50% equity, shares of Goa Maritime Private Limited. VSD's Goa mining assets includes processing plants, barges,

jetties, transhippers and loading capacities at Mormugoa port.

Sesa Goa goes public with 42,000 Indian shareholders holding 60% of its shares and the remaining 40% held by Finsider International (later became ILVA International). In 2003, Sesa Goa equity in Sesa Industries raised to 88.25%.

Sesa Goa starts a barge construction unit at Sirsaim which has since developed into a Ship Building division. Sesa Shipping is launched in January 1995 with acquisition of Transhipper M.V. Orissa.

The exports of Goan iron ore by SESA Goa Ltd by 2009-10 was about 15 million tons and non Goan iron ore through Goa waterways was about 1.14 million tons with a distribution of exports to various countries with percentages of 83% (China), 3% (Europe), 3% (Japan), 4% (South Korea) and 7% domestic.

M/S Sesa is world's top four iron ore mining companies. Their project iron ore production for the year 2013 is 50 million tons in their mines located in Goa, Karnataka and Orissa. Out of which 20 million tons production is in Goa.

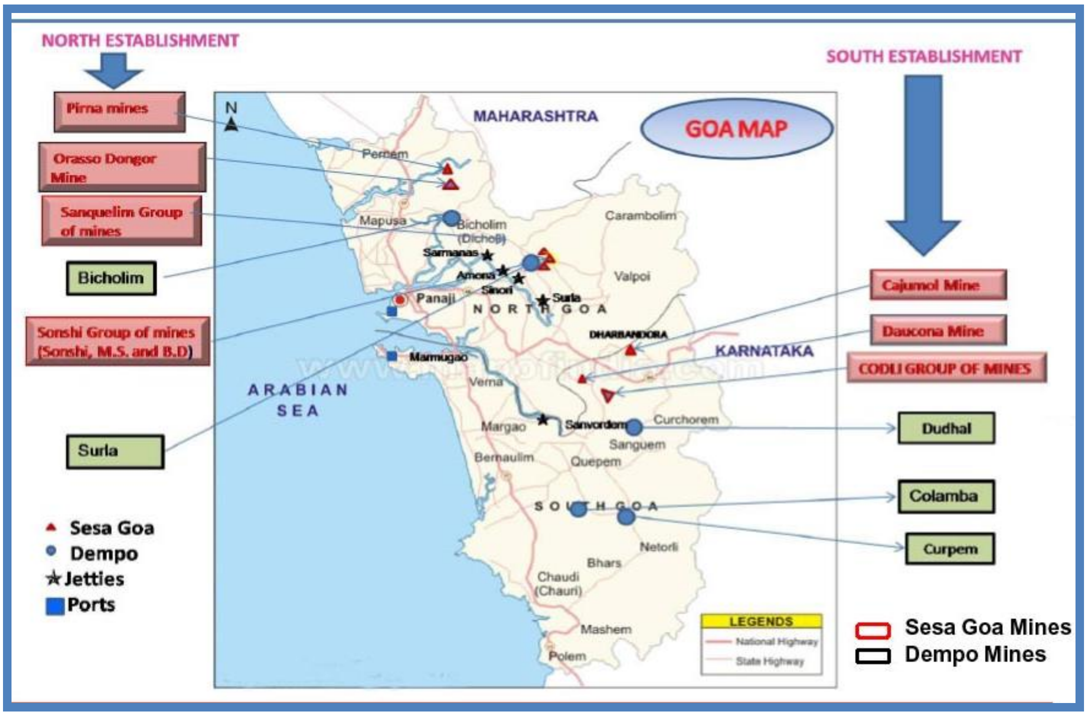


Fig.2.11 : The establishments (mines) and loading jetties of Sesa Goa / Dempo

CHOWGULE & CO. PVT. LTD.

Established in 1941, Chowgule and Co. Private Limited is the parent Company of Chowgule Group of Companies. The Company laid the foundation of industry in Goa and made pioneering contribution to its development. The Company shipped 1,500 tonnes of manganese ore to Czechoslavakia in 1947. And in 1950, a shipment of 9,000 tonnes of iron ore to Japan, opened new economic vistas not only for the Company, but also for Goa.

In 1951, adopting a unique combination of practical, down-to-earth approach and a 'vision', the Company wrote a new theory of success. A theory best exemplified by the 'Chowgule Formula' - a historic agreement signed by the Company with the Japanese steel industry. The arrangement was unique. The Japanese would loan out equipment, men, and money to mechanize their mines. And the Company would repay the loan through the cost of the ore exported to Japan. A brilliant strategy that boosted the volume of iron ore exports from Goa. And the beginning of a saga of success. The saga continues even today with exports of 5.5 million tons in 2009-10.

The mechanization of mines was soon followed by modernization of the transport system that carried the ore and loaded it onto the ships for export. Slow and inadequate country craft was traditionally used for transporting iron ore through the inland waterways up to the sea port. The Company ordered self-propelling barges from Japan, speeding up delivery time and cutting costs. Naturally, these barges needed maintenance. So, a repair yard was built. Moving over from repairing barges, the yard started building barges with its' own expertise. Before long, the yard was putting out different kinds of vessels onto internationals waters.

Innovation in Ship loading: The ore was loaded onto a ship in a traditional way. That is loading a ship partly alongside the port, due to 'low draft'. And the rest, mid-stream, by winch-loading. Only to delay the dispatch of a vessel. So in 1969, the Company introduced the 'uptopping' by a Transhipper - an ocean-going vessel equipped with conveyor belts and cranes that drew alongside a ship mid-stream and loaded the ore onto the ship. Dispatch of vessels was now quicker.

As the volume of exports grew, it soon became evident that the ore-handling facilities at Mormugao Port were highly inadequate. Bottlenecks were slowing down the speed of dispatch and increasing freight charges and demurrage. Taking the initiative yet again, the Company solicited Japan's help and a completely mechanized, all-weather ore-handling plant was installed at Berth no. 6 at Mormugao Port. Designed to work around the clock, the plant at once liberated the Goan Iron Ore industry. Saving time and money. And making it more internationally competitive in world markets. And also set the pace for a bigger Mechanical Ore-Handling Plant, now in operation.

V.M. Salgaocar Group

M/S V.M. Salgaocar and Bro.Pvt. Ltd. (VMSB) is a flagship company and a leader in the Iron Ore trade in Goa and on the West Coast of India. The company exported its first consignment of 16,500 tons of iron ore to Nippon Steel Corporation (NSC) in 1952. Since then, the company has been a competitive and reliable supplier of processed iron ore to NSC and POSCO, besides other steel mills in China, Romania and the Middle East. The company has planned, integrated approach to the business process that encompasses surveying, extracting, processing, transporting by trucks and barges, transshipping and handling at Berth No. 9 at the Mormugao Port.

The Company has its own mining leases in Goa. Since its inception, VMSB has continuously updated itself with the latest developments in technology to become a fully integrated iron ore company. It has invested in heavy earth moving excavators, trucks, dumpers, generators, screening and beneficiation plants, ore loading facilities and barges. VMSB owns and operates its own transfer vessel at Mormugao Port and has commissioned in 2006 a state –of-the –art transshipper, in a joint venture with another Goan company, at Panaji Port.

The present iron ore exports of Group are over 4 million tons per annum which can be augmented to over 5 million tons to meet additional demand. It has the resources and technology to undertake further expansion in Goa and other states to meet the growing needs of the world's iron and steel industry.

Transportation of ore: The VMSB transports the ore from the mines to the Port by both road and river. The Mandovi river is the main artery for the transport of ore, along its 24 nautical miles from the Vagus Loading Point down to the Mormugao Port. A new ore loading facility at Amona will expand the capacity by another 25,000 tons per day. A fleet of 10 barges, with a total capacity of 22,200 tons, handles the movement of iron ore from the loading point to the Murmugao Port. Barges are also hired as and when required to ferry the additional tonnages.

Port Operations: The Mechanical Ore Handling Plant (MOHP) at Berth No. 9 of Mormugao Port can load vessels up to Length Over All (LOA) of 305 m with a permissible draft of 14.0 m. The MOHP has ship loading capacity of 8000 tons per hour. It has 8 Barge Unloaders, one Continuous Barge Unloader (CBU) and three Stackers with a rated capacity of 2000 TPH, which stockpile the cargo into the stack yard through a conveyer system connected to the Barge Unloaders. A large plot is allotted to VMSB at the MOHP to stockpile iron ore. The stockyard can accommodate up to one million tons of iron ore. Two Bucket Reclaimers reclaim the stocked iron ore, each with a capacity of 4000 tons per hour. Two Ship Loaders, with a rated capacity of 4000 TPH each, discharge the cargo into the vessels docked alongside Berth No. 9. The average loading rate achieved at MOHP Berth No. 9 is 45,000 tons per day.

Transshipping Operations: Panamax size vessels are fully loaded at Berth No. 9 of Mormugao Port Trust at the rate of around 45,000 tons per day. Large Cap sized Vessels are also loaded at Berth No. 9 of the Mormugao Port Trust up to a draft of 14.0 m and are topped up by utilizing Transshippers. The VMSB has its own Transshipper, the M.V. Swatirani, with average loading rate of 20,000 tons per day. The VMSB has jointly owned another Transhipper M.V. Goan Pride, with M/S V.S. Dempo and Co Pvt. Ltd. The Goan pride transhipper can be seen in Fig.2.12. This is a state-of –the-art, modern Cape-size Transhipper Vessel with a storage capacity of over 100,000 tons and aload rate capacity of 4500 tons/hour. The annual handling capacity is estimated at 5.0 million tons. It is capable of loading Vessel up to 300,000 DWT. The vessel meets all International standards for ship to ship transfer, environment and safety.

The Goan Pride Transhipper will have the capacity of loading Panamax Vessels in one day and larger size cape vessels up to 300,000 DWT in three to four days, bringing Goa at par with the loading facilities of the leading iron ore exporting countries like Australia and Brazil. The addition of MV Goan Pride to the export facilities already existing at Mormugao Port Trust and at Panaji Port is expected to increase the exports through the ports of Goa to an all time high with a competitive edge over other exporters from around the world.

Fig. 2.12: Sea Bulk Transshipper (SBT) Goan Pride

The Sea Bulk Transshiper (SBT) is a geared bulk carrier with a self-unloading system for the purpose of transshipping mainly iron ore. Ore carrying barges are loaded up the Mandovi and Zuari Rivers near the mine. The barges will travel 22 nautical miles out to deeper water near Marmagao where the SBT will be used to transship the iron ore into Cape Size Ocean going vessels.

2.5.2 Destination wise exports of Goan iron ore

The destination wise exports of Goan iron ore are presented in Table.2.4. Goan ores are exported mostly to Asian countries, although Japan and South Korea have been traditional markets (Table 4). In the recent years, exports to China have increased considerably. However, the iron ore production and export has been a response on the world demand and supply position, it would be necessary to remain competitive by reducing costs on rising expenditure in the mineral ore industry in the long run. From this angle, the optimal use of Goa waterways for transportation of ore would be the ideal solution.

As per the EXIM policy, Goan ores can be exported to certain countries such as Japan, china, South Korea and Taiwan without any restriction of grade. However, for all other countries, grades up to 64% are permissible. But in any case, bulk of Goan ores to the extent of almost 100% is under 62% Fe.

Table 2.4: DESTINATION WISE EXPORTS OF GOAN IRON ORE					
			Quantity in tons		
S.NO.	DESTINATION	2006-2007	2007-2008	2008-2009	2009-2010
1	CHINA *	21,268,124	24,865,317	32,629,521	40,596,249
2	JAPAN	5,704,563	4,766,284	3,557,775	3,457,749
3	NETHERLANDS	649,194	628,505	265,704	387,097
4	RUMANIA	915,331	789,900	339,300	111,900
5	ITALY			75,509	78,830
6	TURKEY	166,710	149,650		
7	BELGIUM	189,590			
	EUROPE TOTAL (3 TO 7)	1,920,825	1,568,055	680,513	577,827
8	SOUTH KOREA	1,058,374	1,142,904	545,228	969,195
9	PAKISTAN	312,225	610,252	258,029	1,380
10	U.A.E.	111,107	210,967		84,500
11	QATAR			85,340	
12	KUWAIT			65,492	
13	DUBAI			51,500	
14	KENYA	33,000		38,500	
15	SAUDI ARABIA			29,125	
16	OMAN	12,000			
	TOTAL DIRECT	30,420,218	33,163,779	37,941,023	45,686,900
1A	CHINA *	473,735	270,650	134,200	-
	TOTAL GOAN CANALISED	473,735	270,650	134,200	-
	GRAND TOTAL	30,893,953	33,434,429	38,075,223	45,686,900

The percentage distribution of destination wise exports of Goan iron ore to various countries is shown in Fig.2.13. From the figure it is clear that about 81% exports are to China. About 12% of the exports are to Japan and 2.5% of exports to South Korea and the balance 4.5% of exports are to other countries as shown.

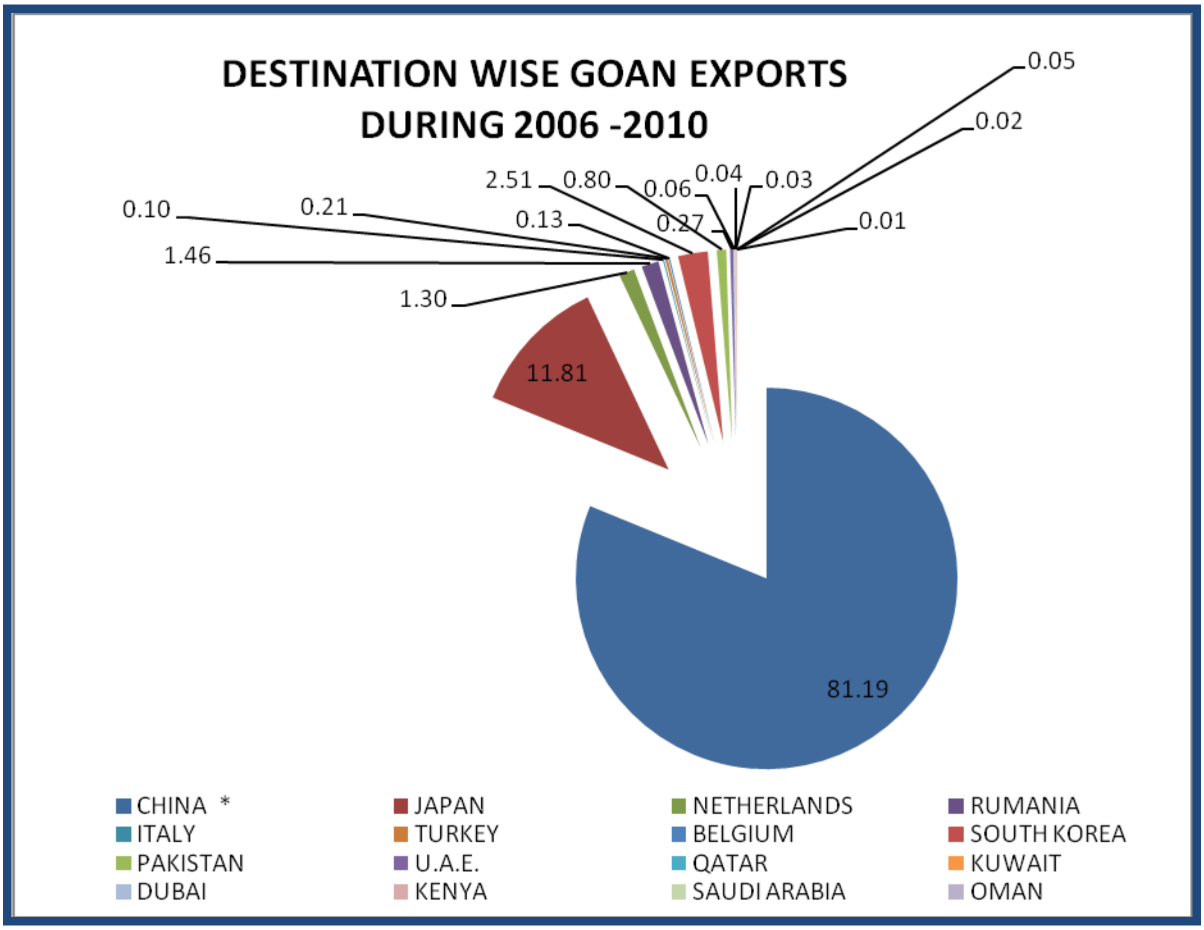


Fig 2.13 : Percentage distribution of destination wise Goan ore exports

The list of parties import iron ore exported from Goa are from Japan, China, Europe & other Asian countries as follows:

Japan

- Nippon Steel Corporation (NSC)
- NKK Corporation
- Kawasaki Steel Corporation
- Kobe Steel Limited
- Nissho Iwai Corporation
- Kawasho Corporation
- Nisshin Steel Co. Ltd.
- Kanematsu (Hong Kong) Ltd.
- Marubeni Singapore Pte. Ltd.

- Shinwa Kigyo Co. Ltd.
- Mitsui & Co. Ltd.
- JFE Steel Corporation
- Sumitomo Corporation

China

- Mitsubishi Corporation
- Chinese Steel Mills
- Ma-Steel International Trade & Economic Corpn.
- PT Resources Pty. Ltd.
- Chertsey International Ltd.
- Pioneer Metals Co. Ltd.
- Sinoluck Shipping Co. Ltd.
- Fremery Resources Ltd.
- Kanematsu (Hong Kong) Ltd
- Cargill International Trading Pte. Ltd.
- Leading Shipping Co. Ltd.
- Caterpillar World Trading Corporation
- Asia Target Enterprises Ltd.
- Noble Resources Ltd.
- Sumitomo Corporation
- Burwill Resources Ltd.
- Venlaks Inc.
- Sino Source Industries Ltd.
- China Chem Co. Ltd.
- Red Horse Resources (Hong Kong) Ltd.
- Beijing CSGC Tiantie Iron & Steel Trade Co. Ltd.
- Adani Global Pte Ltd.
- Sundial International Trading Co. Ltd.
- D. T. Resources Ltd
- General Nice Recursos Commercial Offshore De Macau
- Top Resources Hong Kong Ltd.
- Greathill International Ltd.
- Rizhao Steel Holding Group Co. Ltd.
- China Mining Resources (S) Pte. Ltd.,
- Flower Ocean Enterprise Limited
- Bright Ruby International Limited
- Zhejiang Materials Industry International Co. Ltd.
- China National Building Material & Equipment
- China Shandong Iron & Steel Products Co. Ltd.
- Prosperity Steel United Singapore Pte. Ltd.

Europe

- Ilva S.P.A., Genoa, Italy
- Marin Gasoil Montecarlo, Italy
- N. V. Sidmar, Ghent, Belgium
- Ispat Sidex S.A., Romania

- Corus UK Ltd.

Other Asian Countries

- China Steel Corp. Taiwan
- Emirates Trading Agency (L.L.C.) Dubai
- Commodities Trading Co. (LLC), U.A.E.
- GBA Products Co. Ltd., Posco, South Korea
- Pakistan Steel Mills Corporation (P) Ltd., Pakista

The Goa Mining Association (GMA) is a sister concern of the GMOEA. The GMA is body like the GMOEA which safeguards, promotes and handles the problems of various mine owners who mine iron as well as manganese ores. This Association has strength of 70 members. Membership for the Goa Mining Association is open to any mine owner whose lease is located within the State of Goa.

2.6 IRON ORE PRODUCTION AND EXPORT - A GLOBAL SCENARIO

China General Customs Administration declares that China imported 618.63 million tons of iron ore in 2010 with 1.4% decreased on year-on-year basis.

Reuters quoted according to data issued by customs that Chinese imports of iron ore from Brazil and India fell sharply during 2010 while Australian shipments inched up slightly over the years.

Shipments from India fell 9.98% to 96.59 million tonnes in 2010, and Brazilian deliveries declined by 9.09% to 130.86 million tonnes compared to a year earlier. Imports from Australia reach 265.33 million tons up by 1.36% year over year.

China stung by its dependence on the three dominant global supplier countries, vowed early last year to diversify its sources of iron ore. Australia, Brazil and India provided 79.7% of China total iron ore imports over 2010 down from 81.5% in 2009 and much of the gap was met by increasing shipments from countries such as Iran, Ukraine and Venezuela.

The import price rises constantly due to index pricing system applied in iron ore in 2010. Data shows that the iron ore import in the whole year of 2010 decreases by 9 million mt than that of 2009, while the amount of USD78.9 billion expenses increases by USD28.7 billion from 2009.

According to The United Nations Conference on Trade and Development (UNCTAD) REPORT ON IRON ORE (June, 2010), the World production of iron ore fell by 6.2% in 2009 to 1.6 billion tons. This was the first fall in production after seven years` consecutive growth period. Output decreased in most countries, with a few notable exceptions such as Australia and South Africa but this was not enough to stop the fall. China which used to be the largest producer has now been pushed down (on the converted iron ore content basis) to fourth place at 234 Mt, after Australia at 394 Mt, Brazil at 300 Mt, and India at 257 Mt.

Despite the recession, iron ore trade reached a new record level in 2009 as exports increased for the eighth year in a row and reached 955 Mt, up 7.4 % compared to 2008. The increase was the result of higher demand in China combined with a fall in domestic production.

The three largest iron ore companies, Vale, Rio Tinto and BHP Billiton increased their control over global iron ore production to 35.4 % in 2009 (34% in 2008). The "Big Three" control 61% of the world seaborne trade of iron ore. New iron ore mining capacity taken into operation in 2009, reached almost 75 Mt globally.

The world iron ore market will be characterized by tight conditions and the next few years - by a gradual adaptation of supply, by way of addition of new capacity, to a continuously growing demand. Accordingly, it is believed that supply will gradually catch up and that prices will decline from the present extreme levels, but will stay at a higher level than in the period before 2008.

As reported by China Mining Industry, it is understood that, China will increase its iron ore production to 1.5 billion tons by 2015 up from 1.1 billion tons in 2010 in a bid to reduce its reliance on imports.

The production of finished iron ore is projected to reach 760 million tons by 2015 when demand will be about 1.3 billion tonnes. That will reduce China import dependency rate to about 42% from 63% in 2010.

Meanwhile, overseas iron ore mining rights controlled by Chinese miners will increase to 200 million tons by 2015 from the current 90 million tons as Chinese companies quicken the pace of overseas mine acquisitions.

The global iron ore production and its distribution country wise, global iron ore exports and its distribution country wise based UNICTAD report can be seen in Figs 2.14 to 2.17.

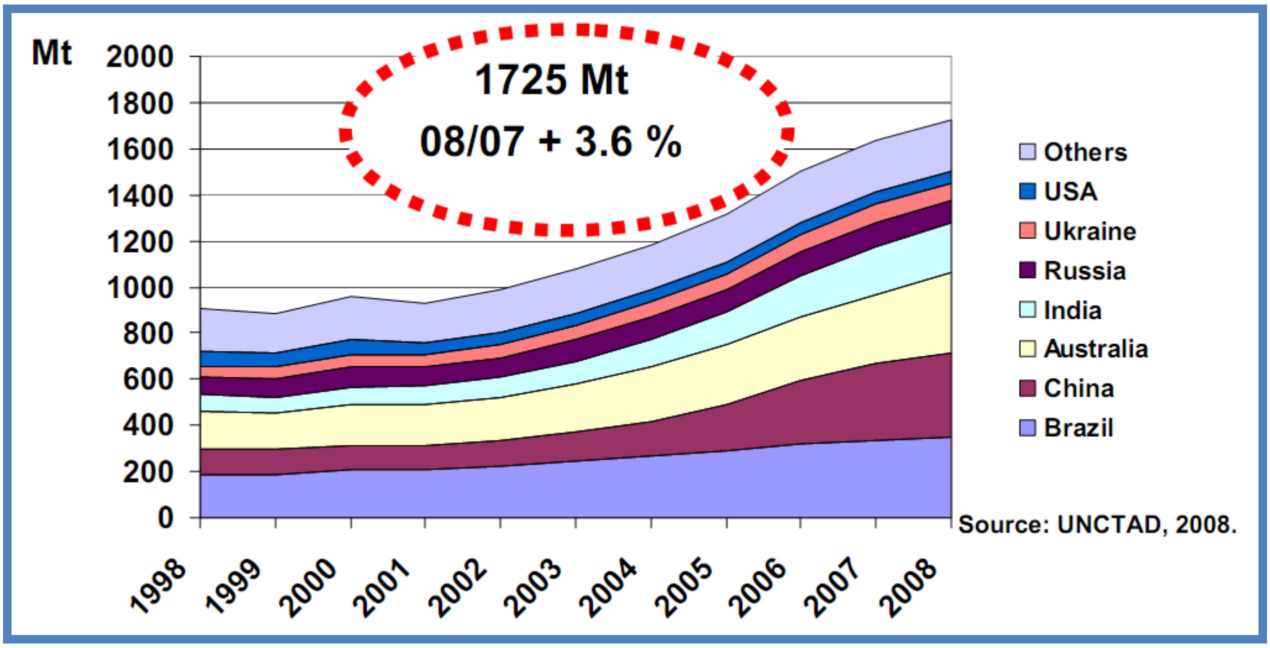


Fig. 2.14: Global iron ore production

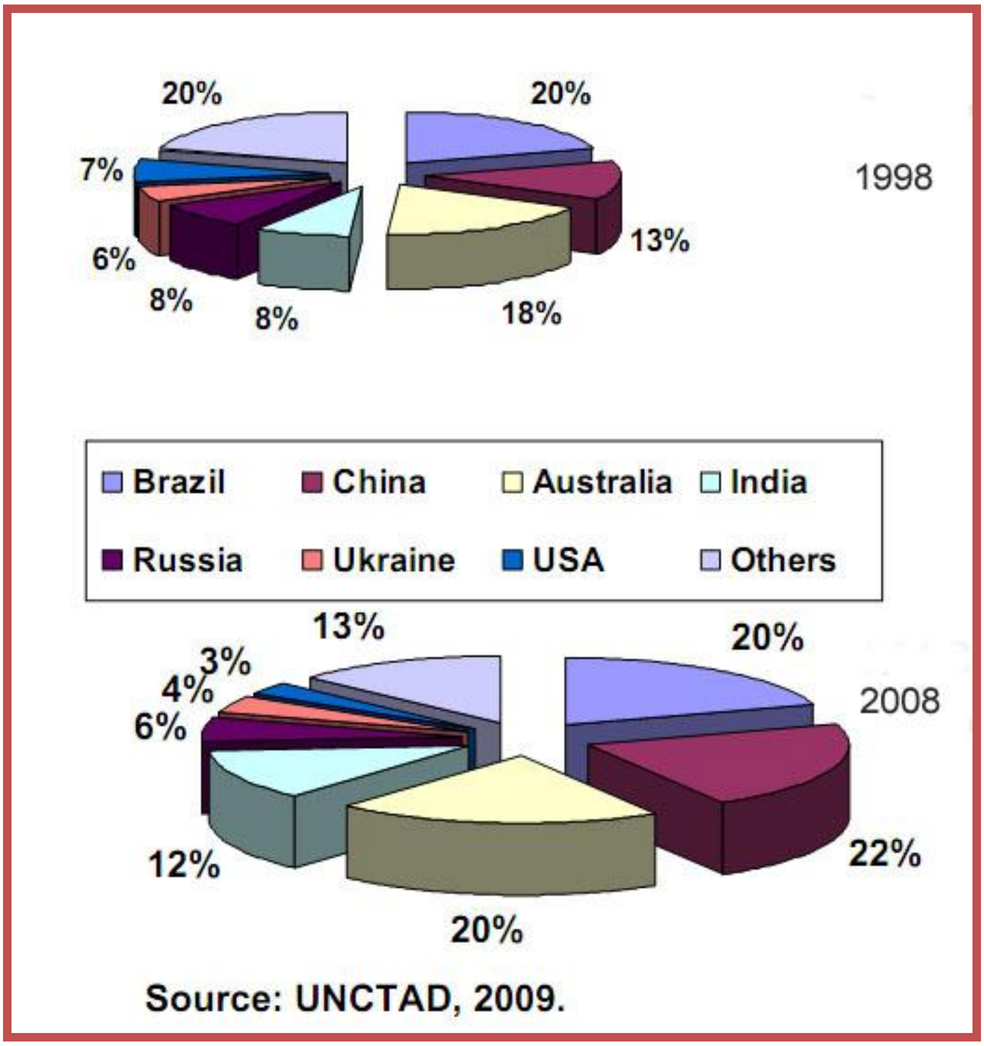


Fig.2.15: Comparison of Global Iron ore production

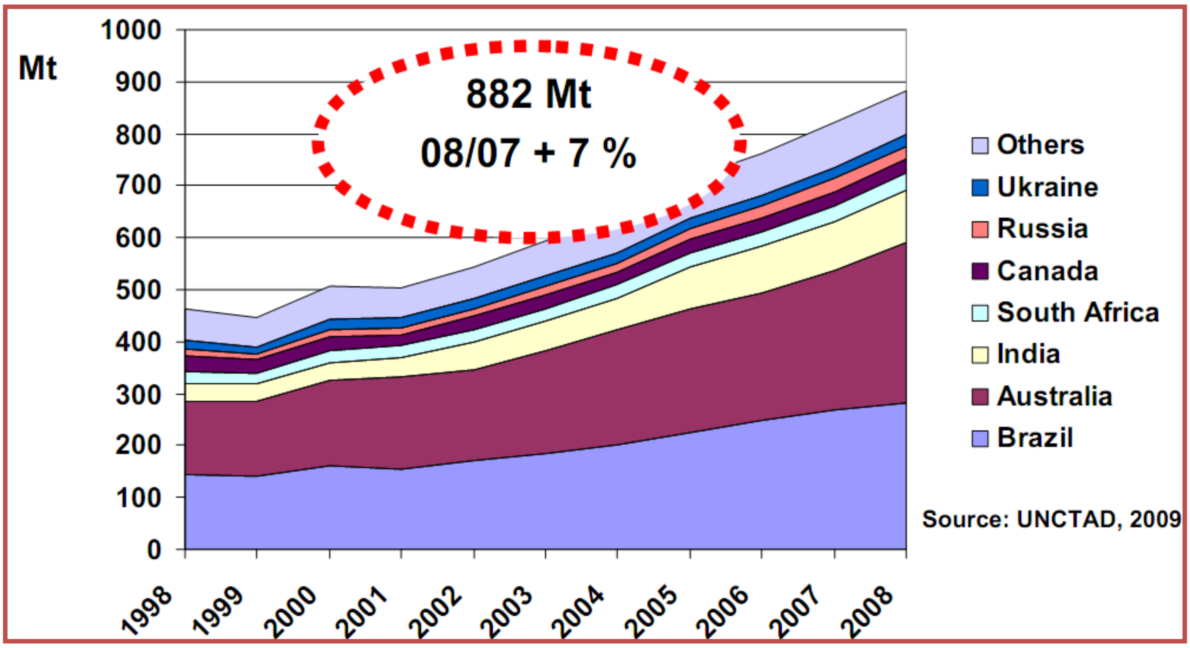


Fig. 2.16: Global Iron ore exports

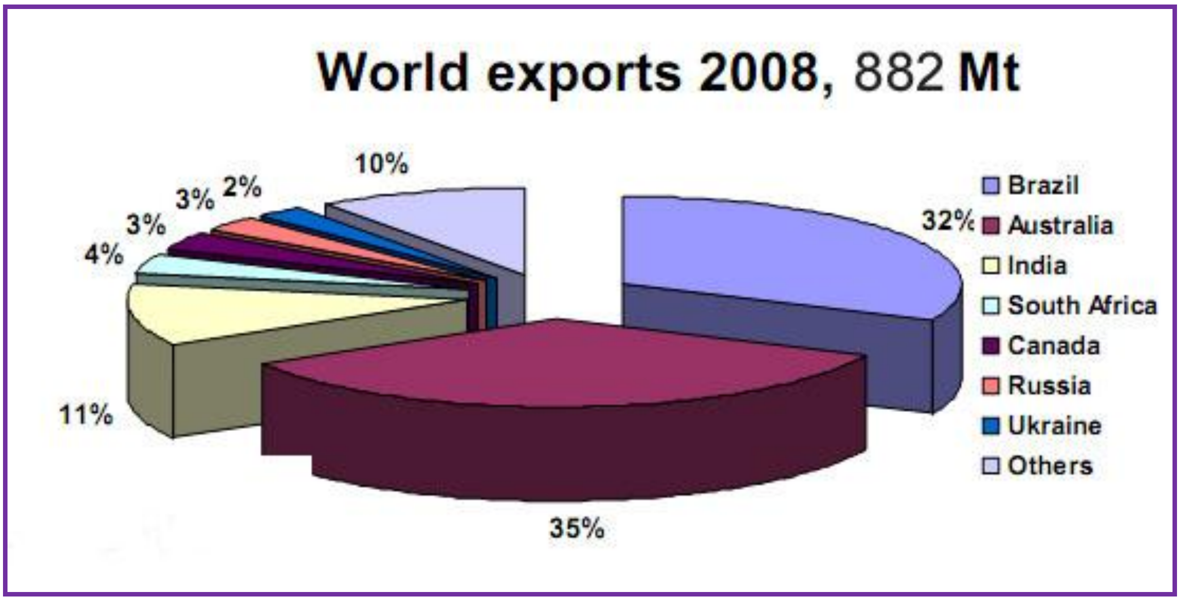


Fig. 2.17 : World Iron ore exports - 2008

2.7 EXPORT POLICY FOR IRON ORE

- The present EXIM policy permits export of iron ore from Goa and Redi sector to all destinations by the iron ore producers; irrespective of the iron content.
- KIOCL is the canalizing agency for its own products (iron ore concentrates and iron ore pellets) since it is a 100% E.O.U. (export oriented unit).
- The export of iron ore with Fe content above 64% is canalized through MMTC.
- Export of Iron of Goa origin to China, Europe, Japan, South Korea and Taiwan (irrespective of Fe content) and Export of ore from Redi region to all markets (irrespective of Fe content) is not canalized.
- However, some types of high-grade iron ore (Fe content above 64%) from specific areas like Bailadila in Chattisgarh are allowed to be exported with restrictions on quantity imposed primarily, with a view to meet domestic demand on priority.
- Present quantitative ceiling of iron ore fixed by the Govt. are as under:

	AREA	ANNUAL QUANTITY (in Million Tonnes)
a)	Bailadila Lumps	Not Exceeding 3.00 MT
b)	Bailadila Fines	Not Exceeding 3.80 MT
c)	High Grade Lumps (Bellary-Hospet Sector)	No limit
d)	High Grade Fines (Bellary-Hospet Sector)	No limit

(Source : Foreign rade Policy, DGFT)

2.8 CURRENT ISSUES AND CHALLENGES

- Ban on transportation of iron ore from the neighbouring Karnataka and the truckers' strike in Goa is worrying the mining industry in the state as these factors might downscale the exports of iron ore for the ensuing season.

- Goa Mineral Ore Exporters Association (GMOEA) predicts the downfall to at least 10 per cent considering the trend of exports till December 2010. The state has exported 28 million tonnes of ore till December 2010, which is much less compared to the seasonal expected total of 53 million tons. Of the total expected 53 million tons, 45 million tons was from the 100 local mining leases while rest was transported from neighboring Karnataka. Since there is recent ban on transportation of ore from Karnataka, and also local factors like strike by truckers play a role for downsizing the iron ore exports to a tune of 10% lower than the expected.

- Many expert agencies have expressed their doubt if the iron ore exports to China can be increased continuously. Although demand for iron ore is increasing due to the strong growth of steel production in the country, consolidation within the Chinese industry and their long term supply concerns are already making them dependent on long term contracts as against spot purchases. Given the fragmentation and regulation in the mining sector in India, it is unlikely that the Indian miners will get engaged in long-term contracts. The India-centric spot market will thus become considerably unattractive.

- Profitability in iron ore exports varies across regions depending on the state of infrastructure in and around the mines, transport logistics, quality of the ores and local factors, etc.. Profitability is significantly lower for exports from the eastern India compared to those from the south. Actual profits coming to the miners are fairly high on an average, yet, significantly lower than those in the popular perception.

- The profitability of the exporters will be sharply hit if the export tax is to be raised. Such a measure will hit the merchant mining companies in the private sector the most, a segment that has accounted for the bulk of the growth in the industry.

- The issue of conservation of iron ore for domestic industry may be reviewed, if there is need for it, as recommended by the Hoda Committee after 10 years or so. Any stoppage to exports will necessarily mean closure of significant mining capacity as the volumes cannot be diverted to domestic use under any circumstances. Closure of mines will involve naturally expected consequences in terms of loss of economic activities including jobs.

- India, the world's third largest iron ore exporter, had shipped over 100 million tonne iron ore in 2009-10 and 70-80% of that is in the form of fines for which export duty has been raised four-times to 20% in the recent budget (2011-12). For lumps, the duty has been raised to 20% from 15% and for fines, the duty raised to 20% from 5% earlier. Because of the hike in export duty, no fresh contracts are signed now. Only earlier contracts are being honoured. Though the impact of export duty hike is not being immediately felt, it will be felt in longer run.

- Karnataka, India’s second-largest iron ore producing state, banned exports of the commodity and said it would stop issuing permits to transport ore to ports for export.

- There is a view that the government may consider imposition of an environmental and social cess on mining to be used fully in rehabilitation and resettlement of the displaced or those affected by mining in the neighbourhood and in specific programmes to mitigate the adversity arising out of the environmental damage.

- Lack of investment in iron ore mining can be attributed partly to a long spell of low iron ore prices worldwide. During 1987-2002, i.e. a span of fifteen years, iron ore fines prices increased only 14.63per cent. It was only during 2002-2007 that the prices increased by a huge 184.4per cent in five years. Even the global seaborne trade in iron ore increased only 23per cent during 1996-2002, while the same jumped 35.34 per cent in the next three years.33 Prospects of iron ore were also under cloud due to stagnation of the steel industry the world over and the low profitability in it due to constant pressure on prices resulting from excess capacity.34 In India, non-captive iron ore market was small and with export prices not so attractive either, there were little incentives to invest. Most of the mining interests in the country were focused on deposits already well prospected and assessed. The Indian government owned exploration agencies like GSI and MECL were focused more on the coal sector. It is only after the China-triggered boom in global iron ore market that huge opportunities came the way of the Indian merchant miners. This led to some improvement in investment and production. But still, bulk of the additional production came from the existing mines which were running at much lower and rather inefficient levels of capacity utilization earlier.

- Investment in such activities as iron ore mining also needs corresponding investment in transport and logistics infrastructure. The mining capacity can be developed at a quick, but, infrastructure development takes a lot of time. With infrastructure development largely a government responsibility, effective mining capacity enhancement has been low so far. Given the government’s increased focus on developing transport infrastructure, especially in the roads and railways sectors, mining capacity development is expected to gain pace.

- The other major constraint seen in raising greenfield iron ore capacity with fresh investment is the fact that many of the major mines are now under legal battles over leasing rights. Some of them pertain also to the disputes arising out of certain State government decisions to transfer the leases to some other parties. Such legal battles in many cases are expected to be long drawn if the prior experiences in India are any indication.

- Investment in iron ore exploration and mining is essential to realize the full potential of India's rich iron ore resources. In the past, factors such as infrastructure constraints, depressed prices and delays in clearances had adversely affected the pace of investments in this sector. However, with the global boom in the market and the resultant increase in investor interest, there is a potential to raise the level of investment provided the policy and regulatory environment is considered conducive by investors.

- The China government has imposed a ban on import of low grade iron ore while major Chinese companies are buying up ore mines with two billion worth of reserves in Africa. Three Chinese companies including the M/S Wuhan Iron & Steel, are jointly buying a mine with reserves worth 800 million tonnes at Soalala in Madagascar. M/S Wuhan has also purchased controlling stakes in the Bong Iron Ore company based in Liberia. Bong has proven reserves of over 1.3 billion tonnes. The ban will surely have an effect because about 50% of our exports are low grade iron ore. India sold 107 million tonnes accounting for 18% of Chinese imports in 2009. The ban came into effect after the China Iron and Steel Association (CISA) advised ore buyers at a conference to stop buying low grade ores. Though, CISA has not yet issued a formal notification but the ban is already having an effect.

- As per the National Steel Policy estimates in 2005 the total demand of iron ore is placed at 290 million tonnes including 190 million tonnes for domestic consumption & 100 million tonnes for export by 2019-20.

2.8.1 Issues Regarding Future Exports of Iron Ore

- The studies conducted by Australian Bureau of Agricultural and Resource Economics (ABARE) have forecast that the iron ore production in India can grow only at about 6.5 per cent annually to reach about 250 million tonnes by 2012. The report says that if Indian government removes or significantly reduces the impediments to Greenfield iron ore expansions, the future iron ore production growth in India could rise faster. The report, however, forecasts iron ore exports from India to grow annually only at about 4.6 per cent a year.

- India's iron ore export potential to China will also depend on the relative competitiveness of Indian iron ore exporters' vis-à-vis suppliers from Australia and Brazil. As per ICRIER study, the country-wise trend of imports of iron ore into China shows that iron ore exports to China increased by 13.1 per cent from Australia in 2006 over the previous year. The corresponding figures for Brazil, India and South Africa were 39.6 per cent, 9 per cent and 19 per cent respectively. There was also a record of a significant fall in the share of Indian origin ores in the total imports of China. It is interesting to see from the data that China has significantly diversified its iron ore sourcing as more and more ores are being imported from relatively smaller source countries like Peru, Kazakhstan, Iran, Venezuela, Philippines, Vietnam, Chile, Ukraine and even Canada and Russia. Imports from many of these countries are in the agglomerated form (pellets).

- The AME Group, a global firm of independent economists in the metal and mineral industries with research offices in Australia and affiliations in China, North America, South America and Africa forecasts that China will soon account for over 50% of traded world seaborne iron ore imports. China is also pursuing strategic targets overseas, acquiring significant overseas equity and encouraging the development of overseas projects for iron ore imports. Though the year 2009 was initially a bad year for iron ore exporters, with substantial fall in prices, in late 2009 spot producers reveled in prices approaching US$135/t in a sign that supply is stretched in meeting Chinese import demand and the recovered growth in the rest of the world. China is the key driver of the global iron ore industry, and will remain this way for the foreseeable future.

- Changes in Chinese steel production hold the greatest influence over world iron ore trade, as the appetite for high quality ore will be satisfied by imports.

- Despite a surge in domestic mine output, which jumped by over 16% CAGR from 2000 to 2009 on a run-of-mine basis, China remains the dominant buyer.

- Chinese iron ore demand is primarily driven by GDP growth, which considerably exceeds Western World growth rates, rapid industrialization and urbanization on a huge scale.

2.9 TRAFFIC FORECAST

To arrive at the traffic forecasts for iron ore export which is a major and in fact the only cargo moving by barges in Goa waterways, an assessment of several factors that influence the trade in iron ore has been made are briefly highlighted below:

Positive indications

- The eleventh five year plan has projected the iron ore demand of the country at about 156 million tonnes by 2011 – 12. India has exported around 95 million tons of iron ore during the current fiscal (2009-10) which is almost half of its annual output of about 200 million tons, with the bulk of it going to top consumer China.

- Goa has been the biggest exporters of iron ore of India. Among all the ports of India, Goa has been 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 around 40% for the period of 2006-07 through 2008-09.

- Goa has exported 53.24 million ton of iron ore in the year 2009-10. The compound annual growth rate for Goan iron ore export during the last decade (2001-02 to 2009-10) is about 11 %.

- As per National Steel Policy (2005), the total demand of iron ore likely to increase to 290 million tonnes by 2019-20 both on account of domestic requirements (190 million tonnes) and export (100 million tonnes), capacity of around 305 million tonnes per annum (MTPA) is required at 95% capacity utilisation by 2019-20.

- The Goa state economic survey 2009-10 has indicated that the Gross State Domestic Product (GSDP) of Goa at constant prices has registered a compound annual growth rate of 7.5% during the period 1999-2000 to 2008-09 and 10.7% during the eleventh plan (2006-07 to 2010-11). The iron ore mining and export has registered an annual growth of 4.7% in 2008-09 in terms of GSDP at constant prices. The average growth of 4% can be considered in terms of GSDP.

- Global trade in iron ore has increased from 445 million tons in 2001 to 675 million tons in 2005 at a compounded annual growth rate of 11%. Iron ore imports by the rest of the world has grown by only 3% while the Chinese demand for iron ore has grown by 31%.

Negative impacts

- The China government has imposed a ban on import of low grade iron ore.
- Changes in Chinese steel production hold the greatest influence over world iron ore trade, as the appetite for high quality ore will be satisfied by imports.
- The major Chinese companies are buying up ore mines with two billion worth of reserves in Africa.

- According to The United Nations Conference on Trade and Development (UNCTAD) REPORT ON IRON ORE (June, 2010), the World production of iron ore fell by 6.2% in 2009 to 1.6 billion tons. This was the first fall in production after seven years` consecutive growth period. Output decreased in most countries, with a few notable exceptions such as Australia and South Africa but this was not enough to stop the fall. China which used to be the largest producer has now been pushed down (on the converted iron ore content basis) to fourth place at 234 million tons, after Australia at 394 million tons, Brazil at 300 million tons, and India at 257 million tons.

- As reported by China Mining Industry, it is understood that, China will increase its iron ore production to 1.5 billion tons by 2015 up from 1.1 billion tons in 2010 in a bid to reduce its reliance on imports.

- India's iron ore export potential to China will also depend on the relative competitiveness of Indian iron ore exporters' vis-à-vis suppliers from Australia and Brazil.

- The export duty for iron ore fines which Goa exports have been raised four-times to 20% in the recent budget (2011-12). For lumps, the duty has been raised to 20% from 15% and for fines, the duty raised to 20% from 5% earlier. Because of the hike in export duty, no fresh contracts are signed now. Only earlier contracts are being honoured. Though the impact of export duty hike is not being immediately felt, it will be felt in longer run.

  In view of the large diversifying scenarios and also keeping in view of the volatile international market, the traffic forecasts have been made under three scenarios - low, medium and high. The assumptions involved in each of these scenarios include general economic, political, industrial trends, GDP growth rate of Goa, competitive situation etc.

2.91 Forecast of Iron Ore Exports

The exports of iron ore from Goa are based on the demand from China as it is the largest iron ore importer from Goa. The second biggest importer is Japan followed by South Korea and European countries. While the compound growth rate of exports to china in the recent period zooming, the growth rate of exports to other countries has been declining.

The forecast of iron ore exports is rather complicated and involve several uncertainties such as political, economical, volatility in international market demand, competition etc. The forecast has been made considering the growth in iron ore export continues with lesser pace at an average recent growth rate of state GDP and iron ore demand in the world market particularly China. Further the export of iron ore to international market has been considered separately for China alone and all other countries together (Japan, South Korea, Pakistan, European countries etc.)

Table: Traffic projections - Iron Ore export

Year	Iron ore in tons		
	Export to China	Export to Other countries	Total
2010	47,533,430	5,598,572	53,132,002
2011	49,434,767	5,822,515	55,257,282
2012	51,412,158	6,055,415	57,467,573
2013	53,468,644	6,297,632	59,766,276
2014	55,607,390	6,549,537	62,156,927
2015	57,831,686	6,811,519	64,643,204
2016	60,144,953	7,083,980	67,228,933
2017	62,550,751	7,367,339	69,918,090
2018	65,052,781	7,662,032	72,714,814
2019	67,654,892	7,968,514	75,623,406
2020	70,361,088	8,287,254	78,648,342
2021	73,175,532	8,618,744	81,794,276
2022	76,102,553	8,963,494	85,066,047
2023	79,146,655	9,322,034	88,468,689
2024	82,312,521	9,694,915	92,007,436
2025	85,605,022	10,082,712	95,687,734

SHIPPER - WISE EXPORTS OF GOAN IRON ORE DURING 2009-10

Annexure 2.1

Quantity in tons

S.No.	SHIPPER	FINES	LUMPS	TOTAL
1	SESA GOA LIMITED	9565953	1728025	11293978
2	V.S.DEMPO & CO. LIMITED	3961766	753499	4715265
3	V.M.SALGAOCAR & BRO. PVT. LIMITED	2940715	1203610	4144325
4	V.M.SALGAOCAR SALES INTERNATIONAL	970303	364657	1334960
5	SOCIEDADE DE FOMENTO INDL. PVT. LTD.	2261335	487730	2749065
6	PRIME MINERAL EXPORTS PVT. LIMITED	1927785	699733	2627518
7	FOMENTO (KARNATAKA) MINING CO. PVT. LTD.		4390	4390
8	CHOWGULE & COMPANY PVT. LTD.	2892380	279198	3171578
9	CHOWGULE & COMPANY(SALT) PVT. LTD.	154210		154210
10	SALGAOCAR MINING INDUSTRIES PVT. LTD.	2249326		2249326
11	TUNGBHADRA MINERALS PVT. LTD.	145500		145500
12	TIMBLO PRIVATE LIMITED	885718	174768	1060486
13	TIMBLO ENTERPRISES	757780	244461	1002241
14	PEC LIMITED	1182629	346692	1529321
15	DAMODAR MANGALJI & CO. LTD.	1343850	409368	1753218
16	MSPL LIMITED	679186	428103	1107289
17	V.G. METHA EXPORTS	377755	156422	534177
18	BANDEKAR BROTHERS	198614		198614
19	VENTURES RESORTS HOLDING	161200		161200
20	VASSANTRAM METHA & CO. PVT. LTD.	52200		52200
21	VENTURE REAL STATE	50000		50000
22	MINESCAPE MINERALS PVT. LTD.	442812	73313	516125
23	DINAR TARCAR RESOURCES (INDIA) PVT. LTD.	340866	87854	428720
24	KARISHMA EXPORTS	375383		375383
25	KARISHMA GOA MINERAL TRADING PVT. LTD.	109882		109882
26	KARISHMA GLOBAL MINERAL EXPORTS PVT. LTD.	106509		106509
27	PHULCHAND EXPORTS	411280	147480	558760
28	RAJARAM BANDEKAR (SIRIGAO) MINES PVT. LTD.	344450	39400	383850
29	NARAYAN BANDEKAR & SONS PVT. LTD.	20700	70160	90860
30	RAJARAM N.S. BANDEKAR & CO. PVT. LTD.	46000		46000
31	D.B. BANDODKAR & SONS PVT. LTD.	360845		360845
32	SHREE BHAVANI MINERALS	80640		80640
33	ORIENT (GOA) PRIVATE LIMITED	10066		10066
34	GANGADHAR NARSINGDAS AGRAWAL	407634		407634
35	SHREE MALLIKARJUN SHIPPING	282515		282515
36	KLA INDIA PUBLIC LIMITED	208783	68200	276983

37	MUKTAR MINERALS PVT.LTD.	177484	80459	257943
38	PRASANNA V. GHOTAGE	139700	58900	198600
39	STAR PVG EXPORTS	20000		20000
40	SUHAS V. GHOTAGE	135227		135227
41	GHOTAGE LOGISTICS PVT. LTD.	60393		60393
42	MAGNUM MINERALS PVT. LTD.	168859		168859
43	UPSURGE MULTI TRADE PVT. LTD.	63470	31775	95245
44	SHANTDURGA TRANSPORT COMPANY P. LTD.	40000	54600	94600
45	PANDURONGA TIMBLO INDUSTRIES	73000		73000
46	ESMERALDA INTERNATIONAL (EXPORTS)	53978		53978
47	BILASRAIKA SPONGE IRON INDIA PVT.LTD.	52532		52532
48	RAMACANTA V.S. VELINGKAR	46700		46700
49	RAMACANTA VELINGKAR MINERALS	4851		4851
50	GENERAL NICE MINERAL RESOURCES (INDIA) PVT. LTD.	49770		49770
51	MINERALS & METALS TRADING CORPORATION	47100		47100
52	SSTA LOGISTICS (INDIA) PVT. LTD.	44895		44895
53	RAWMIN MINING & INDUSTRIES PVT. LTD.	44000		44000
54	BEML LIMITED	43499		43499
55	KRUPADEEP TRADERS	43320		43320
56	BEST GRAND MINERALS PVT. LTD.		42000	42000
57	ASHAPURA MINICHEM LIMITED	33500		33500
58	ALPINE INTERNATIONAL		3255	3255
	TOTAL GAON ORE	**37648848**	**8038052**	**45686900**

Annexure 2.2

SHIPPER - WISE EXPORTS OF NON GOAN IRON ORE THROUGH GOA DURING 2009-10

Quantity in tons

S.No.	SHIPPER	FINES	LUMPS	TOTAL
1	PRIME MINERAL EXPORTS PVT. LTD.	529278	259699	788977
2	SOCIEDADE DE FOMENTO INDL. PVT. LTD.	124685	36750	161435
3	FOMENTO (KARNATAKA) MINING CO. PVT. LTD.		139391	139391
4	SESA GOA LIMITED	860640	277574	1138214
5	PEC LIMITED	771662	542691	1314353
6	MSPL LIMITED	214530	107200	321730
7	ZEENATH TRANSPORT COMPANY	314827		314827
8	MINERALS & METALS TRADING CORPORATION	163710	64600	228310
9	ALPINE INTERNATIONAL	136160	47565	183725
10	BGH EXIMS LIMITED	179085		179085
11	SHANTDURGA TRANSPORT COMPANY P. LTD.	159957		159957
12	MUKTAR MINERALS PVT. LTD.	51500	108400	159900
13	ESMERALDA INTERNATIONAL (EXPORTS)	101733	54000	155733
14	BAGGADIA BROTHERS	153117		153117
15	DODDANAVAR BROTHERS	152670		152670
16	SUHAS V. GHOTAGE	77688	33100	110788
17	GHOTAGE LOGISTICS PVT. LTD.	38207		38207
18	PRESIDENCY EXPORTS & INDUSTRIES LTD.	98815		98815
19	SSTA LOGISTICS (INDIA) PVT. LTD.	97950		97950
20	KLA INDIA PUBLIC LIMITED	96838		96838
21	RAMACANTA VELINGKAR MINERALS	96424		96424
22	SHREE MALLIKARJUN SHIPPING	95635		95635
23	ORIENT (GOA) PVT. LTD.	28314	62128	90442
24	MINERAL ENTERPRISES PVT. LTD.	90060		90060
25	TUNGBHADRA MINERALS PVT. LTD.	69812		69812
26	SHIV SHIPPING	66950		66950
27	DECAN MINING SYNDICATE (P) LTD.		63000	63000
28	YAZDANI	54800		54800
29	MYSORE SALES INTERNATIONAL	54441		54441
30	KARISHMA EXPORTS	43073		43073
31	KARISHMA GLOBAL MINERAL EXPORTS PVT. LTD.	5598		5598
32	KARISHMA GOA MINERAL TRADING PVT. LTD.	5318		5318
33	GNG EXPORTS	53510		53510

34	INFRASTRUCTURE LOGISTICS PVT. LTD.		51630	51630
35	SWETHA EXPORTS	51000		51000
36	BHARAT MINES & MINERALS LTD.		46918	46918
37	ICG INDIA	45817		45817
38	FAIRDEAL	45488		45488
39	MUNIR ENTERPRISES	44098		44098
40	BILASRAIKA SPONGE IRON INDIA PVT. LTD.	43700		43700
41	KB STEEL	42200		42200
42	GREMACH INFRASTRUCTURE EQUIPMENT & PROJECTS LTD.	42175		42175
43	PMS VENTURES	40761		40761
44	TWENTY FIRST CENTURY WIRE ROADS LTD.		39470	39470
45	MODEL BUCKET & ATTACHMENTS PVT. LTD.	31210		31210
46	CAUVERY COFFEE TRADERS	24612		24612
47	BEML LTD	23588		23588
48	MULTIPLE EXIM	22700		22700
49	FROST INTERNATIONAL LIMITED	22500		22500
50	ICG TRADING	22150		22150
51	ZANN COMMODITIES PVT. LTD.	22000		22000
	TOTAL	**5,510,986**	**1,934,116**	**7,445,102**

SHIPPER - WISE EARLIER GOAN IRON ORE & PALLETS EXPORTS

Annexure – 2.3

Quantity in tons

S.No.	SHIPPER	Year				
		2004-05	2005-06	2006-07	2007-08	2008-09
1	SESA GOA LIMITED	4288326	4830205	4802390	7529441	10210820
2	V.S.DEMPO & CO. LIMITED	3853138	3445994	3998095	3644954	4347543
3	V.M.SALGAOCAR & BRO. PVT. LIMITED	2664248	2544722	3289305	3365130	3269000
4	CHOWGULE & COMPANY PVT. LTD.	2499515	3507155	3288653	2900071	3053484
5	SALGAOCAR MINING INDUSTRIES PVT. LTD.	1523702	1655404	1336730	2460435	2708666
6	SOCIEDADE DE FOMENTO INDL. PVT. LTD.	1230625	1023339	2003935	2496103	2348970
7	PRIME MINERAL EXPORTS PVT. LIMITED	270670	443668	618526	991011	1644432
8	DAMODAR MANGAL JI & CO. LTD.	643692	351864	741058	1282371	1609731
9	TIMBLO PRIVATE LIMITED	1136822	1240824	854461	942712	1192689
10	PEC LIMITED				348550	1005108
11	TIMBLO ENTERPRISES	642141	536649	674515	700263	658996
12	KARISHMA EXPORTS	137568	22563	124350	223250	568559
13	BANDEKAR BROTHERS PVT. LTD.	267402	303925	450240	250336	496503
14	V.M.SALGAOCAR SALES INTERNATIONAL	505902	585111	622773	836980	488920
15	V.G. METHA EXPORTS	156951	259265	627107	249616	436570
16	ON & OFFSHORE HITECH ENGINEERS P. LTD.					255334
17	D.B. BANDODKAR & SONS PVT. LTD.	191430	265948	416895	195088	252375
18	MINESCAPE MINERALS PVT. LTD.					249960
19	VASSANTRAM METHA & CO. PVT. LTD.	138842	168450	53300	54100	248970
20	CHOWGULE & COMPANY(SALT) PVT. LTD.	190915				222200
21	PRASANNA V, GHOTAGE		313932	993123	493938	211476
22	SHREE KRISHNA ENTERPRISES					206272
23	GANGADHAR NARSINGDAS AGRAWAL				182423	187175
24	PHULCHAND EXPORTS	25800			311850	168734
25	RAJARAM BANDEKAR (S) MINES PVT. LTD.		50815	264651	376318	168374
26	VENTURES RESORTS HOLDING		54700	460020	146702	159470
27	RAJARAM N.S. BANDEKAR & CO. PVT. LTD.					142660

28	BAGGADIA BROTHERS					134398
29	SHREE MALLIKARJUN SHIPPING		647512	991619	284925	125587
30	FOMENTO (KARNATAKA) MINING CO. PVT. LTD.					119964
31	ALPINE INTERNATIONAL					114983
32	MSPL LIMITED					103550
33	MAGNUM MINERALS PVT. LTD.					72560
34	TRIMURTHI EXPORTS	46369	80904	435302	378342	71900
35	SHREE BHAVANI MINERALS				69610	63600
36	RIKA GLOBAL IMPEX LIMITED					57700
37	SUHAS V. GHOTAGE				41290	51678
38	RAMACANTA V.S. VELINGKAR	51000	197503	97605	41800	50700
39	KARISHMA GOA MINERAL TRADING PVT. LTD.			42000	89000	50650
40	NAWAZ EARTHMOVERS					50345
41	VENTURE REAL ESTATE				40200	46500
42	NARAYAN BANDEKAR & SONS PVT. LTD.			83853	152919	46300
43	RAMACANTA VELINGKAR MINERALS				47268	45051
44	R. PIYARELAL GLOBAL IMPEX LIMITED					44000
45	STAR PVG EXPORTS			628631	312534	38000
46	MUKTAR MINERALS PVT. LTD.					37900
47	CHOWGULE & COMPANY PVT. LTD. (MANDOVI PALLETS)	208485	93952		171200	37500
48	CANARA OVERSEAS LIMITED					28000
49	SHANTDURGA TRANSPORT COMPANY P. LTD.					22345
50	ADANI ENTERPRISES LIMITED				79852	14821
51	STCL LIMITED			302559	523305	
52	INFRASTRUCTURE LOGISTICS PVT. LTD.	96574	214960		173794	
53	KARISHMA IMPEX	43510	142575	165510	139770	
54	RE - SORT AND EXPORT				116850	
55	KINNETA MINERALS & METALS				115307	
56	DODDANAVAR BROTHERS		80337	36052	84000	
57	PVGE EXPORTS PVT. LTD.				81928	
58	SRI KUMARSWAMY MINERAL EXPORTS			30115		
59	METAL SCRAP TRADING CORPORATION LTD.		39640	23400		
60	DAMODAR MANGAL JI MINING		245427			

61	WEST BENGAL ESSENTIAL COMMODITIES		169443			
62	V.S. LAD MINING CO.		41250			
63	STATE TRADING CORPORATION		40516			
64	INTEGRAL LOGISTICS CO. PVT. LTD.		39704			
65	RELIANCE POLYCATE		8593			
66	LINDSAY INTERNATIONAL (p) LTD.	1302457	723103	301571		
67	ANANT V. SARMALKAR			189165		
68	V.S. LAD & SONS			124543		
69	ADANI EXPORTS LIMITED		48520	98410		
70	SUNRISE MINING CO. PVT. LIMITED	101935				
71	SKANDA EXPORT COMPANY	71505				
72	N.S.I.L. EXPORTS LIMITED	70365				
73	BHARAT MINMET CORPORATION	69450				
74	KARISHMA GOODS SERVICE	46440				
75	SALLITHO ORES PVT. LIMITED		116110	428386	74935	
76	GENERAL NICE RESOURCES				49943	
77	ZEENATH TRANSPORT COMPANY		208059	759664	48700	
78	PHATARPEKAR ASSOCIATES		9668	35370	44300	
79	GHOTAGE LOGISTICS PVT. LTD.		163593		18000	
80	ORIENT (GOA) PRIVATE LIMITED	185912	76201	26336	2635	
81	S.S. EXPORTS	39619				
	TOTAL BY GOAN SHIPPERS	**22701310**	**24992103**	**30420218**	**33164049**	**37941023**
	M.M.T.C. (GOAN ORIGIN ONLY)	**606723**	**545821**	**473735**	**270650**	**134200**
	GRAND TOTAL	**23308033**	**25537924**	**30893953**	**33434699**	**38075223**

Annuxure – 2.4

SHIPPER AND DESTINATION WISE EXPORTS OF GOAN IRON ORE DURING 2009-2010

Quantity in tons

Sl. No	SHIPPER	JAPAN	CHINA	SOUTH KOREA	EUROPE	PAKISTAN	U.A.E	TOTAL
1	SESA GOA LIMITED	307,020	10,034,086	564,395	387,097	1,380	-	11,293,978
2	V.S.DEMPO &CO. LTD	422,675	4,292,590	-	-	-	-	4,715,265
3	V.M.SALGAOCAR & BRO.PVT. LTD.	468,950	3,469,175	206,200	-	-	-	4,144,325
4	V.M.SALGAOCAR SALES INTERNATIONAL	-	1,136,360	198,600	-	-	-	1,334,960
5	SOCIEDADE DE FOMENTO INDL. PVT. LTD.	817,321	1,819,844	-	111,900	-	-	2,749,065
6	PRIME MINERAL EXPORTS PVT. LTD.	-	2,627,518	-	-	-	-	2,627,518
7	FOMENTO(KARNATKA) MINING CO.P.LTD.	-	4,390	-	-	-	-	4,390
8	CHOWGULE & CO. PVT. LTD.	1,441,783	1,678,795	-	-	-	51,000	3,171,578
9	CHOWGULE & CO.(SALT) PVT. LTD.	-	154,210	-	-	-	-	154,210
10	SALGAOCAR MINING INDUSTRIES P. LTD.	-	2,249,326	-	-	-	-	2,249,326
11	TUNGBHADRA MINERALS PVT. LTD.	-	145,500	-	-	-	-	145,500
12	TIMBLO PRIVATE LIMITED	-	981,656	-	78,830	-	-	1,060,486
13	TIMBLO ENTERPRISES	-	1,002,241	-	-	-	-	1,002,241
14	DAMODAR MANGALJI & CO. LTD.	-	1,753,218	-	-	-	-	1,753,218
15	PEC LIMITED	-	1,529,321	-	-	-	-	1,529,321
16	MSPL LIMITED	-	1,107,289	-	-	-	-	1,107,289
17	V.G.M. EXPORTS	-	534,177	-	-	-	-	534,177
18	BANDEKAR BROTHERS PVT. LTD.	-	198,614	-	-	-	-	198,614
19	VENTURE RESORT HOLDINGS	-	161,200	-	-	-	-	161,200
20	VASSANTRAM MEHTA & CO. PVT. LTD.	-	52,200	-	-	-	-	52,200
21	VENTURE REAL ESTATE	-	50,000	-	-	-	-	50,000
22	MINESCAPE MINERALS PVT. LTD.	-	516,125	-	-	-	-	516,125
23	DINAR TARCAR RESOURCES (INDIA) P. LTD.	-	428,720	-	-	-	-	428,720
24	KARISHMA EXPORTS	-	375,383	-	-	-	-	375,383

25	KARISHMA GOA MINERALS TRADING PVT. LTD.	-	109,882	-	-	-	-	109,882
26	KARISHMA GLOBAL MINERALS EXPORT PVT. LTD.	-	106,509	-	-	-	-	106,509
27	FULCHAND EXPORTS	-	558,760	-	-	-	-	558,760
28	RAJARAM BANDEKAR (S) MINES PVT. LTD.	-	383,850	-	-	-	-	383,850
29	NARAYAN BANDEKAR & SONS PVT. LTD.	-	90,860	-	-	-	-	90,860
30	RAJARAM N.S. BANDEKAR (S) CO. PVT. LTD.	-	46,000	-	-	-	-	46,000
31	D.B. BANDODKAR & SONS PVT. LTD.	-	360,845	-	-	-	-	360,845
32	SHREE BHAVANI MINERALS	-	80,640	-	-	-	-	80,640
33	ORIENT (GOA) PVT. LTD.	-	10,066	-	-	-	-	10,066
34	GANGADHAR NARSINGDAS AGARWAL	-	407,634	-	-	-	-	407,634
35	SHREE MALLIKARJUN SHIPPING	-	282,515	-	-	-	-	282,515
36	KLA INDIA PUBLIC LIMITED	-	279,983	-	-	-	-	279,983
37	MUKTAR MINERALS PVT. LTD.	-	257,943	-	-	-	-	257,943
38	PRASANNA V. GHOTAGE	-	198,600	-	-	-	-	198,600
39	STAR PVG EXPORTS	-	20,000	-	-	-	-	20,000
40	SUHAS V. GHOTAGE	-	135,227	-	-	-	-	135,227
41	GHOTAGE LOGISTICS PVT. LTD.	-	60,393	-	-	-	-	60,393
42	MAGNUM MINERALS PVT. LTD.	-	168,859	-	-	-	-	168,859
43	UPSURGE MULTI TRADE PVT. LTD.	-	95,245	-	-	-	-	95,245
44	SHANTADURGA TANSPORTCO. PVT. LTD.	-	94,600	-	-	-	-	94,600
45	PANDURONGA TIMBLO INDUSTRIES	-	73,000	-	-	-	-	73,000
46	ESMERALDA INTERNATIONAL (EXPORTS)	-	53,978	-	-	-	-	53,978
47	BILASRAIKAR SPONGE IRON INDIA PVT. LTD.	-	52,532	-	-	-	-	52,532
48	RAMCANTA V.S. VELINGKAR	-	46,700	-	-	-	-	46,700
49	RAMCANTA VELINGKAR MINERALS	-	4,851	-	-	-	-	4,851
50	GENERAL NICE MINERAL RESOURCES (I) P.LTD.	-	49,770	-	-	-	-	49,770

51	MINERALS & METALS TRADING CORPN.	-	47,100	-	-	-	-	47,100
52	SSTA LOGISTICS (INDIA) PVT. LTD.	-	44,895	-	-	-	-	44,895
53	RAWMIN MINING & INDUSTRIES PVT. LTD.	-	44,000	-	-	-	-	44,000
54	B.E.M.L. LIMITED	-	43,499	-	-	-	-	43,499
55	KRUPADEEP TRADERS	-	43,320	-	-	-	-	43,320
56	BEST GRAND MINERALS PVT. LTD.	-	42,000	-	-	-	-	42,000
57	ASHAPURA MINICHEM LIMITED	-	-	-	-	-	33,500	33,500
58	ALPINE INTERNATIONAL	-	3,255	-	-	-	-	3,255
	TOTAL GOAN ORIGIN							
		3,457,749	40,596,249	969,195	577,827	1,380	84,500	45,686,900

Annuxure – 2.5

SHIPPER AND DESTINATION WISE EXPORTS OF NON GOAN IRON ORE DURING 2009-2010

Quantity in tons

Sl.No.	SHIPPER	JAPAN	CHINA	PAKISTAN	SOUTH KOREA	EUROPE	TOTAL
1	PEC LIMITED	-	1,314,353	-	-	-	1,314,353
2	SESA GOA LIMITED	211,506	736,708	40,000	60,000	90,000	1,138,214
3	PRIME MINERAL EXPORTS PVT. LTD.	-	788,977	-	-	-	788,977
4	SOCIEDADE DE FOMENTO INDL. PVT. LTD.	16,945	94,490	-	-	50,000	161,435
5	FOMENTO(KARNATKA) MINING CO.P.LTD.	-	139,391	-	-	-	139,391
6	MSPL LIMITED	-	321,730	-	-	-	321,730
7	ZEENAT TRANSPORT COMPANY	-	314,827	-	-	-	314,827
8	MINERALS & METALS TRADING CORPN.	-	228,310	-	-	-	228,310
9	ALPINE INTERNATIONAL	-	183,725	-	-	-	183,725
10	BGH EXIMS LIMITED	-	179,085	-	-	-	179,085
11	SHANTADURGA TANSPORTCO. PVT. LTD.	-	159,957	-	-	-	159,957
12	MUKTAR MINERALS PVT. LTD.	-	159,900	-	-	-	159,900
13	ESMERALDA INTERNATIONAL (EXPORTS)	-	155,733	-	-	-	155,733
14	BAGGADIA BROTHERS	-	153,117	-	-	-	153,117
15	DODDANAVAR BROTHERS	-	152,670	-	-	-	152,670
16	SUHAS V. GHOTAGE	-	110,788	-	-	-	110,788
17	GHOTAGE LOGISTICS PVT. LTD.	-	38,207	-	-	-	38,207
18	PRESIDENCY EXPORTS & INDUSTRIES LTD.	-	98,815	-	-	-	98,815
19	SSTA LOGISTICS (INDIA) PVT. LTD.	-	97,950	-	-	-	97,950
20	KLA INDIA PUBLIC LIMITED	-	96,838	-	-	-	96,838
21	RAMCANTA VELINGKAR MINERALS	-	96,424	-	-	-	96,424
22	SHREE MALLIKARJUN SHIPPING	-	95,635	-	-	-	95,635
23	ORIENT (GOA) PVT. LTD.	-	90,442	-	-	-	90,442
24	MINERALS ENTERPRISES PVT. LTD.	-	90,060	-	-	-	90,060

25	TUNGBHADRA MINERALS PVT. LTD.	-	69,812	-	-	-	69,812
26	SHIV SHIPPING		66,950	-	-	-	66,950
27	DECCAN MINING SYNDICATE (P) LTD.	-	63,000	-	-	-	63,000
28	YAZDANI	-	54,800	-	-	-	54,800
29	MYSORE SALES INTERNATIONAL	-	54,441	-	-	-	54,441
30	KARISHMA EXPORTS	-	43,073	-	-	-	43,073
31	KARISHMA GLOBAL MINERALS EXPORT PVT. LTD.	-	5,598	-	-	-	5,598
32	KARISHMA GOA MINERALS TRADING PVT. LTD.	-	5,318	-	-	-	5,318
33	GNG EXPORTS	-	53,510	-	-	-	53,510
34	INFRASTRUCTURE LOGISTICS PVT. LTD.	-	51,630	-	-	-	51,630
35	SWETHA EXPORTS	-	51,000	-	-	-	51,000
36	BHARAT MINES & MINERALS	-	46,918	-	-	-	46,918
37	ICG INDIA	-	45,817	-	-	-	45,817
38	FAIRDEAL	-	45,488	-	-	-	45,488
39	MUNIR ENTERPRISES	-	44,098	-	-	-	44,098
40	BILASRAIKAR SPONGE IRON INDIA PVT. LTD.	-	43,700	-	-	-	43,700
41	KB STEEL	-	42,200	-	-	-	42,200
42	GREMACH INFRASTRUCTURE EQUIP. & PROJECTS LTD.	-	42,175	-	-	-	42,175
43	PMS VENTURES	-	40,761	-	-	-	40,761
44	TWENTY FIRST CENTURY WIRE RODS LTD.	-	-	39,470	-	-	39,470
45	MODEL BUCKET & ATTACHMENTS PVT. LTD.	-	31,210	-	-	-	31,210
46	CAUVERY COFFEE TRADERS	-	24,612	-	-	-	24,612
47	BEML LIMITED	-	23,588	-	-	-	23,588
48	MULTIPLE EXIM	-	22,700	-	-	-	22,700
49	FROST INTERNATIONAL LIMITED	-	22,500	-	-	-	22,500
50	IGC TRADING	-	22,150	-	-	-	22,150
51	ZANN COMMODITIES PVT. LTD.	-	22,000	-	-	-	22,000
	TOTAL NON - GOAN ORIGIN	228,451	6,937,181	79,470	60,000	140,000	7,445,102

CHAPTER - 3

TRANSPORT LOGISTICS

3.1 BACKGROUND

Goa is famous for its mining industry that largely comprises of iron ore and manganese ore mines. Goa has earned the status of the largest exporter of iron ore in India. The Goan iron ore deposits have been a source of iron ore to the steel industry, for different countries across Asia and Europe notably, Japan, China, Korea etc. The Goan iron ore is normally of iron content of 58% - 63% and used as a blend with high grade ore. The iron ore exports comprise of fines as lumps. Processing of the ore normally comprises of crushing to meet the requisite size specification and / or washing to remove the impurities as well as upgrade the iron content to the specific buyer requirement. Magnetic processing is also utilized to upgrade the iron ore.

The advantage of the Goan mining industry has been the net work of rivers that connect the mines with the natural port that provides a cost effective and efficient mechanism to transport the ore besides the abundant reserve of iron ore deposits.

The recent demand for iron ore from China has seen a boom in this industry that has seen large inflow of investment in processing plants and handling facilities as well as new entrants. The major players in the Goan iron industry are Sesa Goa, Chowgules, Salgaocars, Dempos, Fomento and the Timblos.

3.2 IRON ORE HANDLING FACILITIES

3.2.1 Mormugao Port

Marmugao Port, which is a major port, is an open type natural harbour. The harbour has been constructed on the leeward side of Marmugao 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 Panamax 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. 3.1.

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. 3.1: 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 transshipers 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.

These transhippers are provided and managed by the private exporters. Currently, there are seven transhippers operating within the Goan coast, namely:

- Maratha Deep
- Swati Rani
- Priyamvada
- Sunrise
- Orissa
- Satisha
- Goan Pride

Due to these transhippers, vessel of more than 200,000 DWT can be easily loaded at an average output of around 20,000 to 25,000 tons / day per transhipper. Goa is, thereby able to export an average of 15 million tons due to the complementary services provided by these transhippers. On an average, around 35 to 40% of the total exports from Goa is loaded by transhippers. The largest Iron Ore Vessel that has called in Goan Ports is M.V. Alster Cove, which was 300,000 DWT.

The midstream operations are closed during monsoon that normally occurs during June - September.

The details of loading of iron ore by various means as discussed above at Mormugao port are presented in Table 3.1.

Table 3.1: Mode of loading-iron ore at mormugao port

(1994-95 TO 2009-10)

YEAR	BERTH NO.9	BERTH NO.6	BERTH NO.11	TRANSHIPPER	FLOATING CRANE	BARGE LOADING			
						MOORING DOLPHIN	MIDSTREAM	WEST OFF BREAK WATER	TOTAL
1994-95	8,702,001	,---	,---	5,674,903	,---	,---	917,555	,---	15,294,459
1995-96	8,442,212			6,047,022	,---	,---	637,961	,---	15,127,195
1996-97	8,458,869			5,856,295	,---	,---	442,427	,---	14,757,591
1997-98	9,717,768			8,341,328	,---	,---	618,675	,---	18,677,771
1998-99	9,209,490			5,413,163	,---	,---	346,004	,---	14,968,657
1999-00	9,127,462	,---	,---	4,365,609			317,609		13,810,680
2000-01	10,829,437			4,767,520	,---	,---	115,700	,---	15,712,657
2001-02	10,688,862		15,210	5,867,146	691,853	,---	313,649	,---	17,576,720
2002-03	10,988,598			7,179,192	242,467	,---	308,250	,---	18,718,507
2003-04	11,730,700			87,265,455		,---	2,635,070	,---	22,631,225
2004-05	12,427,638	208,801		8,924,230		,---	3,049,012	,---	24,609,681
2005-06	11,940,342			9,387,839		3,371,943	226,372	,---	24,926,496
2006-07	12,594,502			7,926,290		4,692,747	1,348,363	,---	26,561,902
2007-08	10,308,776			7,679,475		5,139,900	735,656	2,982,555	26,846,362
2008-09	11,582,870			8,223,619	1,496,213	5,973,634	373,361	6,116,864	33,766,561
2009-10	11,781,026			9,257,928	2,263,577	5,761,262	986,782	9,453,671	39,504,246

Iron ore is mainly brought from Goa and Hospet-Bellary region in Karnataka and exported to various countries China, Japan, Pakistan, South Korea and Europe. The total cargo handled at the MPT was 48.85 million tons in 2009-10. Out of which the exports were 40.96 million tons and imports were only 7.89 million tons. Out of the total exports the iron ore export was 40.32 million tons. Hence, the iron ore is the most important commodity for MPT constituting about 83% of total cargo handled at the port during 2009-10. It is almost 99% of the total export cargo and all the iron ore comes to port by Inland Water Transport (IWT), a remarkable role played by the Goan waterways.

3.2.2 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 Aguda 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.

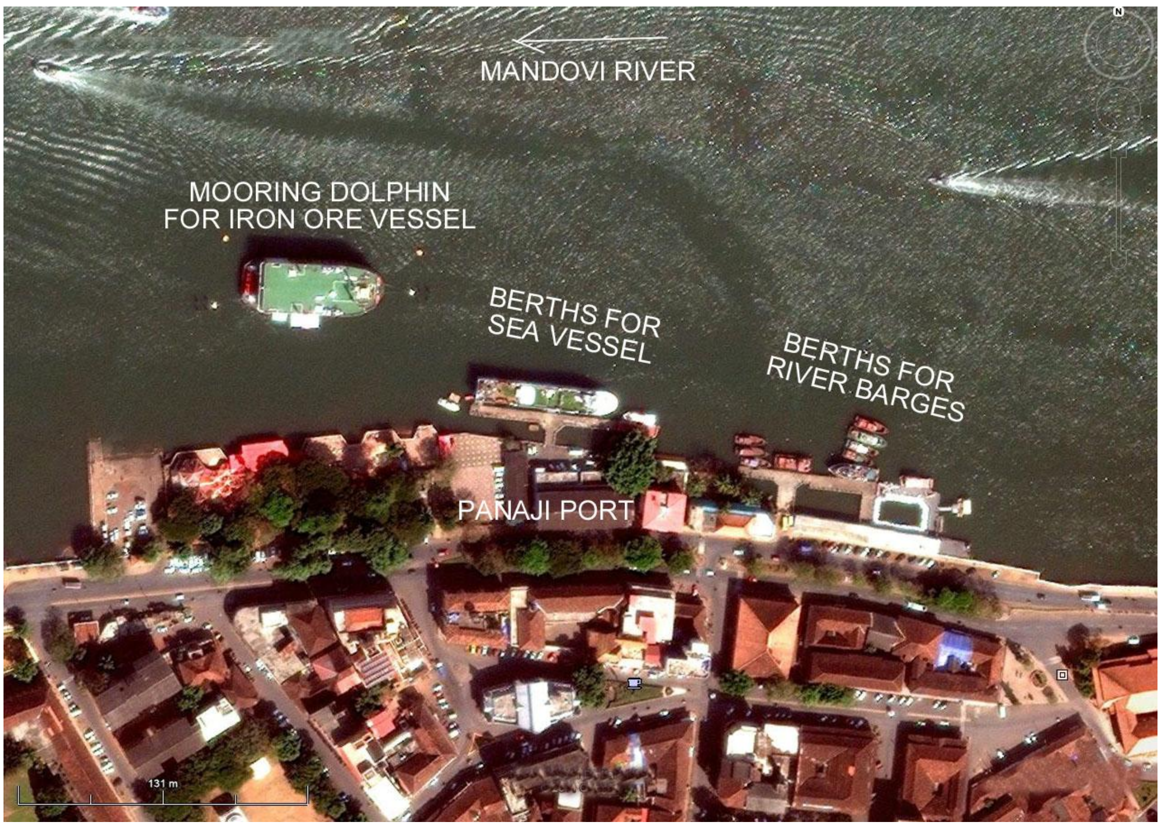


Fig 3.2: Layout of Panaji port – Iron ore handling facilities

3.3 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 3.3 and 3.4.

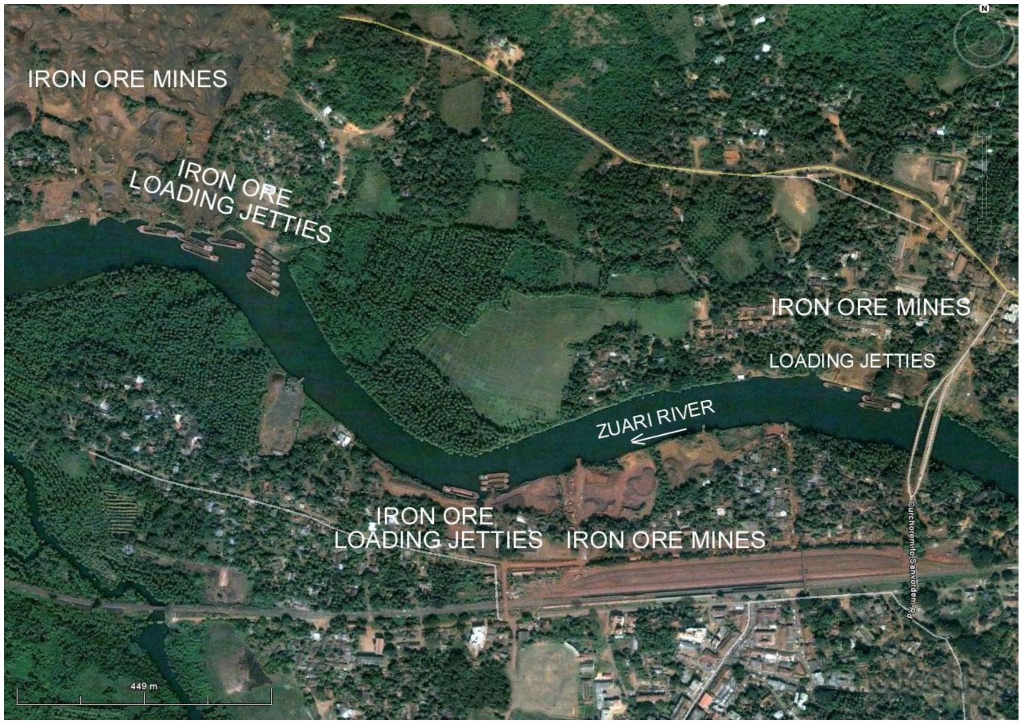


Fig. 3.3: Typical iron ore loading jetty locations along the banks of river Zuari

Fig. 3.4: Typical iron ore loading jetty locations along the banks of river Mandovi

3.3.1 Barge loading

Loading of barges is done at the jetty, after which the ore is carried to the sea going ships berthed / anchored at Marmugao / 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.3.5. 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 Marmugao / 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.3.5: 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. 3.6 . 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.3.6: Iron ore processing and staking yard on the banks of Mandovi river

3.4 EVOLUTION OF BARGE INDUSTRY

Goa is bestowed with an excellent system of interconnected and navigable inland waterways which are instrumental in transporting the bulk of iron ore from the mines to Mormugao Port and nearby Panjim port for export. The two main rivers, the Zuari and Mandovi are navigable for as much as 50 to 60 km in land from their mouths and are mainly utilized for barge transport of iron ore, the iron ore being loaded in to the barges at riverside terminals. Almost all of the iron ore handled at the Mormugao port and nearby Panjim Port is shipped to the port through barges on waterways.

By 1950, keeping in pace with the demand for Goan iron ore, the size of the barges carrying iron ore had also been increased. In the early years, the ore was transported to the harbour by means country crafts which used to sail between iron ore loading jetties and export point at harbour. These barges were of 20-50 tons capacity. Later, a number of country crafts were joined and tugged by a mechanized boat (Tug). Increase in exports coupled with the difficulties in sailing boats during vagaries of nature, rough sea conditions during south west monsoon season and cyclone periods, look the exporters in search of more economical and reliable mode of transport. In December, 1951, the first propelled barge of 100 DWT was imported in Goa waterways. This evolution process continued and progressed through the years. Presently, the sizes of barges operating in inland waterways of Goa have increased to 2500 DWT.

3.4.1 Transportation of iron ore by barges

Earlier river Mandovi carried the bulk of the barges, with over 70% of the traffic coming to Mormugao. At present, the share of ore transport through Mandovi and Zuari River is 64% and 34% respectively. The use of Cumberjua canal by barges is only about 2% particularly during peak monsoon season when the movement of barges is difficult at Aguda bay to reach Mormugao port due to severe open sea conditions.

The iron ore from Karnataka is brought by rail up to Sanvordem (40 km from Vasco). From there the ore is shifted to the nearby barge loading point by road and is brought to Mormugao Port or Panjim port by barges on the inland waterway system. The same rake after unloading at Sanvordem continues to Mormugao Port, where it picks up the imported coal/coke from berths 5A & 6A to transport it to JSW at Toranagulu, Karnataka, about 340 km from Vasco. As per Government Policy, the Karnataka iron ore rich in Fe content needs to blended with Goan ore to bring down the Fe content. It is understood that the blending is not homogenous.

Presently there are about 400 barges of total capacity 6, 75,000 tons plying in Goan waters for the transport of the iron ore from the mines. All these barges in total make about 31,500 trips per annum to transport the iron ore to Mormaugao and Panaji ports from the mines. These barges carried a total of about 53 million tons of iron ore to Mormugao Port and nearby Panjim port in 2009-10. The average capacity of the barge fleet in 2009-10 is about 1685 tons as shown in Fig. 3.7. The economy afforded by this mode of transport has made the Goan iron ore competitive in the international market, as it more than compensates for the higher shipping costs incurred due to slower turnarounds.

The growth of barge fleet operation during the last 17 years (1993-2009) in Goan waters is given in Table 3.2.

The IWT barges are operated by various private operators. The Barge Owner's Association is there for coordinated effort. The list of barge operators and the details of the barges such as name of the barge, year built, DWT, GRT, length, breadth, depth and loaded draft of the barges are provided in Annexure – 3.1.

Some of the typical IWT barges and Transhipper are shown in Figures 3.9 to 3.14.

As per the barge details provided in Annexure 3.1, it is understood that many of the barges currently plying in Goa waterways are having a loaded draft of 3.2 m with capacity varying between 2000 DWT and 2500 DWT. The depth requirement for these barges is 3.7 m below CD.

The maximum size of the vessel currently plying is:

Length : 74.98 m
Width : 14.32 m
Depth : 4.23 m
Loaded draft : 3.20 m to 3.45 m
Capacity : 2525 DWT
Depth below CD : 3.7 m

To meet the projected cargo demand, either the number of vessels is required to be increased or the capacity of the vessel shall be increased.

The design vessel proposed is:

Length of the vessel : 78.4 m
Width : 14.8 m
Depth : 4.7 m
Loaded draft : 3.5 m to 3.7 m
Capacity of the vessel : 3000 DWT
Depth below CD : 3.9 m to 4.0 m

Table: 3.2 Growth of Barge / Fleet Operations in Goa waterways

YEAR	NO. OF BARGES	TOTAL TONNES	AVERAGE SIZE
1993	126	125,910	999
1994	136	138,686	1020
1995	141	145,980	1035
1996	125	139,978	1120
1997	141	166,980	1184
1998	138	160,838	1165
1999	134	163,923	1223
2000	137	167,230	1221
2001	147	178,918	1217
2002	127	165,040	1300
2003	137	224,075	1342
2004	232	338,125	1457
2005	247	384,965	1559
2006	261	412,479	1580
2007	264	421,979	1598
2008	300	494,179	1647
2009	322	542,129	1684

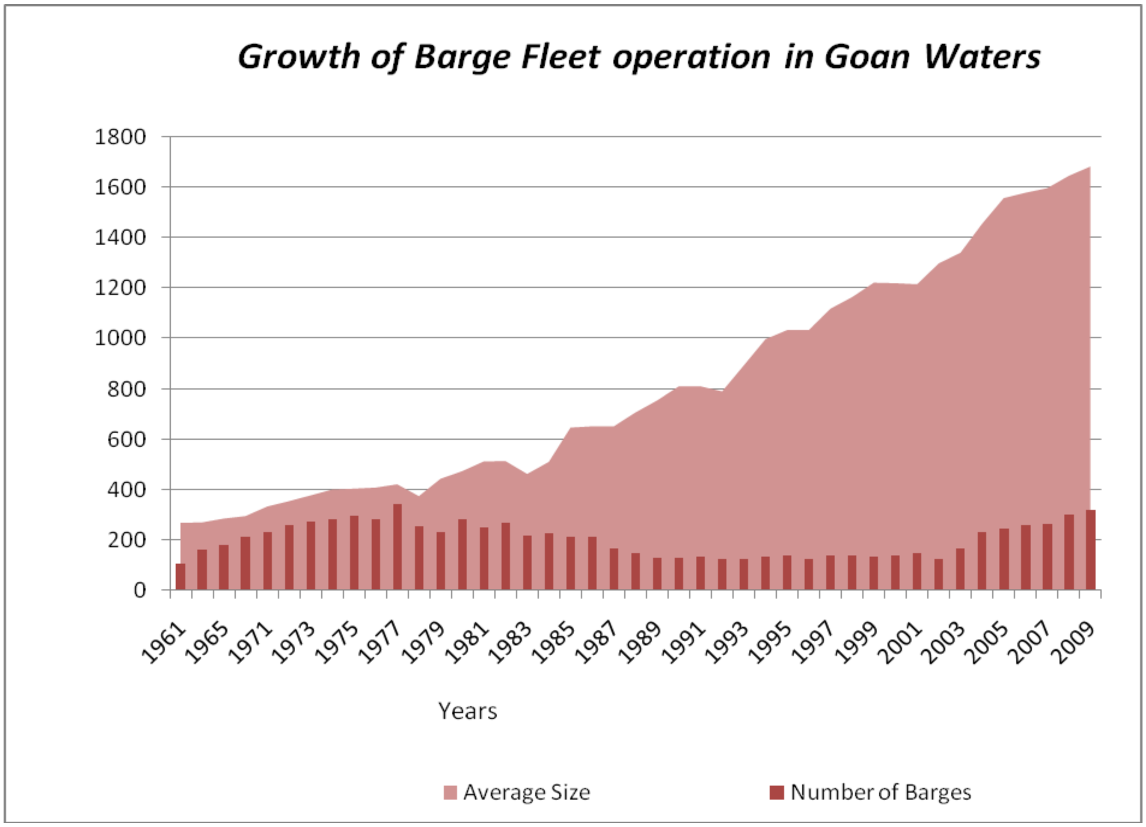


Fig. 3.7: Growth of Barge fleet in Goa waterways

3.4.2 Details Of Goan Barges Capacity Wise

The details of 171 barges are available with Goa Barge Owners Association (GBOA) has been collected and furnished in annexure 3.1. The details of Goan barges capacity wise/draft wise obtained from Goa Barge Owners Association (GBOA)is presented below in table 3.3(A). However as per information available from Goa Barge owner Association (GBOA),the number of barges plying in Goa waterways at present are 400. The details of barges capacity wise are summarized in Table 3.3(B).

Table 3.3 (A): Capacity wise details of Goan barges

S.No.	Barge Capacity (in Tons)		Number of Barges	Number of Barges Draft Wise		Remarks
	From	To		Draft Range (in M)	Numbers	
1	500	1000	51	2.0 - 2.5 m 2.5 – 3.0m	4 43	30%

				>3.0 m	4	
2	1000	1500	14	2.0 - 2.5 m 2.5 – 3.0m >3.0 m	1 9 4	8%
3	1500	2000	31	2.0 - 2.5 m 2.5 – 3.0m >3.0 m	1 3 27	18%
4	2000	2500	73	2.0 - 2.5 m 2.5 – 3.0m >3.0 m	Nill Nill 73	43%
5	2500	3000	2	2.0 - 2.5 m 2.5 – 3.0m >3.0 m	Nill Nill 2	1%

Table 3.3 (B): Capacity wise details of Goan barges

S.No,	***Number of barges***	***Length (in Meters)***	***Breadth (in Meters)***	***Depth (in Meters)***	***Capacity (in Tons)***
1	35	40.0. - 50.0	9.0 – 10.0	3.35	Up to 800 tons
2	40	51.0 – 65.0	10.5 – 12.0	4.00	800 to 1500 tons
3	305	65.50-70.0	12.5 – 14.0	4.35	1500 to 2200 tons
4	20	71.0 – 75.0	14.0	4.75	2200 to 2500 tons
Total = 400 nos					

3.5 INFRASTRUCTURE FACILITIES

3.5.1 Vessel Repair Facilities

Goa has shipbuilding yards for building inalnd vessels up to almost 3000 to 4000 DWT vessels. As on day, some of the builders have been delivering inland vessels of 2500 to 2800 DWT in a period of about 4 to 6 months. Presently, there may be around 1000 vessels operating in the inland trade, offshore, supply vessels, fuel and bunkering vessels, tugs, coastguard vessels and vessels of Indian Navy which require high quality and time efficient services for their dry docking and reapirs.

Since there is a large fleet of barges of about 400 barges exclusively operate in Goa waterways for transportation of iron ore from loading points along mines to the unloadng points at Murmagao port and Panjaiji port, there is a need to have dry docks for vessel repair. The details of existing dry dock facilities for vessel repair in Goa are furnished in Annexure – 3.2. Most of the dry dock facilities are providing by private agencies.

The barge details as provided in Annexure 3.1 show that the barges as old as 40 years have been still operating in business of iron ore transportation. These age old barges have the capacity of about 750 to 1000 tons. These old barges require dry docking for annual maintenance as well as frequent emergency repair purpose. These barges are not economically viable due to less throughput and frequent repairs. Hence, these age old barge are to be phased out by introducing higher capacity new barges for higher throughput and efficiency.

3.5.2 Vessel Tracking System

As per the statistics available in 2009-10, there are about 322 barges of total capacity 5, 50,000 tons plying in Goan waters for the transport of the iron ore from the mines. All these barges in total make about 31,500 trips per annum to transport the iron ore to Mormaugao and Panaji ports from the mines. These barges carried a total of about 53 million tons of iron ore to Mormugao Port and nearby Panjim port in 2009-10. The average capacity of the barge fleet in 2009-10 is about 1685 tons. Each barge make around 17 to 18 trips per month. About 100 barges are called the ports of Marmugao and Panaji every day. The barge movement in Goa waterways is the busiest in India and even comparable to the world busiest waterways like Rhine in Europe and Yangtze in China. Hence, there is a need to vessel tracking system to be introduced from safety point of view to avoid any untoward incidents and also optimize the turnaround time of the vessel. As per the recent information available in 2011, the number of vessels operating in the Goa waterways for export of iron ore is increased to around 400 which makes the waterway more congested. The typical sketch of vessel tracking system is shown in Fig.3.8

3.5.3 Technical Details of the Vessel Tracking System:

Vehicle tracking system provides advanced vehicle tracking and fleet management system for today's busy world. Vehicle tracking system is a modern transport control system with integrated GPS receiver and GSM/GPRS trans receiver module. The device records different parameters, including time, speed, stops and location of the vessel.

GPS-enabled Automotive Vessel Tracking and Monitoring System with Cargo information on system (AVTMCS) which allows the fleet operator to track the movement of its vessels, loading time at the mines, unloading time at the ports, in real time or on historical basis and also providing meaningful real-time information to vessel operators / iron ore exporters. The data stored in the system is disseminated to all the stake holders of the iron ore industry. The fleet tracking system not only provides the information one line but also ensures all safety security aspects.

3.5.4 Salient features the vessel tracking system are:

- GPS data is transmitted via available radio frequency network/GSM
- Automatic polling at preset intervals.

- Current position/Travel route can be viewed on highly accurate, geo referenced digital maps.
- Server at base station
- GSM Network
- Transmitters and receivers at base station and vessel.
- Digitized and geo-referenced maps.
- Software to view the vessel position and generate reports.

3.5.5 Vehicle Tracking systems Benefit and Features:

Improved Vessel Routing:

Vehicle tracking system helps in routing of the vessel , which vessels are closest to job site and provide help to drivers with turn by turn directions. This leads into faster response time,more productive use of vessels, drivers and better customer satisfaction. Vehicle tracking system also provides the route history based on selected dates on google maps and google earth. Mapping historical routes can provide a visualization of drivers route, thus helps in selecting best route to reduce cost structures in wasted mileage and improve on time deliveries.

Decrease in Idle Time:

Time is money. Tracking the fleet eliminates unauthorized idle time. Comparing daily route reports increases the productivity and generates more revenue per trip. Drivers spending too much time at one location and charging idle time to the company, when engaged in personal activities or being in locations that are outside the boundaries of the suggested route, that driver supposed to cover, can be tracked and proven.

Reduce fuel cost by monitoring speed:

Vehicle tracking system helps in preventing the vessel thefts and unauthorized use.Tracking vessel location and activity can providea complete record of the vessel. It also helps in providing better routes to drivers,reduce delivery time and fuel costs every trip.

Lower insurance premiums:

Vessels that consistently exceed max speed limit use more fuel, experience increased wear and tear and require more frequent maintenance. The vehicle tracking sysyem monitor the speed of vessels thus enforce the safer operations and also reduce the chances of accidents and reduce the cost of insurance premiums.

Easy setup and Display:

Vehicle tracking system can be configured as per the requirement, it can be installed at any ocation on the vessel and can be watch live on google maps.

Improved Customer Service:

Better routes will improve delivery time and on time deliveries,lead to client satisfaction.If ssess is given on Mormugao port Trust/ Panaji Port the vessels can be track for delivery status.

Export of Reports to ERP and CRM systems:

Vehicle tracking system generates flash speed reports, providing six crucial reports,which can be utilized to enhance the fleet management system more efficiently. Fleet status report,speed port, detail report, start & stop report, begin and end report and alerts report. all report can be xported to excel,pdf and many other formats for use of internal CRM and ERP systems. Improved record keeping will reduce paper work.

Live Location on Google Map:

Vehicle tracking system provides the vessel location on Google earth and Google maps.

GPS (Global positioning System) is a technology that utilizes the radio frequency of multiple satellites orbiting the earth to specify a position on the surface of earth with high accuracy. Vehicle tracking system ‘s unit will translate the satellite signal into a position and calculates speed,heading and distance based on multiple positions. This information then tied into a system that recives inputs from surrounding envoirment and transmits it through the celluar network based on preset combinations of rules and commands.The celluar network delivers the message from the hardware device to vehicle tracking systems,s backend servers which in turn uses a complex set of algorithms to analyse, calculate and saves the message. Once the behavior of the hardware component, either a web browser or a mobile, to view the activities of the carrier location on an interactive map. The hardware components can be atteached to a vehicle, a piece of equipment, a toolbox or even carried by person. In addition to the ability to specify position and activities, the user has the abilities to send commands to the device using a mobile phone..

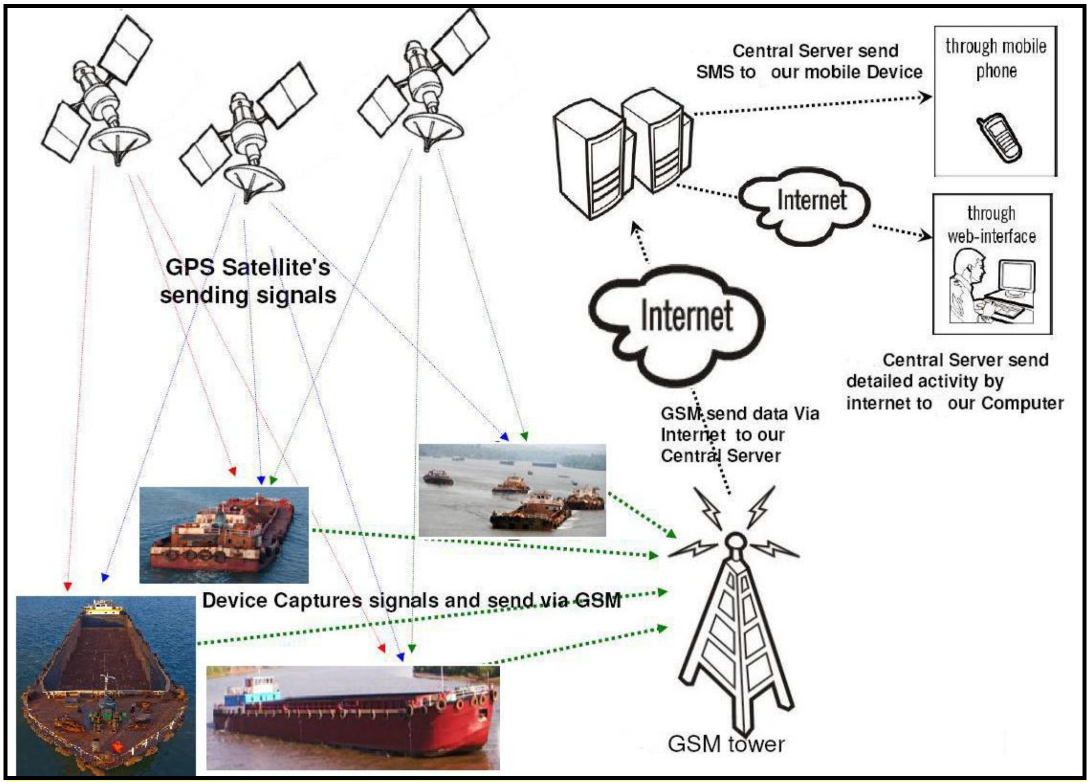


Fig. 3.8 Typical sketch of vessel tracking system

Several organizations provide the vessel tracking software, system operations and demonstration. Vessel Tracking System (VTS) is a web based solution which is developed and deployed using state-of-art technology with appropriate authentication and authorization methodologies and open standards. Oracle10g or higher will be back end Database. The cost of system is around Rs. 1 crores.

3.6 ADMINISTRATION

3.6.1 Enforcement of Rules and Regulations

All the inland waterways within Goa state are maintained and managed by Captain of Ports, Goa. In other words the Captain of Ports Department, Government of Goa is responsible for maintenance of all minor ports and inland waterways within Goa state. With this point in view, the Captain of Ports department shoulders the responsibility of developmental works of inland waterways of Goa including Mandovi, Zuari and Cumberjua canal. The developmental works include the following:

- Periodical hydrographic surveys
- Dredging of rivers

- Maintenance of lighthouses and beacons
- Providing necessary navigational aids to the vessels
- Imparting training to the needy students who would like to build their career at sea
- Provide landing facilities for both passenger boats and cargo vessels at jetties etc.

The Captain of Ports is not only in charge of all activities of inland waterways of Goa, but also implements the following Acts and Rules:

(1) The Inland Vessels Act, 1917
(2) The Goa, Daman and Diu Barge Tax Act, 1973

(3) The Goa, Daman and Diu Barge (Taxation of Goods) Act, 1985
(4) The Goa, Daman and Diu Ports Rules, 1983
(5) The Indian Ports Act, 1908

The other sub-offices such as Dy. Captain of Ports situated at Mormugao, Maritime School at Britona, and Marine Slipway at Britona, Marine Secretaries Offices at Chapora, Betul and Talpona are under the overall control of the Captain of Ports.

3.6.2 Services provided by the Captain of Ports Department

(1) Registration of vessels both mechanised and non-mechanised plying in the inland waters of Goa and collects registration fees as per rules.
(2) Endorsement of certificates of competency issued by the other states of India.
(3) Issues certificates of competency for Serang, 1^{st} & 2^{nd} Class Master, 1^{st} and 2^{nd} Class Engine Driver.
(4) Extension of survey certificates.
(5) Extension of 'No Objection' letters for fishing stakes.
(6) Supply of hydrographic charts as per the requirement of the public.
(7) Matters connected with illegal occupation of government riverine land.
(8) Issue of permission to use government jetties for vessels and in turn collects revenue by way of wharfage dues, tonnage dues, mooring charges etc.
(9) Clearing of inward/outward of the ships calling at Panaji port outer harbour anchorage and collects relevant dues from the ships in-charge, as per the rules in force.
(10) Lighthouses and beacons are made available for fair direction to thevessels operators plying in the inland waterways.

3.6.3 Procedure for Registration of Mechanised Vessels

(a) Before construction of a vessel under Inland Vessels Act 1917, the applicant has to inform this department indicating the intension to construct the vessel and the details of the vessels such as height, breadth, length and depth
(b) The applicant has to submit the drawings of the vessels for approval. (c) The applicant has to submit declaration of ownership duly notarized.
(d) After examining the request, the applicant will be issued forms for registration of vessels viz. Form No.1, Form No. II and Survey Form No.1
(e) The applicant has to pay (i) Registration fees (ii) Survey fees and (iii) Approval of drawings fees through challan
(f) Then the applicant will be allowed to construct the vessel and during the construction, stagewise inspection/survey will be carried out by this department and if found suitable N.O.C. to ply the vessel will be issued
(g) After construction of the vessel the owner has to pay
  (i) Annual licence fees
  (ii) Port dues
  (iii) Barge tax and
  (iv) Annual survey fees by challan in respect of (i) and (ii) and in the prescribed forms in respect of (iii) & (iv)

Barge Tax can be paid yearly or quarterly. On quarterly payment 10% more tax has to be paid. If the Barge is not in operation during a particular quarter then the owner has to submit a declaration of non use in Form 'F' to void payment of Barge Tax for that quarter.

3.6.4 Maritime school, Britona

The Captain of Ports department has a Maritime School, unique of its kind at Britona, Bardez – Goa, which imparts seamanship and marine engineering training to the personnel seeking employment/working on inland water and other categories of transport mechanized vessels

The institute conducts mainly two types of courses in a year. They are:

(A) New Entrants Training Course – Deck & Engine Room
(B) Advance Refresher Training Course – Deck & Engine Room

3.6.5 Issue of permission to use government jetties / Barges / Dredger

The vessel owner has to inform the Captain of ports department for use of jetties by paying the necessary fees such as (a) port dues according to the tonnage of the vessel/cargo loaded (b) mooring charges etc. by challan. The Department also has barges and dredger and are available on rental for private use.

3.7 ISSUES RELATED TO BARGE INDUSTRY

Considering the importance of mining industry to Goa's as well as country's economy, and its dependence on inland waterways, it cannot afford to sit on the achievements of its success so far in inland water transportation. The iron ore export scenario has changed rapidly in the last five years. Increase in demand for iron ore from China has caused sudden increase in the quantities of export of iron ore from Goa. The resultant situation has now created new challenges for Inland Water Transport industry in Goa waterways.

With the increase in size and number of barges plying in the Goa waterways, there is an urgent need to upgrade the existing infrastructure on the following fronts:

- Shallow patches, shoals, sand bars which are hampering navigation particularly during low tide, are required to be dredged to provide a depth of minimum 3.6 m for the barges currently in operation (2500 DWT) to facilitate round the clock navigation even during low tide

- There is a need to increase the size of the vessels to 3000 DWT to meet the increasing demand of iron ore transport.

- The increase in size of the vessels requires additional draft which needs least available depth (LAD) of 3.9 m to 4.0 m to ply 3000 DWT vessels.

- The increase in the size and number of barges cause concerns about safety of navigation through rivers of Goa. In order to address these concerns, there is a need to mark the channel with navigation marks and provide navigational aids to ensure smooth and uninterrupted navigation throughout the day and night.

- In order to cope with expected congestion in the waterways, suitable traffic control arrangement is required to be put in place.

- Safe anchoring sites, waiting bays shall be provided for barges at all tidal conditions.

Fig. 3.9: IWT Barges at the Pier for loading - Goa

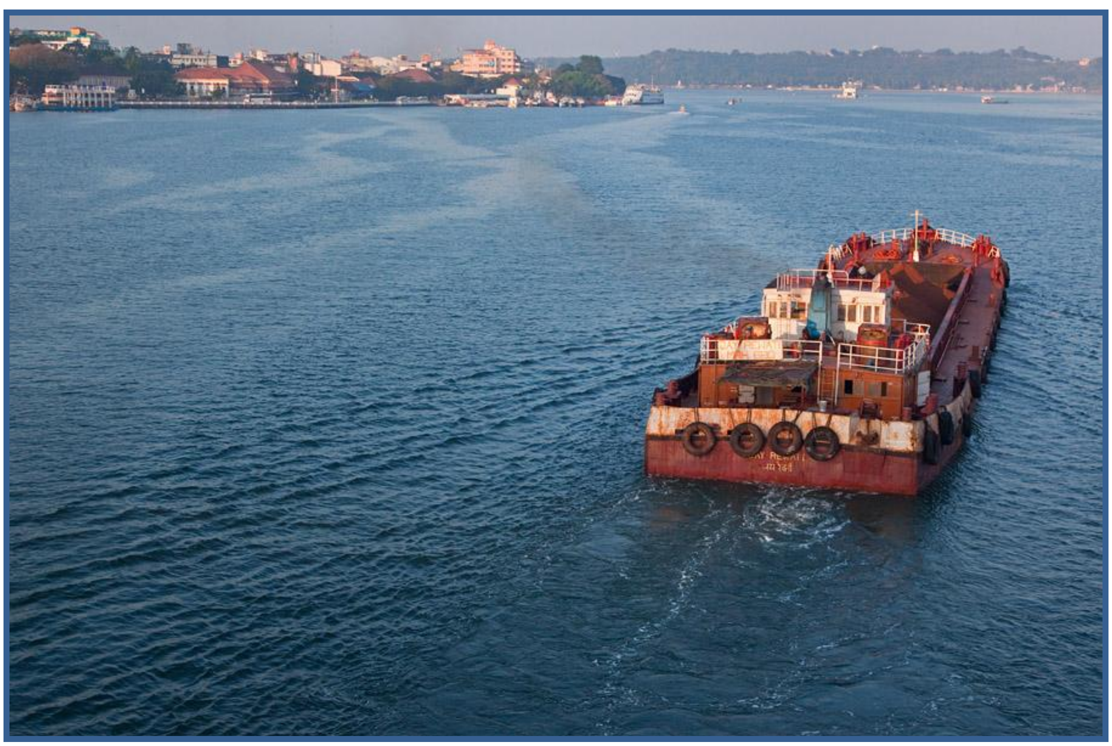


Fig. 3.10: IWT Barge transporting iron ore in Mandovi river – Goa

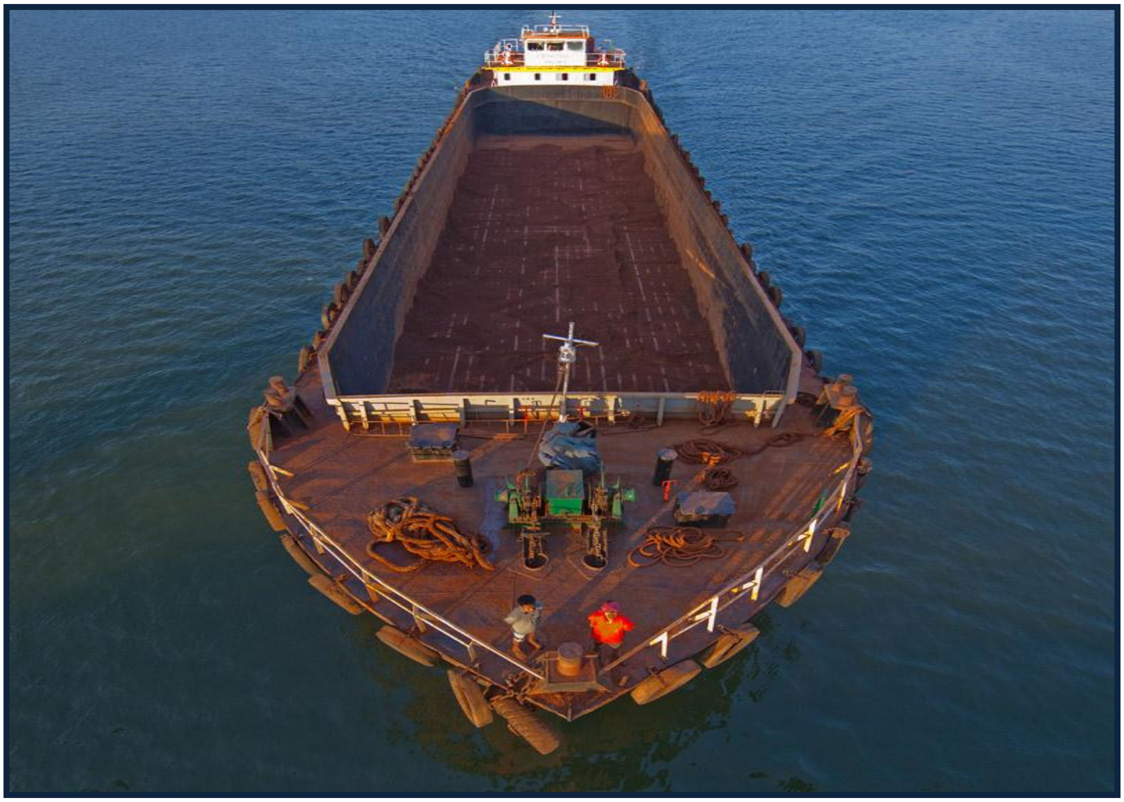


Fig. 3.11: Iron ore barge prior to loading

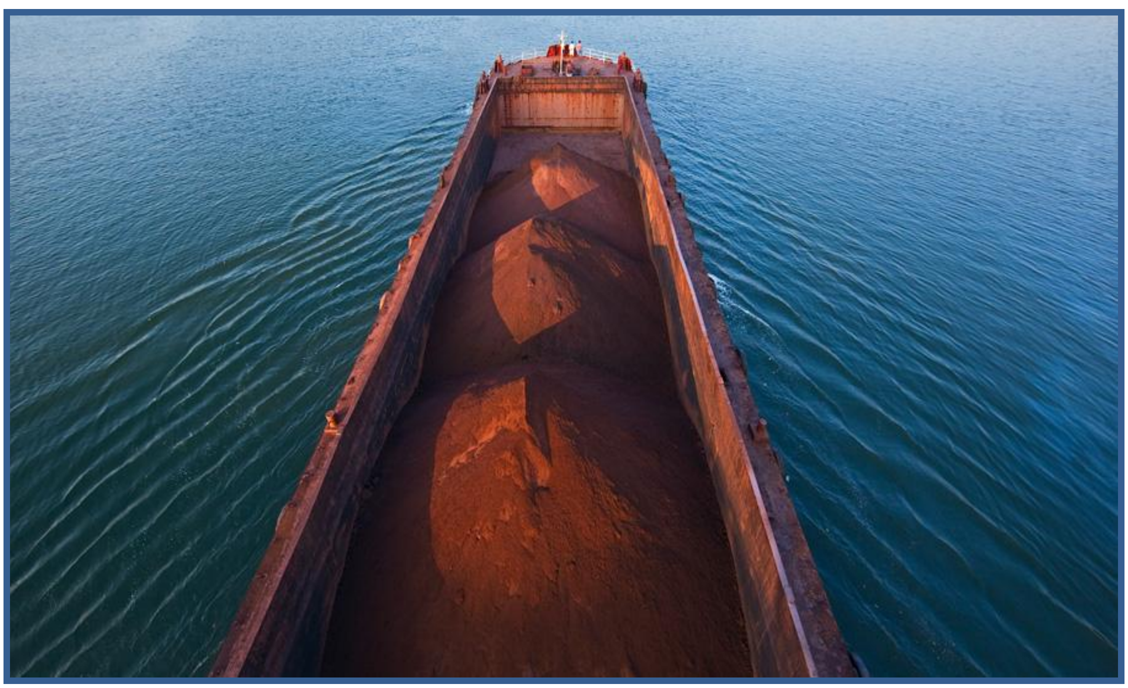


Fig. 3.12: Iron ore laden barge

Fig. 3.13: Barges loading at river terminal

Fig. 3.14: The Transhipper MV Priamvada - loading iron ore in to mother ship anchored mid sea

Annexure –3. 1

The details of IWT barges for transportation of iron ore in Goa waterway

Sr.No.	Name of the Company	Name of the Barge	DWT	Year of Built	G.R.T	Length (m)	Breadth (m)	Depth (m)	Loaded Draft (m)
1	M/S Emmanuel Shipping	Sneh-III	805	1975	447.321	49.21	8.75	3.27	2.7
2	M/S Sanghi Bros. (I) Pvt. Ltd.	Sumitra	775	1972	444.67	49.12	8.75	3.27	2.7
3	M/S Shree Manuesh Entp.(M)P. Ltd.	Roshan	790	1975	526.61	49.7	9	3.5	2.85
4	M/S Siddesh Ore Carriers	Sneh	750	1975	433.537	49.12	8.75	3.27	2.6
5	M/S Mandovi Ore Carriers	Pragati	745	1977	458	49.6	8.75	3.2	2.6
6	M/S Mataparvati Marine Carriers	Zuari Endurance	805	1974	510.93	49.12	8.75	3.25	2.6
7	M/S Vasco Ore Carriers	Shakti	730	1975	246.61	49.12	8.75	3.1	2.45
8		Bhakti	781	1980-81	440.29	49.12	8.75	3.27	2.6
9	M/S Sagar Marine Services	Rajamoniama	775	1972	471.77	49.12	8.75	3.25	2.6
10	M/S Shradha Shpg. Co. Pvt. Ltd.	Orient Champion	873	1973	523.33	49.98	9	3.2	2.85
11	M/S Laxmi Ore Carriers	Sea Star	750	1980	475.11	55	9.7	2.8	2.2
12	M/S Shruti Ore Carriers	Shruti-I	850	1975	529.26	49.12	8.75	3.25	2.7
13	M/S Balaji Ore Carriers	Harshavardhan	772	1982	476.7	49.79	10	2.9	2.3
14	M/S Carsons	Carsons	750	1977	382	45	9	3.25	2.6
15	M/S Azoic Carriers	Rio Martina	810	1975	515.67	49.12	8.75	3.35	2.7
16	M/S Oceanic Shipping	Devashish	750	1974	422.08	49.12	8.75	2.5	2.6
17	M/S Kapila Shipping Co.	F/Kartik	775	1974	444.02	49.12	8.75	3.25	2.6
18	M/S Rahi Enterprises	F/Phalguna	815	1975	440.37	49.12	8.75	3.35	2.7
19	M/S M.R. Ore Carriers	Suvarna	800	1972	469.52	49.12	8.75	3.35	2.7

20	M/S Shree Krishna Ore Carriers P.L.	F/Bhadrapada	815	1973	404.33	49.12	8.75	3.35	2.7
21	M/S Vishal Shipping Co.	Mahima	825	1982	526.52	52	9	3.35	2.7
22	M/S Cosme R. Silveira	Satyawati	860	1978	500.78	51.42	9.06	2.7	2.7
23	M/S Swetat Shipping Co.	Jay Mahendra	881	1985-1986	473	50.74	8.8	3.6	2.9
24	M/S Simran Shipping	Osricap	861	1976	533.712	50	10.3	3.21	2.6
25	M/S Samudra Shipping	Sea Horse I	765	1971	428.26	49.12	8.75	3.25	2.6
26	M/S KGN Ore Carriers	Noor III	765	1970	428.26	49.12	8.75	3.25	2.6
27	M/S Amonkar Shipping	Konkan Mariner	795	1976	447.32	49.12	8.75	3.35	2.6
28	M/S R & N Waterways	Ivycab	785	1977	409.16	49.12	8.75	3.25	2.6
29		Aqua Mariner	795	1979	432.74	49.12	8.75	3.25	2.6
30	M/S Suhas Vasudev Ghotage	Vyjayanti	755	1977	483.86	47.63	9	3.3	2.6
31		F/Ashada	820	1973	428.26	49.12	8.75	3.25	2.6
32	M/S Kedar Waterways	Besant	850	1974	530.38	45.03	10.02	2.3	2.8
33	M/S Carbral & Company	Mayacab	1050	1973	457.576	57.07	12	3	2.4
34	M/S Srimanguesh Shpg. Co. Ltd.	Devesh	1125	1984	638.67	52.4	10	3.8	3.1
35	M/S SKS (Ship) Ltd.	Vishal Laxmi	1036	1983	649.75	58	11	3.5	2.6
36	M/S Agencia Ultra Marina Pvt. Ltd.	Anna	1065	1982	406.73	49.85	9	2.6	2.9
37	M/S Arabian Shipping	Vishal Annesh	1171	1984	649.75	55.2	11	3.5	2.8
38	M/S Jag Shipping & Transports	Vishal Sharvani	1375	1985	761.64	58	11	4.1	3.2
39	M/S Navdurga Shpg. Co. Ltd.	Anupama	1120	1976-1977	712.28	60.15	10.3	3.35	2.6
40	M/S Costa River Transports Pvt. Ltd.	Cecilia	1301	1985	800.25	60.54	10	4	3.2

41	M/S KGN Ore Carriers	Noor II	970	1985	671.34	55.42	10	3.8	3.1
42	M/S Kaveri Shipping	Mahalsa	924	1981	558	52	9	2.8	2.15
43	M/S Syndicate Shipwright	Jay Gomanteshwar	950	1982	583.12	52	10	3.6	2.92
44		Saarika	950	1983	583.12	52	10	3.6	2.92
45	M/S Vasco Gal. Fab. & Engineers	Anemone	960	1958	638.53	55	9.5	3.38	2.7
46	M/S Lkar Shipping Pvt. Ltd.	Jay Baingneshwar	980	1977	578.86	52	10	3.6	2.92
47	M/S R & N Waterways	Sahil	971	1973	576.87	49.68	8.75	3.9	3.05
48	M/S Fairway Barge Op. Pvt.	Jay Parmeshwar	967	1978	583.12	52	10	3.6	2.92
49	M/S Jos Shipping	Jos-I	962	1982	469.606	50.65	10.1	3.8	2.9
50	M/S Daniel Eng. Works & Ship Rep.	Jay Bhagwati	945	1984	573.8	55	10	3.25	2.6
51		Jay Saraswati	945	1986	573.8	52.5	10	3.25	2.6
52	M/S Vishal Ore Carr. Pvt. Ltd.	Janardhan	974	1982	499.88	52	9	3.5	3.05
53	M/S Trilok Navigation Pvt. Ltd.	Nitya Sushil	950	1981-1982	523.36	49.98	9	3.5	2.85
54	M/S N.K. Shipping	Neil	980	1987	1067.78	58	11	3.2	2.55
55	M/S Oceanic Shipping	MPL-1	1000	1979	499.27	50.1	10	3.3	2.75
56	M/S R & V Shipping	Samrat Star	1110	1983	619.3	50.65	10	3.82	2.9
57	M/S Rohini Ore Carriers	Samrat Sapphire	1110	1983	619.3	50.65	10	3.82	2.9
58	M/S Shree Sateri Shp. Services	Shivpriya	1158	1982	712	53	10	4.04	3.2
59	M/S Vasco Marine Services	Jay Dyaneshwar	954	1983	583.12	52	10	3.6	2.92
60	M/S Rolex Waterways	Blue Bell	970	1972	576.87	49.68	8.75	3.9	3.2
61	M/S Cheyne Marine	Kashi	932	1970	630.6	65	9	4.5	2.5
62	M/S Desa Goa	Siddarth	950	1976	576.87	49.12	8.75	3.9	3.2
63	M/S Orion Shpg. Co.	Sri Anantlaxmi	1400	2009	606.6	62	12	3.6	2.9

	Ltd.								
64	M/S Rimula Ore Carriers	Antares	975	1975	576	49.68	8.75	3.9	3.2
65	M/S Vaqlient Shpg. Co. Pvt. Ltd.	V.Vikram	1075						
66	M/S Atreya Shpg. Pvt. Ltd.	Prakruti	2300	1991	1203.56	67.2	14	4	3.2
67	M/S Costa River Transports Pvt. Ltd.	Costa Voyager	2100	2005	1282	69.7	13	4.25	3.2
68		Costa Venture	1700	1996	917.25	70	12	3.65	3.2
69	M/S Rahi Enterprises	Dolphin	2000	2004	1101	67.5	12.5	4.2	3.2
70	M/S Goa Ore Carriers	F/Varsha	2034	1993	1216	70	14.5	4	3.2
71		Sea Bird	1893	2000	1277	65.6	12	4.2	3.2
72	M/S S.N. Enterprises	Shivraj	1900	1998	1170.93	67.5	12.5	4.2	3.2
73	M/S Reshmi Ore Carriers Pvt. Ltd.	Srilaxmi	2300	2006	1314.4	69.7	13.4	4.25	3.2
74	M/S Super Services	Shiva Maya	2000	2004	1179	67.5	12.5	4.2	3.2
75		Vasundhara	2000	2006	1330.03	69.7	13.4	4.25	3.2
76	M/S Super Services Shp. Pvt. Ltd.	Shari Hari	2133	2005	1282.4	69.7	13	4.25	3.2
77		Shari Nidhi	2293	2005	1330	69.7	13.4	4.25	3.2
78	M/S Siddesh Ore Carriers	Om Datta Sindhurani	2300	2006	1290	69.8	13.4	4.35	3.2
79		Om Datta Jalrani	2000	2004	1101	67.5	12.5	4.2	3.2
80	M/S SKS (Ship) Ltd.	Royal Sharayu	2371	1997	1538.14	74.98	14.3	4.2	3.2
81		Royal Vikrant	1850	1997	1014	62.27	12.3	4	3.16
82		Royal Kali	1850	2004	1014	65	12.3	4	3.16
83		Royal Kaveri	2525	1998	1538.15	74.98	14.32	4.23	3.2
84	M/S Shardha Spg. Co. Pvt. Ltd.	Rashtroli	2067	2004	1130	70	13	4.1	3.2
85		Shri Sateri	2000	2008	1294.52	70	13	4.35	3.3
86	M/S Nav Bharat Carriers Pvt. Ltd.	Mahesh	1930	1997	973.18	70	12	4.4	3.2
87		Ganesh	1970	1997	973.18	70.35	12	4.2	3.2
88		Jal Shakti	1840	2004	1101	67.5	12.5	4.3	3.2
89	M/S Datsun	Datsun	2000	2005	1087	67.5	12.5	4.2	3.2

	Shipping Pvt. Ltd.								
90	M/S Matadi Shpg. Trad Co. Pvt. Ltd.	Jai Matadi	2000	2004	1132	68.5	13	4.2	3.2
91	M/S Mayur Shipping Pvt. Ltd.	Shri Naguesh	1904	2004	1048	67.5	12.5	4.2	3.2
92	M/S Neville Ore Movers Shipping Pvt. Ltd.	Cherylyn	1885	1997	1085.13	66	12.5	4.2	3.2
93	M/S Shree Mallikarjun Shpg. Pvt. Ltd.	Girija	2000	1998	1101	67.5	12.5	4.2	3.2
94	M/S Emerald Logistics	Trinity	2150	2004	1330.7	69.7	13.4	4.25	3.2
95	M/S Trinity Shipping	Angelic	2300	2005	1314.4	69.7	13.4	4.25	3.2
96	M/S Vaishnavi Shpg. Co. Pvt. Ltd.	Vaishnavi	1700	1998	1232	65.6	12	4.2	3.2
97	M/S Sree Damodar Shpg. Lines Pvt. Ltd.	Rishiraj	1700	1998	1068	65	12	4.2	3.2
98	M/S Zion Invest & Trad. Co. Pvt. Ltd.	Vishal Amit	1515	1986	933.34	65	12.5	3.6	2.8
99	M/S Vishal Ore Carriers Pvt. Ltd.	Shree Manjunath	2000	2005	1199	68.5	13	4.2	3.2
100		Shree Sainath	2000	2008	1294.52	70	13	4.35	3.3
101		Shree Ramnath	2000	2005	1163	68.5	13	4.2	3.2
102	M/S Balaji Ore Carriers	Shree Veetal	2000	2005	1150	67.5	13	4	3.2
103		Mohlaksh	2000	2006	1287	68.5	13	4.2	3.2
104	M/S Valient Shipping Co. Ore Pvt. Ltd.	Vijeta	1946	2005	1087	67.5	12.5	4.2	3.2
105		V.Vikram	1600	1990	933.34	65	12.5	3.6	2.3
106	M/S Vijay Marine Services	Tolani 15	1800	1997	1077	67	12	4.2	3.2
107		Tolani 16	1900	1998	1179.12	67.5	12.5	4.2	3.2
108		Tolani 17	1900	1998	1179.12	67.5	12.5	4.2	3.2
109	M/S Nirakar Engineering Services	F/Sharad	2049	1994	1217.65	70	14	4	3.15

110	M/S Siddesh Ore Carriers Pvt. Ltd.	Om Datta Sidhiraj	1610	1991	1063.35	68.5	12.3	3.7	2.95
111	M/S Amir Shipping Pvt. Ltd.	Cuncolim	1912	2003	1101	67.5	12.5	4.2	3.2
112	M/S Vaibhavi Shipping Pvt. Ltd.	Yash	2000	2004	1130	70	13	4.1	3.2
113		Vaibhavi	2000	1997	1068	65	12	4.2	3.2
114		Kiran	2000	2004	1163	68.5	13	4.2	3.2
115		Abhinav	2150	2005	1261.8	69.7	13.4	4.25	3.2
116		Prakash	2500	2006	1428	74.84	14	4.25	3.2
117	M/S Mandovi Ore Carriers	Abhijeet	2450	2008	1475	70	14	4.35	3.3
118		Abhishree	2450	2008	1475	70	14	4.35	3.2
119	M/S Sai Waterways Pvt. Ltd.	Sai Saurabh	1850	1998	1402	64	12.8	4.2	3.2
120		Sai Shakti	1800	2004	1101	67.5	12.5	4.2	3.2
121	M/S Manjunath Ore Carriers	Vishal Nikhil	1950	1986	933.34	65	12.5	4.2	3.2
122	M/S Ramakant Naik & Co.	Mitrayani	1590	1987	881	68.15	11.3	3.6	2.95
123	M/S V.S.L. Enterprises	Nishtta	2000	2005	1177	67.4	12.5	4.25	3.2
124	M/S Jay Ram Ore Carriers	Jai Ram 1	2000	2005	1249.7	70	13	4.2	3.2
125	M/S Stream Line	Vishwasagar	2000	2004	1164	6.85	13	4.2	3.2
126		Gita 3	2000	2008	1201	68.5	13	4.2	3.2
127	M/S Cabral & Co.	Osricab II	1800	1998	1073	67	12	4.2	3.2
128		Osricab III	2100	2005	1199	68.5	13	4.2	3.2
129	M/S Fadtle Marine Services	OM	2000	2005	1087	67.5	12.5	4.2	3.2
130		Sri Adilakshmi	2000	2000	1173	67.5	12.5	4.2	3.2
131		Sri Gajalakshmi	1995	2001	1101	67.5	12.5	4.2	3.2
132		Victoria	2000	2005	1087	67.5	12.5	4.2	3.2
133	M/S Tripti Shipping	Gil	1751	1997	1068	65	12	4.2	3.2
134	M/S Delta Engineers	Quelossim	2000	2005	1087	67.5	12.5	4.2	3.2
135	M/S Navdurga Shpg. Co. Pvt. Ltd.	Navdurga	2400	2005	1459	76.5	14	4.2	3.2

136		Purva	2000	2006	1177	67.4	12.5	4.25	3.2
137	M/S MSPL Ltd.	Kali	2000	2004	1087	67.5	12.5	4.2	3.2
138		Tunga	2000	2004	1087	67.5	12.5	4.2	3.2
139		Badra	2000	2004	1087	67.5	12.5	4.2	3.2
140	M/S KGN Ore Carriers	Noor I	2000	2005	1287	68.5	13	4.2	3.2
141	M/S Premier Marine	Jaya Mahalaxmi	2050	2005	1130	70	13	4.1	3.2
142		Jaya Maha Ganapati	2400	2005	1381	76.5	14	4.2	3.2
143		Jaya Mahavenkateshwara	2400	2005	1407	76.5	14	4.2	3.2
144	M/S Shrividha Marine	Gangotri	2130	2005	1206	68.5	13	4.2	3.2
145		Suresh I	2000	2008	1294.52	70	12.5	4.35	3.3
146	M/S Sanghi Bros.(Indore) Pvt. Ltd.	Sanghi I	2213	2004	1199	68.5	13	4.2	3.2
147		Sanghi II	2213	2005	1288.81	67.12	14	4	3.16
148		Sanghi III	2090	2005	1206	68.5	13	4.2	3.2
149		Sanghi IV	2250	2008	1284.1	69.8	13.4	4.35	3.3
150	M/S Tirthraj Shipping	Prithviraj	2000	2004	1164	68.5	12.5	4.2	3.2
151	M/S Pires & Sons	Holy Trinity	2000	2005	1287	68.5	13	4.2	3.2
152	M/S Drshprabhu Shipping Co.	Abhay	2000	2004	1199	68.5	13	4.2	3.2
153		Aarti	2000	2005	1287	68.5	13	4.2	3.2
154		Askshata	2000	2008	1284.1	69.8	13.4	4.35	3.3
155	M/S Dillan Shipping Pvt. Ltd.	Mother Vailankani	2000	2004	1287	67.5	12.5	4.2	3.2
156	M/S Ferromar Shipping Pvt. Ltd.	Karma I	2000	2005	1149.84	70	13	4.1	3.2
157	M/S Kingfisher International	Saumya	2000	2004	1087	67.5	12.5	4.2	3.2
158	M/S Shubhangi Shpg Co. Pvt. Ltd.	Padmini	2000	2006	1294.12	70	13	4.35	3.2
159	M/S Lucky Star Services	Estrelle	2000	2006	1314.4	69.7	13.4	4.2	3.2
160	M/S Trans	Lucky Strike	1600	2004	1032.97	62.5	12.5	4.1	3.1

	Rio Shipping Co.								
161	M/S Ukar Shipping Pvt. Ltd.	Mahaveer I	1825	2005	972.31	64.8	12.8	4	3.2
162	M/S Tanda Shipping Pvt. Ltd.	Gurmit Star	2000	2006	1227	68.5	13	4.2	3.2
163	M/S M.N. Shipping	Vaishnadevi	2000	2006	1177	67.4	12.5	4.25	3.2
164	M/S Kaveri. Shipping	Kamakshi	2000	2005	1201	68.5	13	4.2	3.2
165	M/S Ratna Prabha Marine Services	Ratnadeep	2000	2006	1294.21	69.15	13	4.35	3.2
166		Jay Ashwini	1854	1997	1077	68.5	13	4.2	3.2
167	M/S Karishma Shipping	Karishma	2000	2006	1232.04	68.5	13	4.2	3.2
168	M/S Suddesh Shpg. Co. Pvt. Ltd.	Sea Horse VI	2050	2000	1441.02	70	15	4.2	3.2
169	M/s Sincoale Shipping, Goa	Kshir Sagar	2100	-	-	72	12	-	3.45
170		Jai Madho	1882	-	-	65	12	-	3.20
171		Prakruti	2300	-	-	72	14	-	3.40

Annexure – 3.2

Details of Dry dock facilities for vessel repair

DETAILS OF DRYDOCK/SLIPWAY FACILITIES AVAILABLE IN GOA			
S.NO.	**SHIPYARD**	**CONTACT PERSON**	**CONTACT NOS.**
1	M/S. NIGEL SHIPYARD PVT. LTD. RASCAIM, LOUTOLIM, GOA	MR. OSRIC CABRAL MR. MARK D'SILVA	TEL. : 2777134, 2776453, 2776454, 6480876
2	M/S. WEST COAST SHIPYARD RASCAIM, LOUTOLIM, GOA	MR. OSRIC CABRAL MR. MARK D'SILVA	TEL. : 2777134, 2776453, 2776454, 6480876
3	M/S.GOA ORE CARRIERS RASCAIM, LOUTOLIM, GOA	MR. WILLIAM D'COSTA gocvasco@dataone.in	TEL. : 2510026(0) 6551163(W) 9823100630(M)
4	M/S. SHIRODKAR SHIPYARD RASCAIM, LOUTOLIM, GOA	MR. DEVESH SHIRODKAR	TEL. : 2777033(W) 2512091(O) 2500305(F)
5	M/S. MANDOVI DRYDOCKS PILGAO, BICHOLIM, GOA	MR. P.N.SAWANT	TEL. : 2363202 3207436 FAX: 2361269
6	M/S. BHARATHI SHIPYARD ZORINT, SANCOALE, GOA	MR. SUBIR CHAKRABORTY	TEL. : 2555090 2555091
7	M/S. VIJAY MARINE SERVICES RASCAIM, LOUTOLIM, GOA	MR. JAIRAMI. DIALANI	TEL. : 2777633
8	M/S. CHOWGULE & CO. PVT. LTD. (SHIPBUILDING DIVISION) NEAR BORIM BRIDGE, LOUTLIM GOA	MR. P. CHAKRABARTY SR. GENERAL MANAGER	TEL. : 2858057 FAX: 2858058
9 10	M/S. DEMPO SHIPBUILDING ENGINEERING PVT. LTD., OLD GOA M/S. DEMPO SHIPYARD PVT. LTD. UNDIR, PONDA,GOA	MR. S.A. KANEKAR	TEL. : 2285452 ENTN.: 210 TEL. : 2491202 (DIRECT) 98503982823

DETAILS OF DRYDOCK/SLIPWAY FACILITIES
AVAILABLE IN GOA

S.NO.	SHIPYARD	CONTACT PERSON	CONTACT NOS.
11	M/S. TIMBLO DRYDOCKS PVT. LTD. XELVONA, GOA	MR. D.S. PAI	TEL. : 2650042, 659024(W) 9403686702
12	M/S. VIMANI ENGINEERING WORKS DABOLIM, GOA	MR. MANOJ PATEL	TEL. : 9422437614
13	DREDGING EQUIPMENTS M/S. PRESISION DREDGING MELQUIDES BLDG, 3RD FLOOR, FR. JOSE VAZ ROAD, VASCO-DA-GAMA	MR. DEVANAND SHIRODKAR	TEL. : 2512091(O) 2777033(W) FAX: 2500305(F)
14	M/S. COMPOSITE MATERIALS INDUSTRIES PVT. LTD. CHICALIM GOA	MR. SURAJ DIALANI MR. HARISH CHAWLA	9822982130
15	M/S.ABHISHEK ENGINEERS CHICALIM GOA	MR. UDAY K. NAIK	9822485075
16	M/S. MANDOVI ORE CARRIERS DABOLIM GOA	MR. UDAY K. NAIK	9822485075

CHAPTER – 4

WATERWAY

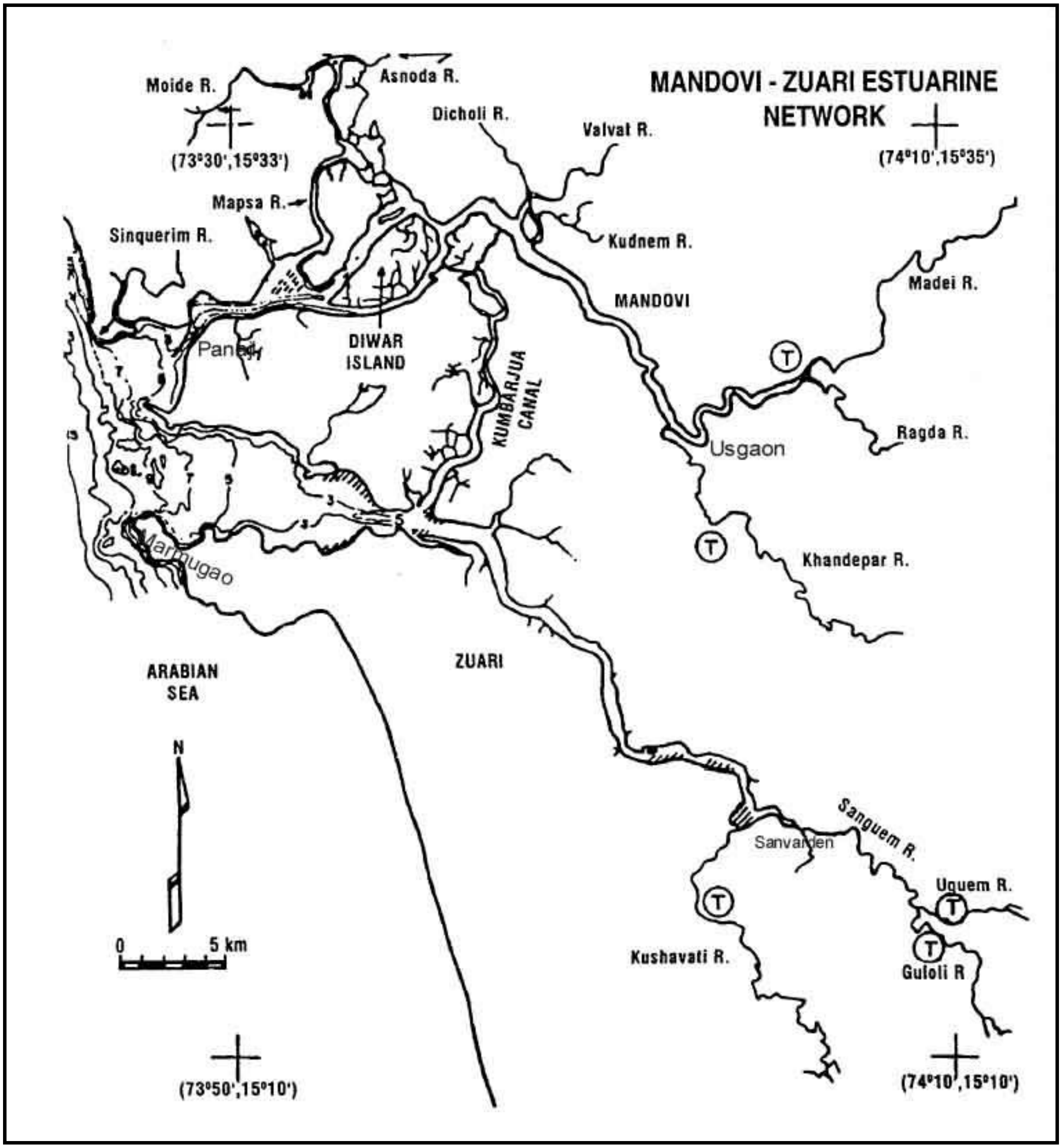
4.1 THE MANDOVI – ZUARI ESTUARINE SYSTEM

The Mandovi and the Zuari are two estuaries located in Goa on the west coast of India and join the Arabian sea (Fig. 4.1). 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 Cumbarjua 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 Kushawati 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.

The influence of the Aguada bar at the mouth of Aguada Bay has been examined by studying the flow and circulation model of the estuary.



(Source – Survey of India top sheet / Edited by RITES)

Fig. 4.1: Index Map of Rivers Mandovi, Zuari and Cumberjua canal system in Goa

4.2 THALWEG SURVEY

The hydrographic survey charts of Mandovi, Zuari Rivers and Cumberjua canal have been collected from Panaji port, Goa. The hydrographic surveys were carried out from 2001 to 2003 by MPSO. The thalweg survey has been conducted in this net work of waterways by RITES LTD during January 2011. The thalweg survey route map is shown in Fig.4.2. The thalweg survey soundings have been reduced to a chart datum (CD) followed by the Panaji port. The value of chart datum (C.D.) at Mormugao Port Trust is 1.3 m below M.S.L. and same has been utilized for reduction of soundings recorded during thalweg survey. Thalweg survey charts of Mandovi, Zuari Rivers and Cumberjua canal along with ground level charts of Cumberjua canal are prepared and are placed in volume 2 of this report.

Fig. 4.2: Thalweg route of Mandovi, Zuari and Cumbarjua canal in Goa

4.2.1 Mandovi River:

The longitudinal bed profile of Mandovi River as per RITES survey (2011) is shown in Fig. 4.3. In the figure, the thalweg survey route is shown from Usgaon Bridge to Aguada

Bay. The longitudinal bed profile along the deepest route based on MPSO survey (2001-03) is also superimposed in the same figure for the purpose of comparison.

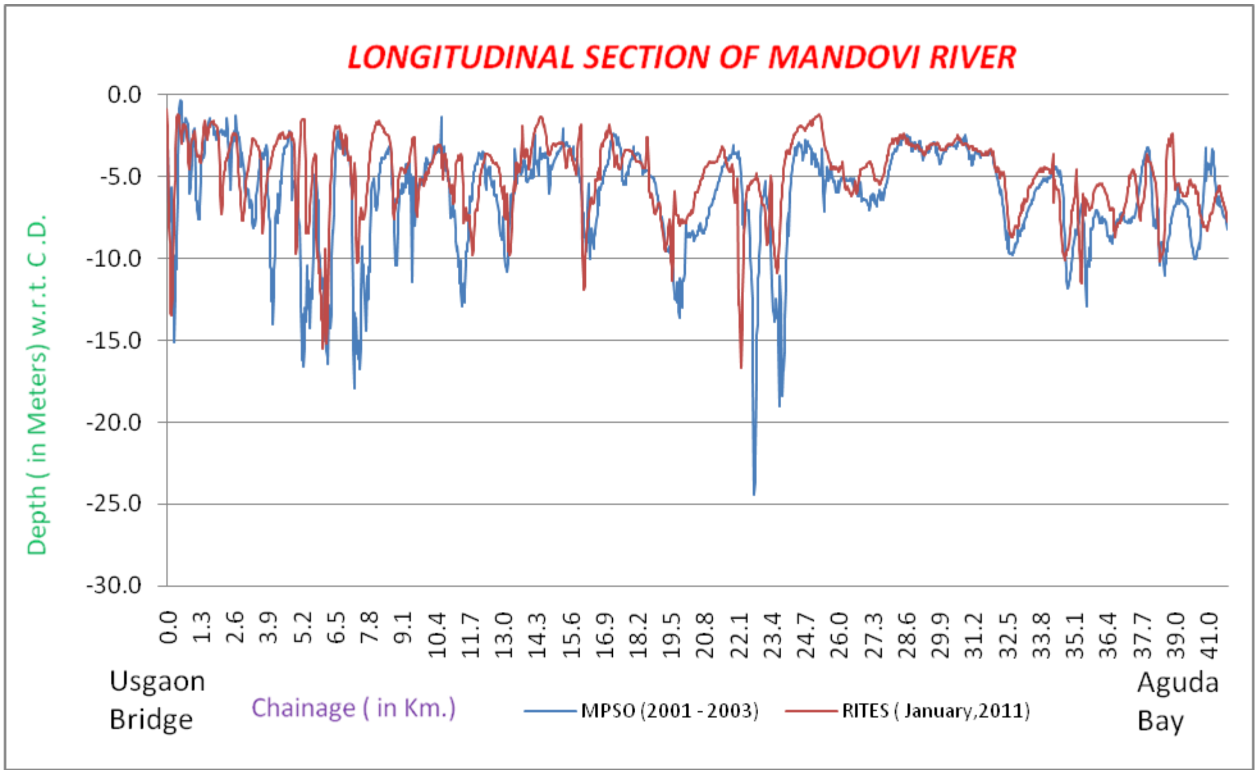


Fig.4.3: The longitudinal section of the Mandovi river

From the longitudinal section of the Mandovi River it can be seen that the depths are less at Usgaon bridge side and the least depths are around 1.2 to 1.5 m below the CD. Though the predominant depths in the upstream reaches are around 2 to 2.5 m, the larger depths as deep as 10 m are also noticed in considerable stretch. Towards, Aguada bay, it is noticed that the depths are generally increasing. When compared to the 2001-03 survey, the depths during the recent survey (2001) are generally less at many places throughout the reach. Hence, it can be attributed that there was a siltation in the Mandovi River during the intervening period.

4.2.2 Zuari River:

The longitudinal bed profile of Zuari River as per RITES survey (2011) is shown in Fig. 4.4. In the figure, the thalweg survey route is shown from Sanvarden Bridge to Marmugao Bay. The longitudinal bed profile along the deepest route based on MPSO survey (2001-03) is also superimposed in the same figure for the purpose of comparison.

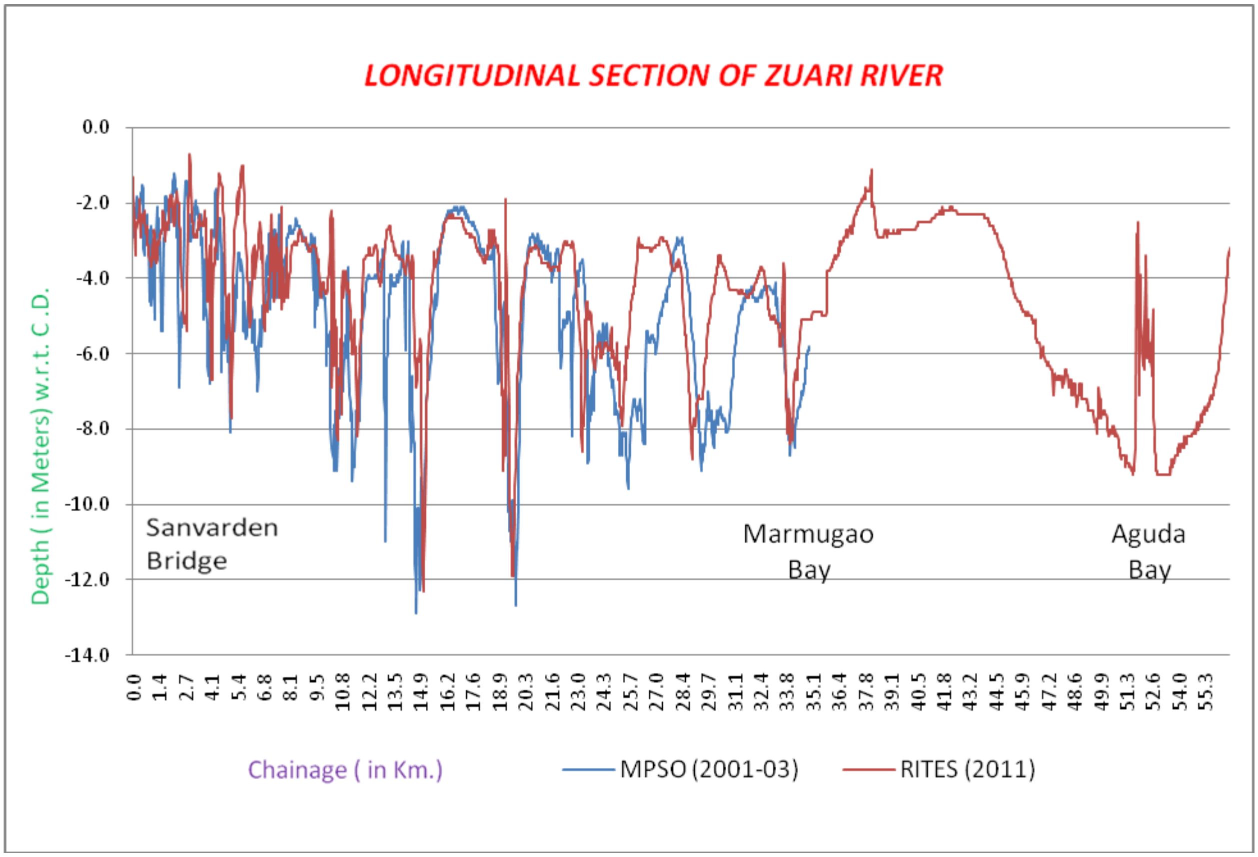


Fig. 4.4: The longitudinal section of the Zuari river

From the longitudinal section of the Zuari River it can be seen that the depths are less in the upstream reaches near Sanvarden bridge side and the least depths are around 1.2 to 1.5 m below the CD. There are deep pools of depths more than 8 m are noticed at certain reaches in the Zuari River from Sanvarden to Marmugao port. Towards, Marmugao bay, it is noticed that the depths are generally increasing. When compared to the 2001-03 survey, the depths during the recent survey (2011) are generally less at many places throughout the reach. Hence, it can be attributed that there was a siltation in the Zuari River during the intervening period. The 2001-03 survey was conducted up to Konkan Rail Bridge across the Zuari River near the river mouth. However, in 2011 survey, the depths have been recorded from Konkan Rail Bridge to Marmugao bay / port to Aguada bay along the mouth of the estuaries as shown in the above figure.

4.2.3 Cumberjua canal:

The longitudinal bed profile of Cumberjua canal as per RITES survey (2011) is shown in Fig.4.5. In the figure, the thalweg survey route is shown from confluence point of Cumberjua canal with Mandovi River to confluence point of Cumberjua canal with Zuari River. The longitudinal bed profile along the deepest route based on MPSO survey (2001-03) is also superimposed in the same figure for the purpose of comparison.

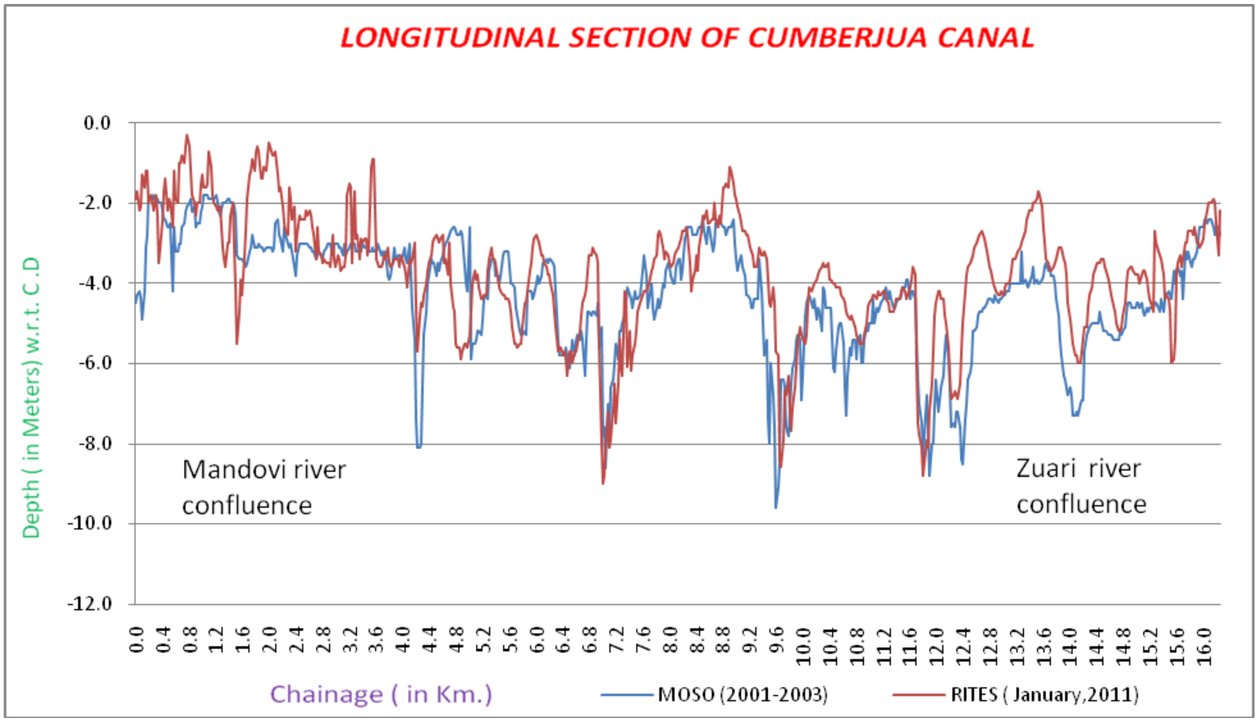


Fig. 4.5: The longitudinal section of the Cumberjua canal

From the longitudinal section of the Cumberjua canal it can be seen that the depths as less as 0.3 to 0.6 m are noticed at the confluence point of Cumberjua canal with Mandovi river. The depths are generally around 3 to 4 m in the middle reaches of the canal between the ends of Mandovi and Zuari sides. Depths exceeding 6 m also noticed at certain reaches. When compared to the 2001-03 survey, the depths during the recent survey (2011) are generally less at many places throughout the reach. Hence, it can be attributed that there was a siltation in the Cumberjua canal during the intervening period.

The detailed general features of the waterways under present study has been described depth wise, width wise and chainage wise and presented in Annexure 4.1 of this chapter. The critical bends of the above waterways are also identified and presented in annexure 4.2.

4.3 MODEL STUDIES

4.3.1 Tidal Dynamics

For the analysis of tide heights, the Fourier series approach has in practice to be made more elaborate than the use of a single frequency and its harmonics. The tidal patterns are decomposed into many sinusoids having many fundamental frequencies, corresponding (as in the lunar theory) to many different combinations of the motions of the Earth, the Moon, and the angles that define the shape and location of their orbits.

For tides, then, harmonic analysis is not limited to harmonics of a single frequency. In other words, the harmonies are multiples of many fundamental frequencies, not just of the fundamental frequency of the simpler Fourier series approach. Their representation as a Fourier series having only one fundamental frequency and its (integer) multiples would require many terms, and would be severely limited in the time-range for which it would be valid.

The study of tide height by harmonic analysis was begun by Laplace, William Thomson (Lord Kelvin), and George Darwin. A.T. Doodson extended their work, introducing the Doodson Number notation to organise the hundreds of resulting terms. This approach has been the international standard ever since, and the complications arise as follows: the tide-raising force is notionally given by sums of several terms. Each term is of the form

$$A \cos (w\, t + p)$$

where A is the amplitude, w is the angular frequency usually given in degrees per hour corresponding to ‘t’ measured in hours, and ‘p’ is the phase offset with regard to the astronomical state at time t = 0 . There is one term for the Moon and a second term for the Sun. The phase ‘p’ of the first harmonic for the Moon term is called the lunitidal interval or high water interval. The next step is to accommodate the harmonic terms due to the elliptical shape of the orbits. Accordingly, the value of ‘A’ is not a constant but also varying with time, slightly, about some average figure. Replace it then by A (t) where ‘A’ is another sinusoid, similar to the cycles and epicycles of Ptolemaic theory. Accordingly,

$$(t) = A\,(1 + A_a \cos(w_a\, t + p_a))$$

which is to say an average value ‘A’ with a sinusoidal variation about it of magnitude ‘A_a’ , with frequency ‘w_a’ and phase ‘p_a’ . Thus the simple term is now the product of two cosine factors:

$$[1 + A_a \cos(w_a + p_a)] \cos(wt + p)$$

Given that for any *x* and *y*

$$\cos(x)\cos(y) = ½\cos(x + y) + ½\cos(x–y)$$

It is clear that a compound term involving the product of two cosine terms each with their own frequency is the same as three simple cosine terms that are to be added at the original frequency and also at frequencies which are the sum and difference of the two frequencies of the product term. Consider further that the tidal force on a location depends also on whether the Moon (or the Sun) is above or below the plane of the equator, and that these attributes have their own periods also incommensurable with a day and a month, and it is clear that many combinations result. With a careful choice of the basic astronomical frequencies, the Doodson Number annotates the particular additions and differences to form the frequency of each simple cosine term.

It can be noted that the astronomical tides do not include weather effects and also, changes to local conditions (sandbank movement, dredging harbour mouths, etc.).

The major 5 tidal constituents are:

- M_2 : Principal lunar semidiurnal constituent
- S_2 : Principal solar semidiurnal constituent
- N_2 : Larger Lunar elliptic semidiurnal constituent
- K_1 : Luni-solar declinational diurnal constituent and
- O_1 : Lunar declinational diurnal constituent

The important tidal constituents for the purpose of prediction are shown in Fig.4.6. Scientists study these to determine amplitude (the magnitude of the difference in elevation between low and high tides at a particular point in a body of water) and phase lag (the time delay with which one rhythmic activity follows another of the same frequency). A month long time series is needed to determine the constituents and hence to predict the tides as shown in Fig. 4.7.

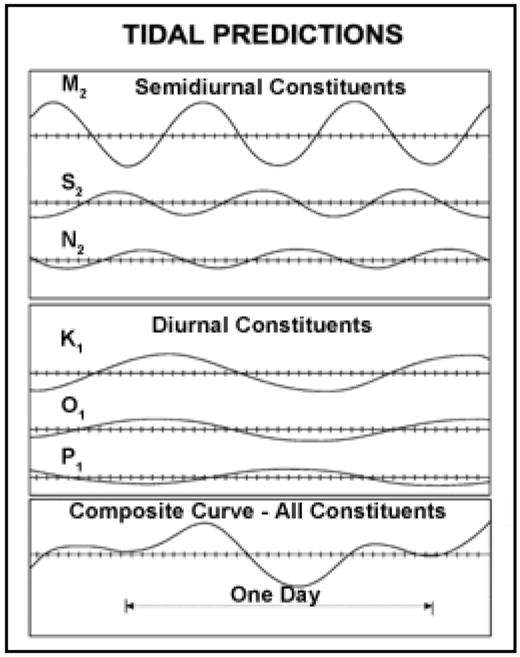


Fig.4.6: The tidal constituents

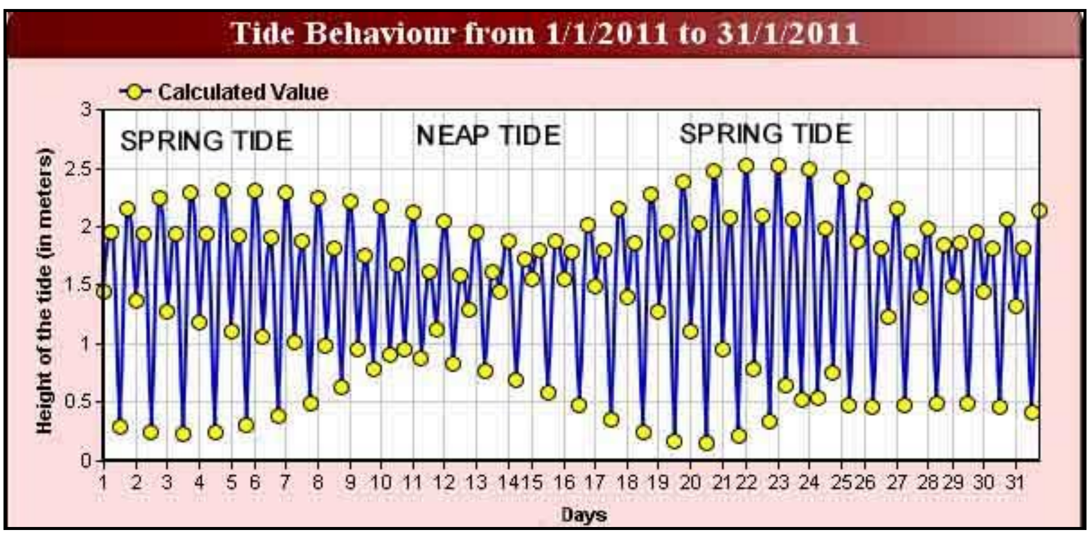


Fig.4.7: Predicted tide at Goa

The Murmagao Port Trust and National Institute of Oceanography regularly measure the tide at the mouth of the estuary using automatic tide gauge. The tide during the survey period as measured by NIO is shown in Fig.4.8. As seen in the figure, the tides at Goa are semi diurnal with two high tides and two low tides in a day.

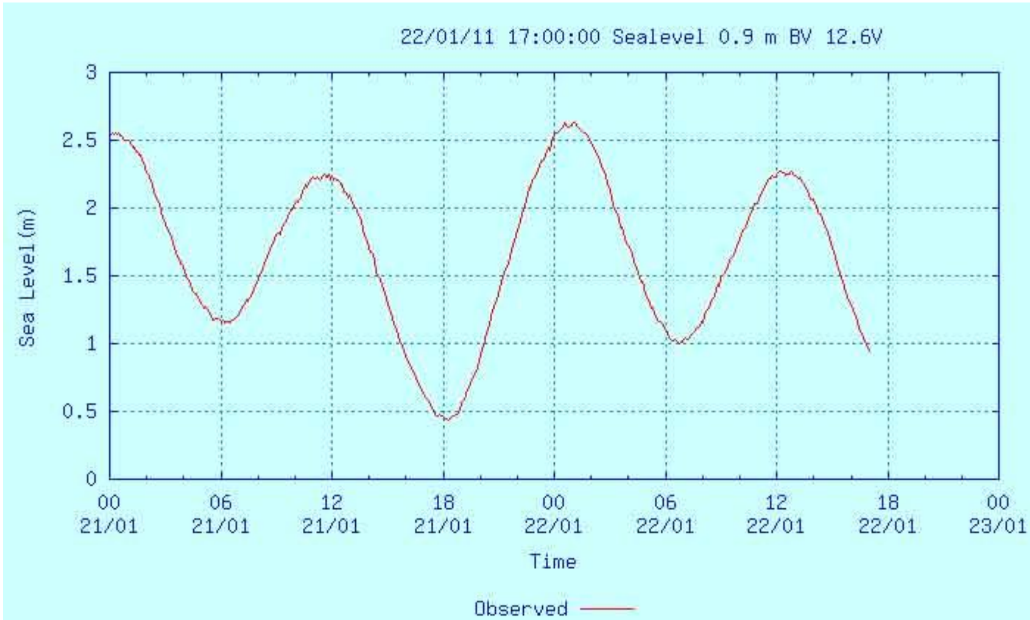


Fig. 4.8: Observed tide at Goa

The tidal information at Goa as per the Mormugao Port Trust is:

- Mean Higher High Water (MHHW) : 2.1 m
- Mean Lower High Water (MLHW) : 1.8 m
- Mean Higher Low Water (MHLW) : 1.0 m
- Mean Lower Low Water (MLLW) : 0.4 m
- Mean Sea Level (MSL) : 1.3 m

The mean tidal range is about 1.7 m at Goa.

Study and knowledge of tides is extremely important for navigation. Ships wait outside harbours for an entry during high tide. Alternately, large investments are made to manufacture transhippers to transfer the bulk cargo on the ships, from small vessels, at offshore locations - without waiting for the high tide and/or a berth in harbour.

Tidal influence is felt in the two estuaries up to a distance of about 50 km. The increase in elevation of the estuarine channels prevents tides from propagating beyond this distance. The runoff in the two estuaries is highly seasonal, just as is the precipitation. The runoff in the rivers is high during June–September when the monsoon is active. The flow in the estuarine channels is primarily tidal after withdrawal of the monsoon, and continues to be so until onset of the next monsoon. Several authors (Shetye S.R., Suresh, I, Sundar D., 2007; Sundar, D., and Shetye S.R., 2005 ;) had carried out tide pole measurements throughout the estuarine system of Goa. The main channels of the Mandovi and the Zuari are connected by the Cumberjua Canal. Its cross-sectional area is, however, much too small to have a major impact on the characteristics of tidal propagation in the two main channels.

In shallow Goa estuarine channels (Mandovi and Zuari) that converge (cross-sectional area decreases from mouth to head), three factors determine tidal propagation. The first is the rate of decrease in channel cross-sectional area from mouth to head. More rapid the decrease, greater is the tendency of the amplitude to grow. This is a consequence of geometry; more confined the available cross-sectional area, greater is the increase in amplitude. Another factor is friction. Greater the friction, greater the decay of the tide as it propagates. Frictional dissipation usually varies among tidal constituents because the nonlinear effects that lead to transfer of energy from one constituent to another depend on the constituent. Numerical models of estuarine tidal circulation are usually successful in accurate simulation of tidal amplitude. While such models are useful in applications, simpler, preferably analytical, models are useful to gain a perspective of the dynamics underlying tidal propagation. A description of the numerical equations is given in many text books (Officer, 1976) and published research articles on estuaries dynamics Unnikrishnan A.S., and Manoj, N.T, 2007).

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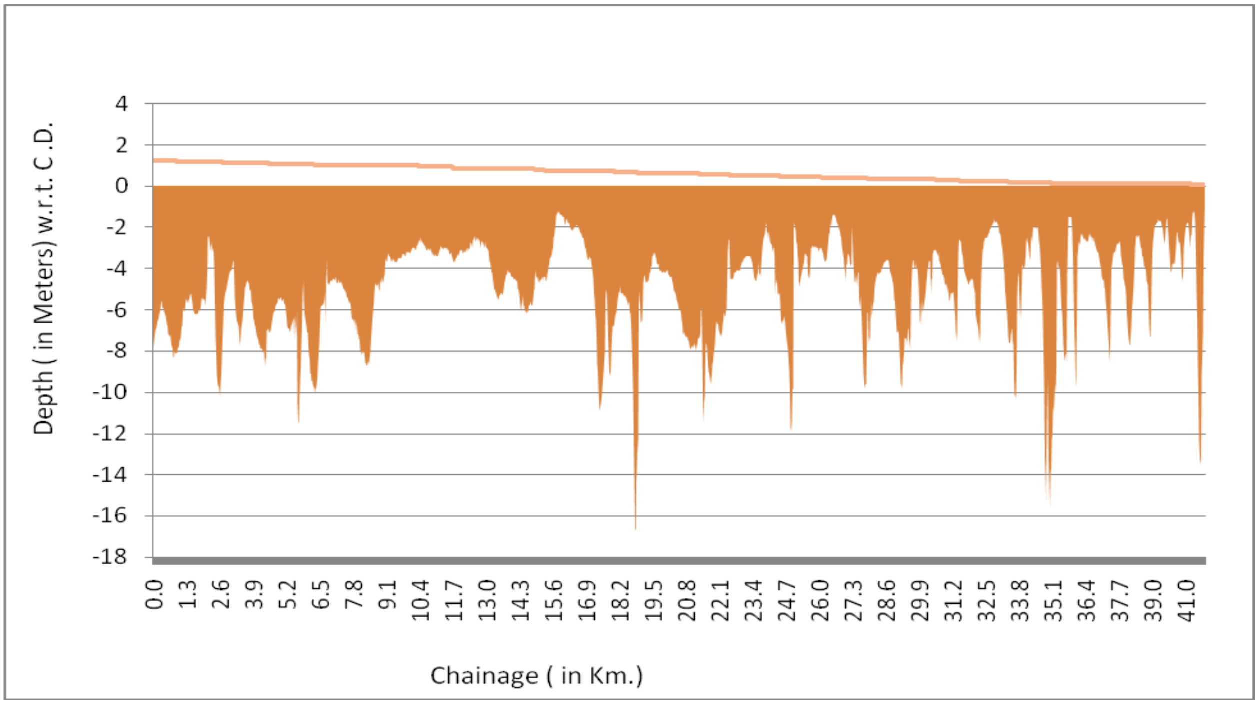
The cross-sectional area of Mandovi and Zuari rivers decreases from mouth to head as shown in Table 4.1, based on the recent surveys carried out in 2011. The cross section area in Mandovi River reduces from 26,348 m^2 at Aguada bay (mouth) to 847 m^2 at the head (Usgaon) over a distance of 40 km. The rate of decrease of cross section area is thus about 638 m^2/ km. The cross section area of Mormugao bay in Zuari estuary (mouth) has been worked out as 25,420 m^2. The cross sectional area progressively reduces from mouth to head and the cross sectional area at the Sanvarden (head of the estuary) has been worked out as 318 m^2. Hence, the cross sectional area is reduced by 25,102 m^2 at the rate of 457 m^2/ km in Zuari estuary.

Table 4.1: Cross sectional area of Mandovi-Zuari-Cumberjua canal system

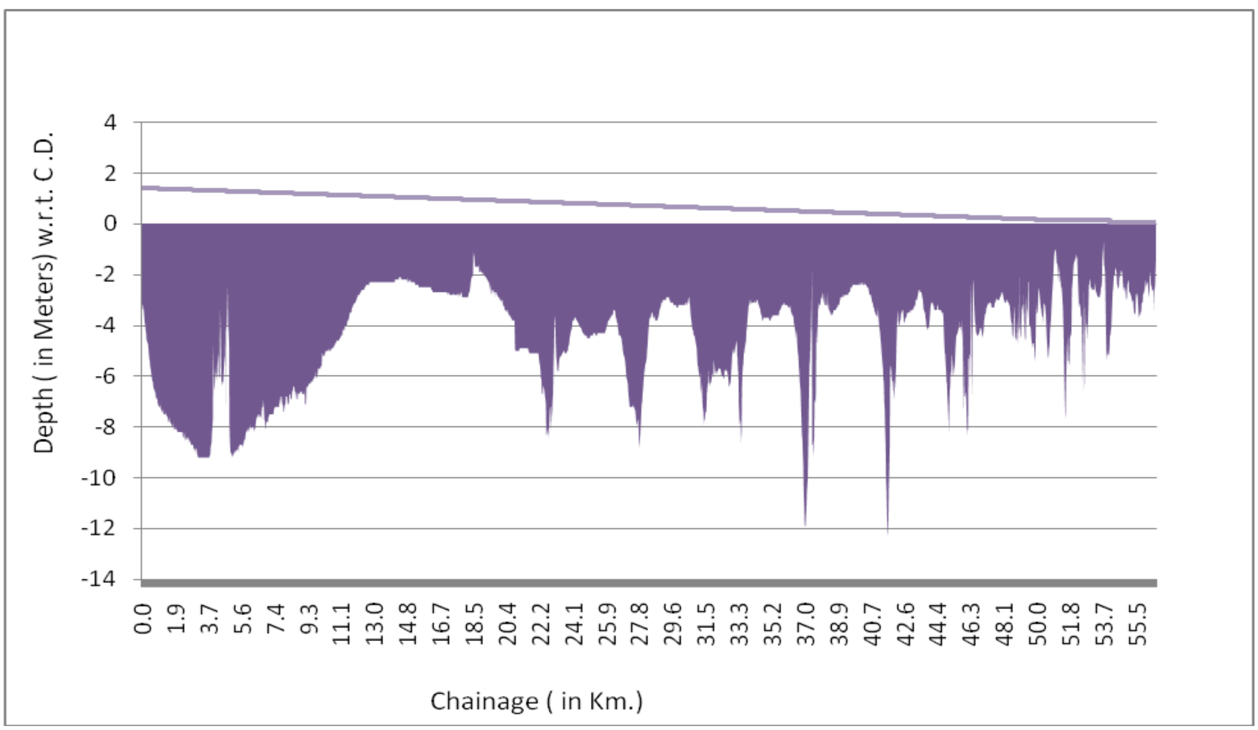
Waterway: Mandovi river		Waterway: Zuari river		Waterway: Cumbarjua canal	
Location	Cross section area (m^2)	Location	Cross section area (m^2)	Location	Cross section area (m^2)
Aguada Bay	26,348	Mormugao bay	25,420	Mouth of Mandovi river	66
Panjim	3,398	Konkan bridge	2,422	Panaji bridge	598
Konkan bridge	1,323	Raitur ferry	1,244	Caundalim bridge	111
Usgaon bridge	847	Sanvarden bridge	318	Mouth of Zuari river	417

The tidal constituents, that is, amplitude of M_2 is increased by about 20% in Mandovi from mouth to head and by about 30% in the Zuari. The increase in K_1 was by about 10% in Mandovi and 15% in Zuari. The phase lag also increased from mouth to head for both diurnal and semidiurnal constituents, but variation was not linear with respect to distance from the mouth.

The channel topography and how water level changed covering a typical cycle of 12 hour duration of spring tide constituents for Mandovi and Zuvari are shown in Fig. 4.9. This will also help in understanding how the water level along the channel changes during a tidal cycle and understand how the increase in channel elevation causes the tidal amplitude to drop at the upstream end in a given estuarine channel.



(a) Mandovi river



(b) Zuari river

Fig. 4.9 : Channel topography in typical cycle of spring tide

4.3.2 Aguada Bar

Location description

The Aguada Bay (parts of which are known as Caranzalem Bay and Sinquerim Bay) in which the Aguada bar is located, is formed by two promontories of Cabo Raj and Aguada headland (Fig. 4.10).

The Aguada Bay and the Mandovi estuary sustain a heavy barge traffic carrying iron and manganese ores to the adjacent port of Mormugao apart from the mechanised fishing boats operating from a base at Panaji and the coastal passenger ships sailing between Panaji and Bombay. The hectic barge movement in Aguada bay of the Mandovi estuary can be seen in Fig. 4.11. However, this waterway has to be closed down during the southwest monsoon months as navigation is rendered hazardous by the shoals/bars (popularly known as Aguada and Reis Magos bars) near the entrance of Mandovi estuary.

The navigational channel in the Mandovi estuary is located close to the left bank and is flanked by two shoals - the Aguada bar and the Reis Magos bar. Of these, the Aguada bar is more prominently developed and projects seaward from Gaspar Dias (Mira Mar; Fig. 4.12). It is reported that (Murthy, 1976) the maximum width of the exposed parts of the bar was 20 m at the near end and l0-12 m at the farther end. These exposed parts showed well developed asymmetric ripples on areas of coarse sediments and poorly developed ones where fine sediments prevailed, as at the seaward end. The Reis Magos is a shoal which is too ill-defined to be termed as a bar. A notable feature is the presence of a ramp along which the navigational channel is located. It has a steep gradient between the 5 and 1.5 m isobaths along the ramp axis.

History of Aguada Bar

The Aguada bar was referred to in Portuguese hydrographic map as “Barra de Agoada” and its features in 1881 were compared with bathymetric surveys of 1976 (Pathak, M.C. et al., 1990) and found that there is no significant topographic changes during the last 100 years are so and the channel was navigated by shallow draft vessels. Hence the shoals at the mouth of the Mandovi estuary are known to have been present here over several centuries. Manuel Godinho de Eredias’s, Map of 1610 (Bois Penrose, 1960) shows these as a single patch of shoal near the entrance of Mandovi estuary.

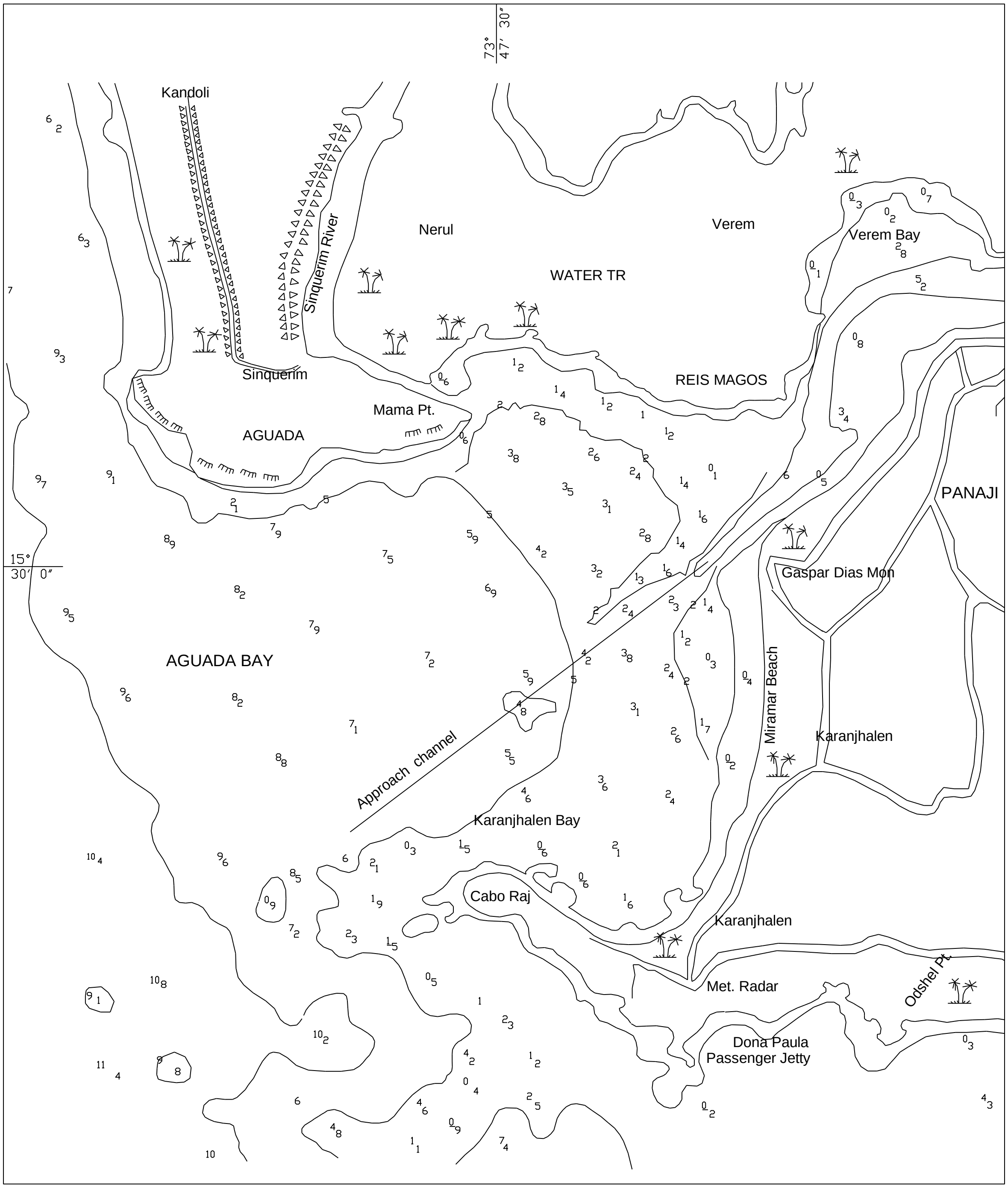


Fig. 4.10: Bathymetry of the Aguada Bay - Goa

Fig. 4.11: Aguada Bay – Mandovi Estuary

Fig.4.12: Aguada bar in the Mandovi estuary mouth

4.3.3 Circulation Model Study at Aguada bay

Looking at the present conditions prevailing in the Bay and in the light of the history behind the bar, it would appear that, so far as these shoals and the navigational channel are concerned, not much has changed over a few centuries. That the shoals/bars have neither grown significantly in size nor have they disappeared completely suggest that a kind of balance exists between the supply and depletion of sediment which maintain the shoals/bars controlled by the interaction of tides, waves, river runoff, etc., which determine the circulation pattern in the bay and in the mouth of the estuary: Further, it is only during monsoon that this region poses navigational problems while during the fair weather season the navigational channel remains relatively deep and well marked. It is, therefore, of interest to understand the mechanism of sediment transport in this region for solving the economically important problems of navigation posed mainly by the Aguada bar. The sediment transport mechanism in turn depends upon the near shore dynamics such as wave activity, tidal propagation, currents and circulation.

The Mandovi estuary and the Aguada Bay have a yearly cycle of variation in their hydrographic features consisting of three distinct phases – the south west monsoon and the preceding and following fair weather seasons – with varying wave climates prevailing in the bay and the adjacent sea coupled with wide fluctuations in the freshwater discharge through the estuary. It is thus a mixed estuary during the fair weather season (December to May) which, with the onset of the south west monsoon (June to September), becomes progressively stratified when the freshwater discharge is at its maximum.

The tides at the Aguada bay as explained elsewhere are of semidiurnal type with a range of about 2 m. In the absence of any significant freshwater discharge, as in the pre-monsoon season, the currents in the estuary are mainly dominated by the flood and ebb tides. As per the geometry of the estuary, the tidal currents in the bay would be of lesser magnitude compared to the constricted part of the estuary.

Wind waves and swells which enter the bay area of markedly different characteristics during south west monsoon as compared to fair weather seasons. Low swells from west to north west predominate during fair weather season, whereas, during the south west monsoon high wind waves from west to south west prevail (Reddy, M.P.M., 1970). Wave heights measured by NIO using wave recorder outside the bay during the fair weather season indicate the prevalence of waves of 6 to 8 sec significant period and 0.38 m significant wave height. The wave breaking phenomena over the shoal in the Aguada bay can be seen in recent satellite imagery (Fig. 4.12).

The studies carried out earlier (Murthy C.S., 1976), have revealed that the incoming wave from the sea at the Aguada bay and the tidal ebb and flood is of importance during the fair weather season since there would be negligible fresh water discharge through the estuary. Due to the steep slope at the Aguada bar and deep channel towards the sea, the flow pattern is linear – either moving out with the ebb or moving in with the flood.

Beyond the bar, towards the estuary, however, the ebbing water encounters the incoming wave transport and the circulation is modified during the transition from ebb to flood when the wave transport and the weak ebb current interact in such a way that the flow takes a turn towards the side of the ramp type Aguada bar slope. With the flood tides slowly taking over and the waves rounding the shoal of Aguada, the circulation takes an eddy form on either side of the bar (Fig.4.13).

The comparison of pre and post monsoon surveys had shown that the fresh water out flow in the monsoon season had a flushing and scouring effect due to strong current in the narrow area but during the lean season the channel return to its original depth (Pathak et al, 1988). It is reported that though the dredging was carried out to deepen the navigation channel but subsequent surveys showed that the channel in between the bars (Aguada bar in the south and Reis Magos bar in the north) silted up to its original depth. In spring low both the bars are visible during fair weather season.

Effect of waves and tides on Aguada bar

The Aguada bay is open to swells from the prevailing south west, west and North West approaches of waves directions of the Arabian sea. Shallow water waves transporting sediments, in part from headlands erosion and in part from offshore sources, would tend to deposit heir loads near the point of changes in alignment of the beaches along the Goa coast as well as near the constriction in the mouth of the estuary. The rise in sea level generally brought about rapid shoaling in estuaries and the most effective agent of sediment transport, under these circumstances, is the waves. That the waves are responsible for the formation of these bars gains additional support when one takes into account the formation of the bar at Reis Magos (Fig. 4.13). Each bar corresponds to one or two wave directions the Aguada bar being mainly a result of west or north westerly waves and the Reis Magos bar of the south westerly waves as shown in figure (Fig. 4.13). The net result of the waves coming from these two directions would be to block the mouth of the estuary which, however, does not happen as the flood and ebb velocities maintain the channel between the two shoals.

Causes for the formation of sand bars in Aguada Bay

The process contributing the formation of the bars may be the deposition caused by the abrupt reduction in the velocity (competency of the flow) of the ebbing waters of the estuary as they enter the bay (constriction near the head of the bay). This process is likely to operate better during the monsoon when higher discharges and attendant sediment loads prevail. However, counteracting this process during the monsoon is the intensification of wave activity (steep short period waves become prominent) which results in the net removal of material from the bay/bar and adjacent beaches. This process leads to extensive loss of material from the bar during the monsoon and build up during the fair weather season. As a result during the monsoon periods the bar is never exposed even at lowest tides because of the deepening of the water over the bar through the removal of material by waves. Contrary to this, during lean period (fair weather season), the bar get exposed.

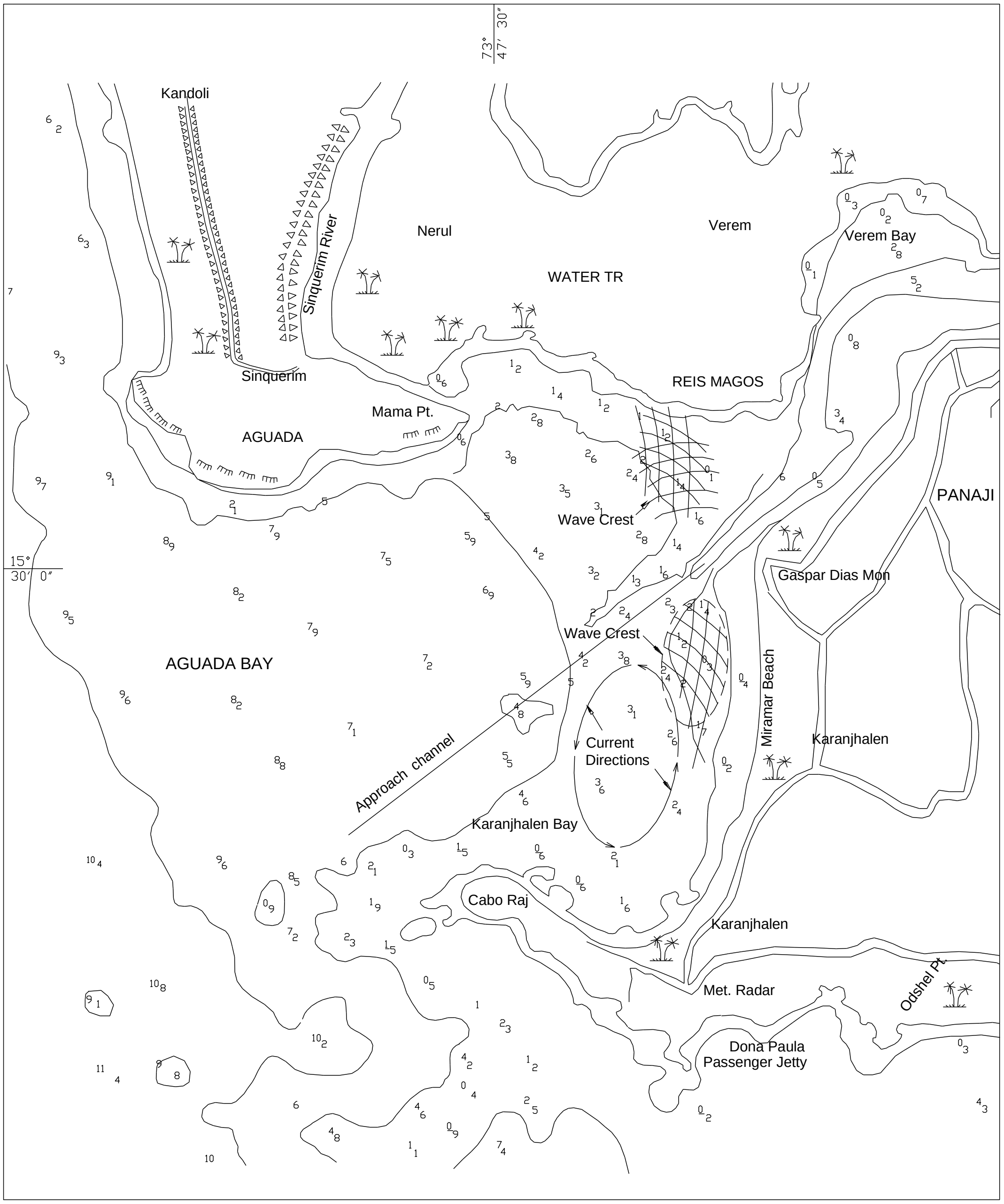


Fig.4.13: Circulation flow pattern in Aguada Bay

Circulation and associated sediment transport

During high tide, the flow around the Aguada bar forms a separate loop with the flood water and the wave surge rounding the shoal and joining the navigational channel at the base (proximal end) of the bar (Fig. 4.13). This may be the reason for the formation of a runnel like feature at the base of the bar where the isobaths curve inwards (Fig. 4.13). It would also mean that during this stage (flood stage) there would be a net sediment transport to the channel from the southern side of the bar. During the low tides, however, when the bar is either exposed or partially exposed at the base, the sediments would not be able to cross over the base to the channel and hence give rise to partial accumulation on the southern side.

The northern edge of the bar (along the navigational channel) is always subjected to tractional forces of a linear flow (either upstream with the flood or downstream with the ebb). No accumulation of sediment is therefore possible here. This is evidenced by the fact that the gradient is very steep on this side and only coarser sediments prevail. However, the flow of sediment across the bar towards the channel due to the circulation pattern described above and the continuous churning of the sediments over the bar caused by the wave crests surging over the bar make good the loss of material on the channel side of the bar. The deep ebb-flood channel thus maintains equilibrium through this balance of removal and supply of sediments.

During the monsoon this particular pattern of water movement and sediment transport would not prevail as the wave activity over the bar then increases significantly. It would then be expected that increased wave disturbed sediment would truncate the bar considerably and there would be a net loss of sediment from the bar to the navigation channel, and hence the navigation channel shallowing up progressively. At the same time a considerable amount of sediment load carried by the monsoonal discharge of the Mandovi River is added at this location. The sudden widening of the estuary near the bar would then slacken the ebb and tend to deposit a part of the suspended sediment here. This process is altogether absent during the fair weather season as the river then carries negligible amount of suspended sediment. During the fair weather period, through the cycles of ebb and flood there is a progressive loss of material (fine sediment) from the edges of the bar as from its surface and from the navigational channel. Thus, as the monsoon recedes, the Aguada bar gradually regains its original shape and size of the fair weather months. This cycle is maintained in essence from year to year.

It can generally be concluded that the monsoon is the period when removal of material is the prevailing feature and that the compensating supply comes during the fair weather season when long period and low swells push the sediments back into the estuary. Moreover, the typical circulation flow patterns in the Aguada bay are of importance in keeping the bar nourished.

4.4 MORPHOLOGICAL STUDY

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 Cumbarjua 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.

4.4.1 Morphological changes of Aguada bar:

The satellite imageries of the Aguada bar in December 2002, November, 2007 and January, 2010 are shown in Figs 4.14 to 4.16. The width of the bar is around 250 m and length of the bar is spread along the coast by about 750 to 800 m in December, 2002. The width of the bar had been widened to 295 m by November, 2007 and again reduced to 270 m in January, 2010. From these satellite imageries of different years it can be noticed that the bar is unstable. As explained in the circulation sediment transport model of Aguada bar, the erosion and nourishment of the Aguada bar is a cyclic phenomena from year to year.

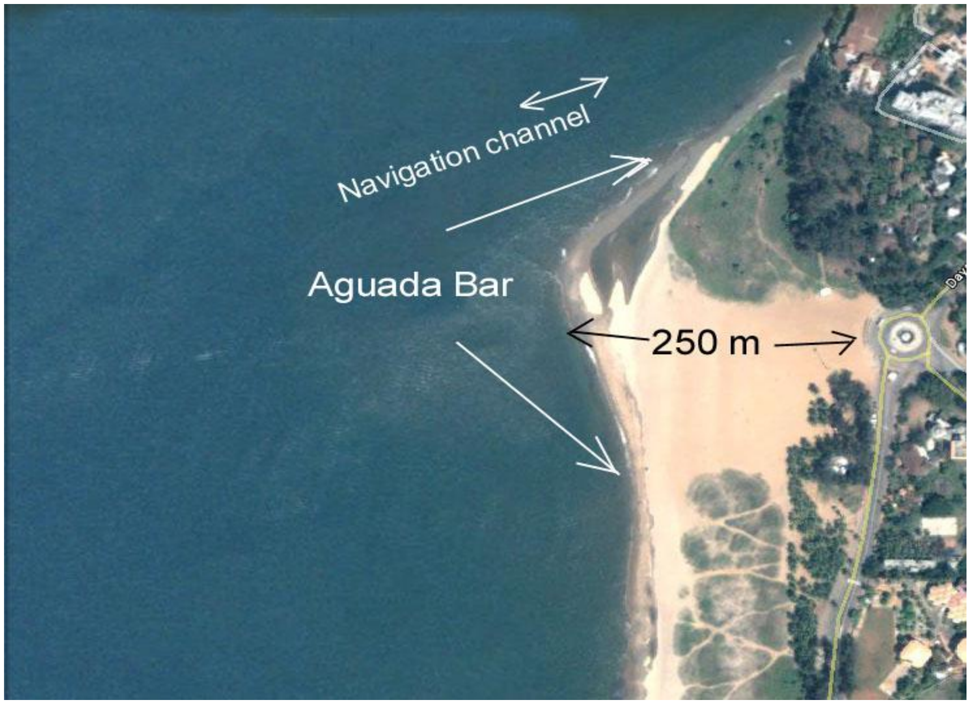


Fig.4.14: Aguada bar in December, 2002

Fig. 4.15: Aguada bar in January, 2007

Fig.4.16: Aguada bar in January, 2010

The cross sections of the Aguada bay have been recorded in January, 2011 at different locations are shown in Fig.17.

The cross section no. 1 recorded at the Cabo Raj rock (Fig. 4.18), that is, at the mouth of the Aguada bay shows that the channel is wide of about 3000 m and deep of about 8 m. There is no much change in bottom topography of the channel when compared to 2001-03 survey.

The cross section no. 2 recorded at the starting point of the Aguada bar (southern end) (Fig. 4.19) shows that the deeper channel is moved away from the left bank (about 3200 m from Aguada bar coast) due to formation of the Aguada bar along the coast of Left Bank. The deeper depths have become less by about 2 m in the recent survey (2011) when compared to the previous survey in 2001-03 due to siltation. It shows that the channel has become shallow from 8 m to 6 m, at this location.

The cross section no. 3 recorded at northern end of the Aguada bar (4.20) shows that the deeper depths are reduced to 5 m and thalweg is close to left bank, that is about 750 m away from the coast. When compared to the previous survey of 2001-03, the recent survey (2011) indicates that the thalweg is moved away from the coast by about 100 to 150 m which reveals that the siltation along the coast. At this location, shallow depths of about 4 m are noticed on the other side of Aguada bar that is, along Reis Magos side due to formation of shoal.

The cross section no. 4 recorded further north of the Aguada bar (4.21) shows that the thalweg hugs along the left bank. The width of the deeper navigation channel is around 150 m and the depths are about 6 m. The deeper channel is followed by shallow depths due to the formation of shoal known as Reis Magos shoal on the right bank of the Zuari estuary. The Reis Magos shoal is quite lengthy of about 2000 m with depths of about 2 to 3 m. When compared to the previous survey of 2001-03, the recent survey (2011) reveals that the depths are reduced on the shoal by about 1 m due to siltation. Though the Reis Magos shoal is submerged during all seasons, it plays a vital role in siltation of the navigation channel and also reduction in width of the channel.

Fig. 4.17: Location of cross sections (CS) – Aguada Bay

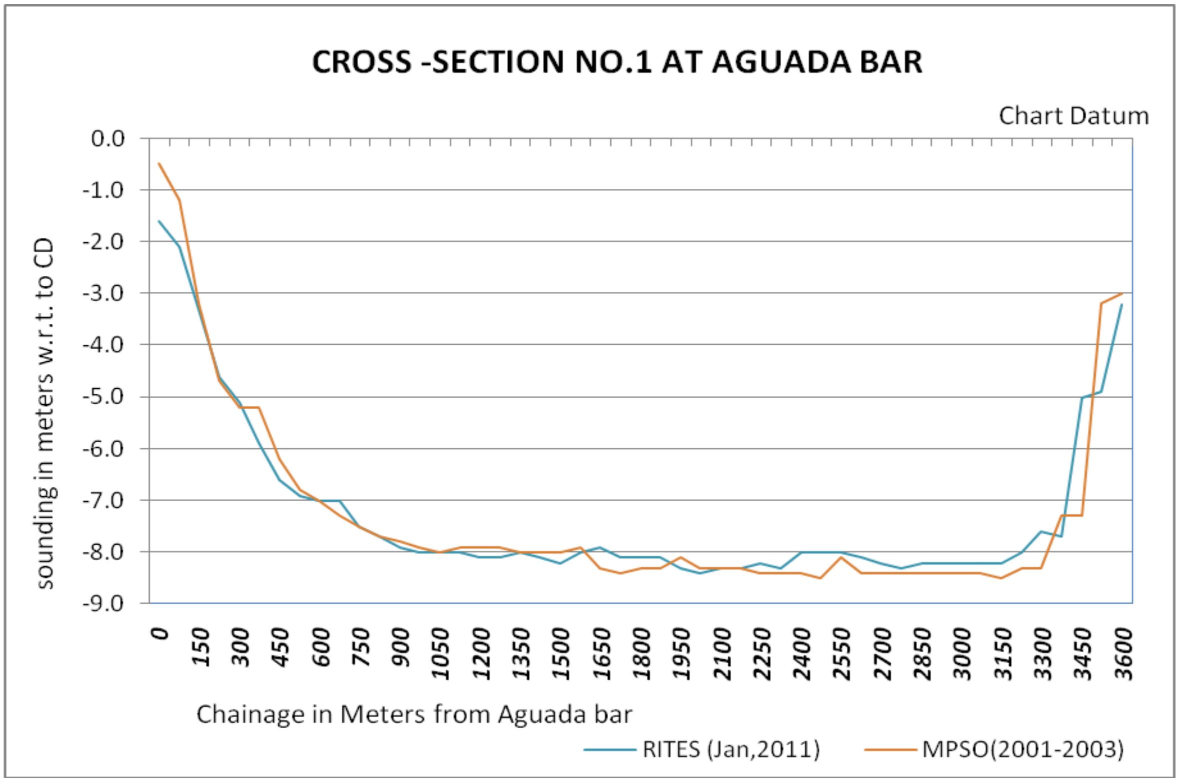


Fig. 4.18 Cross section of Aguada Bay

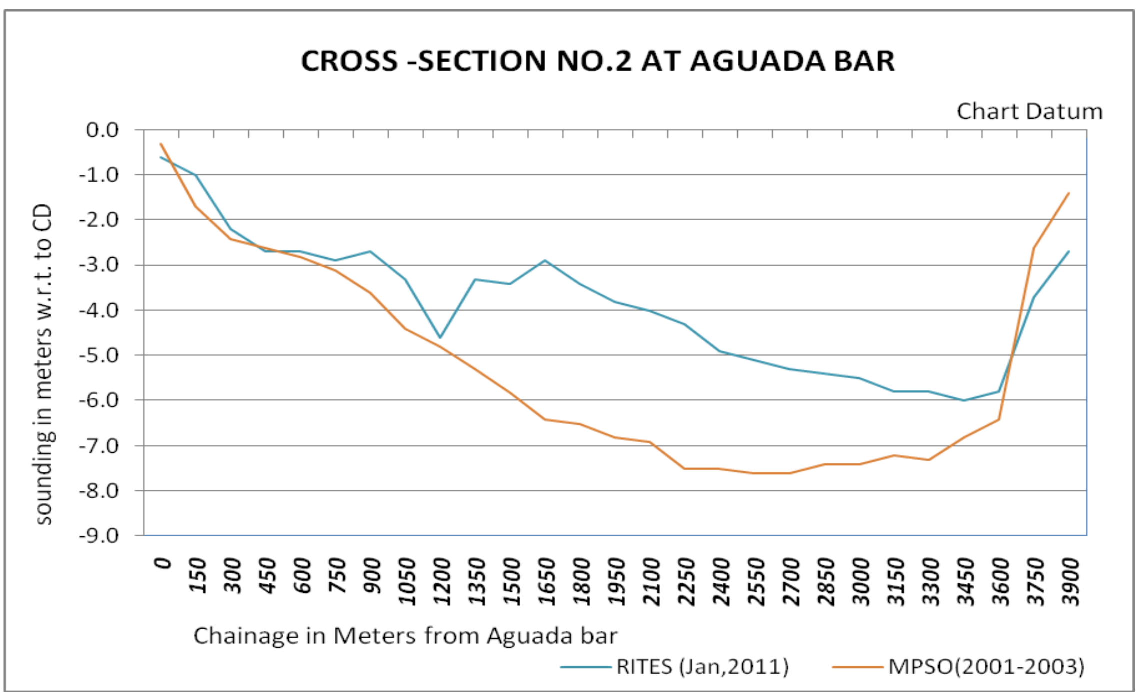


Fig. 4.19 Cross section – South of Aguada Bar

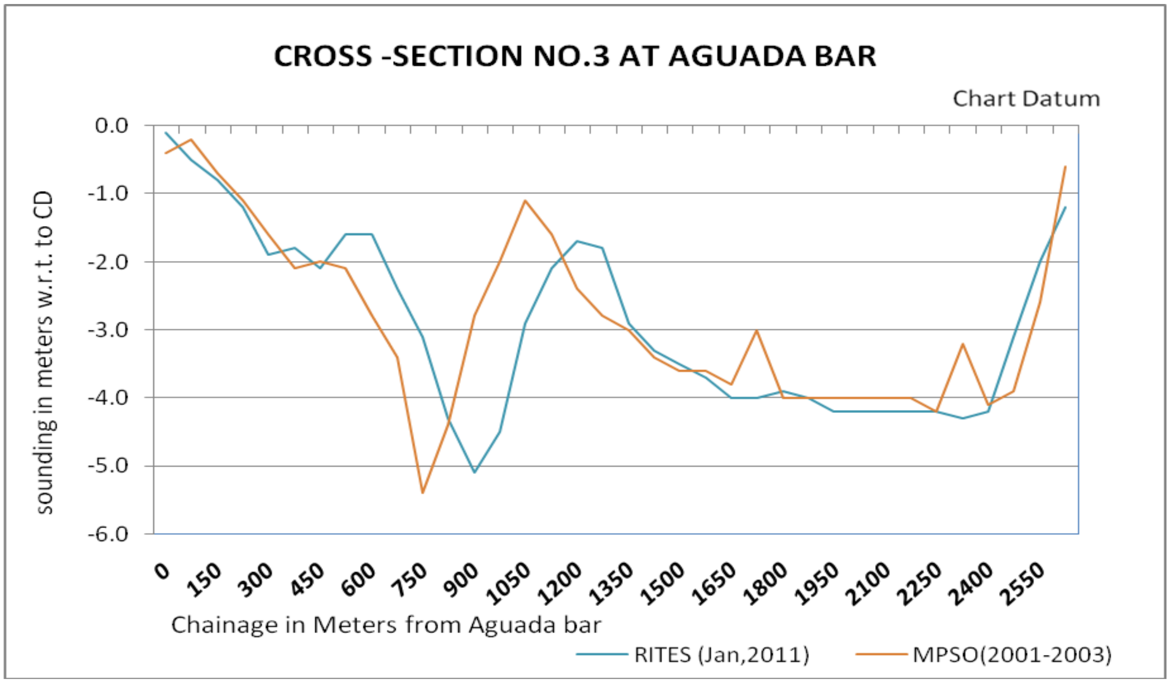


Fig. 4.20 Cross section at Aguada Bar

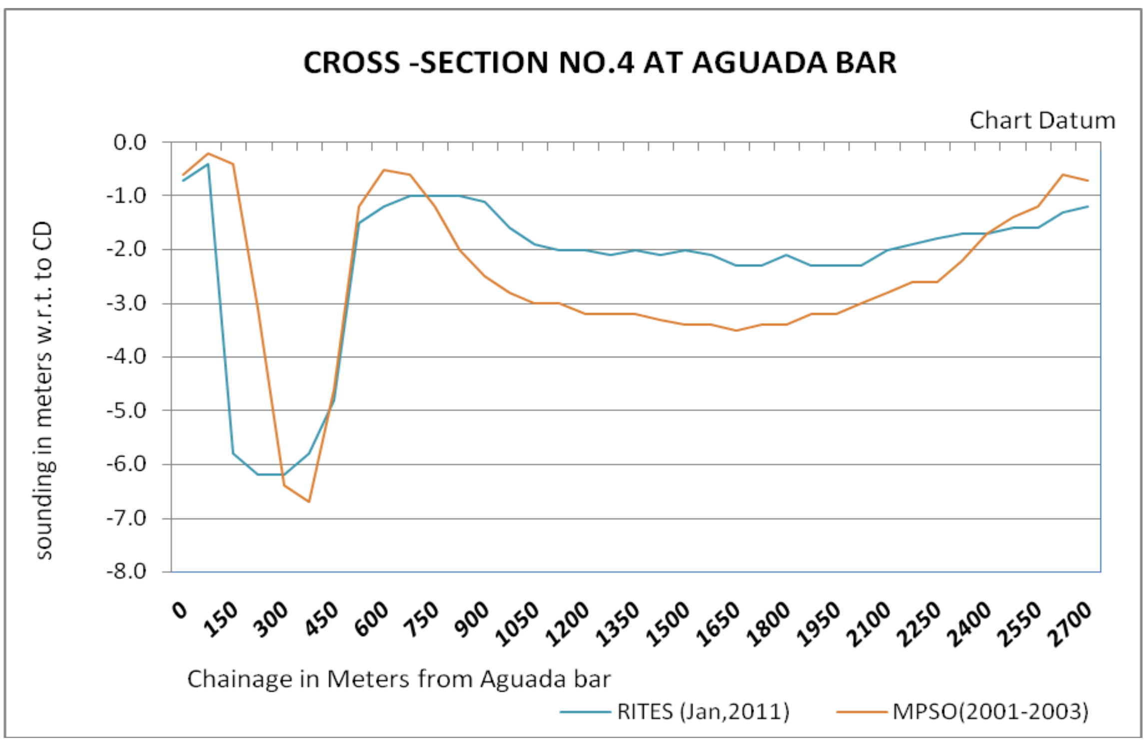


Fig. 4.21 Cross section – North of Aguada Bar

4.4.2 Morphological changes of Mandovi estuary:

The upstream of Aguada bay, after crossing the Aguada bar, the navigation channel continues in Mandovi estuary up to Usgaon (about 40 km). The typical cross sections of the Mandovi River at Khandola village bridge, Konkan Railway Bridge and at Usgaon Village Bridge from downstream to upstream direction are shown in Fig. 4.22 . These cross section drawings show that the waterway has adequate widths of about 250 to 400 m. The cross section recorded at Khandola bridge shows that the navigation depths are around 6 m and the navigation depths at Konkan bridge are less around 2 to 2.5 m. The cross section recorded at Usgaon bridge again indicates that the waterway has good navigation depths of around 6 m even in the upstream end of the waterway. The recent survey shows that in general the depths are reduced when compared to the previous survey conducted in 2001-03.

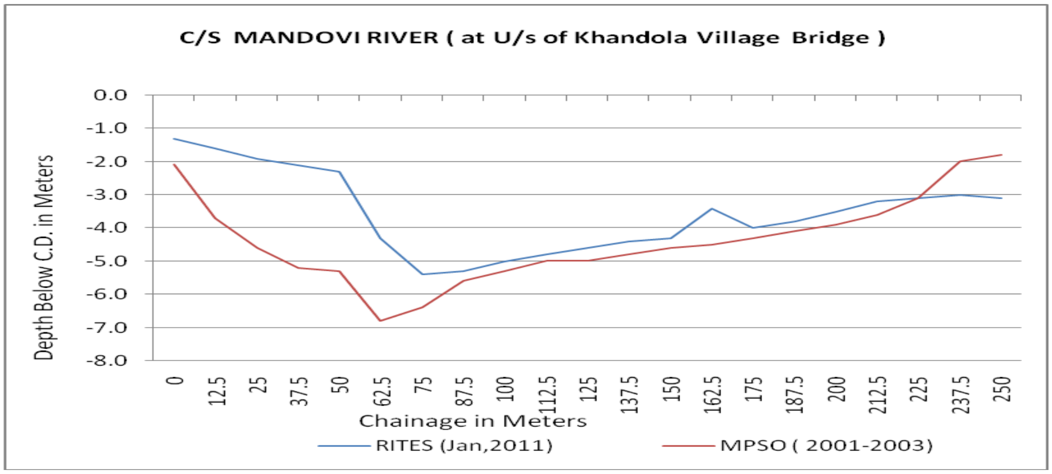
4.4.3 Morphological changes of Zuari estuary:

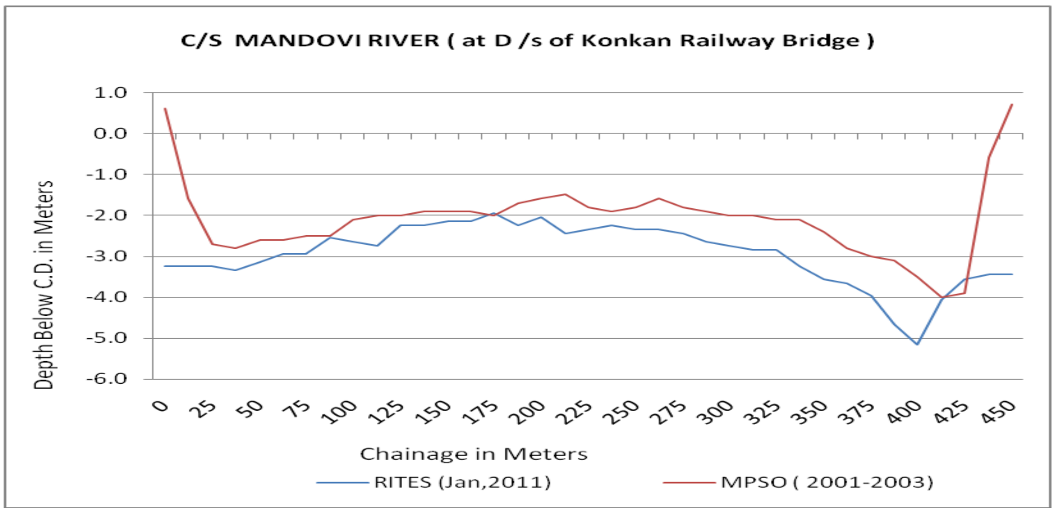
At the mouth of the Zuari estuary, Mormugao port is located. The Mormugao bay is wide, long and shallow. At the head of the bay the depths are around 5 to 6 m. The cross sections recorded in the navigation channel of Zuari river at Konkan rail bridge and at Sanvarden bridge can be seen in Fig. 4.23. The cross section recorded at Konkan rail bridge shows that the river has adequate width about 575 m and depths are around 8 to 9 m. The river width in the upstream reach, that is, at Sanvarden bridge is reduced to about 100 m. The depths are around 4 m. The recent survey shows that the depths are increased at Konkan rail bridge cross section when compared to the previous survey conducted in 2001-03.

4.4.4 Morphological changes of Cumberjua canal:

The Cumberjua canal connects the Mandovi river at about 14 km from its mouth and the Zuari river at about 11 km from its mouth. Cumberjua canal is a navigation canal, during peak monsoon season, the iron ore barges from Mandovi river sail in the Cumberjua canal to reach Mormugao port, due to severe sea conditions at Aguada bar and at Aguada open sea mouth. The Cumberjua is a meandering canal. The canal is narrow and shallow.

Typical cross sections where the canal is narrow and shallow, that is, at the canal joining point of the river Mandovi and another cross section of the canal recorded near Zuari River joining point are shown in Fig.4.24. The cross section drawings show that the canal has only about 50 m width and depths are only around 2 m below CD. The formation of shoals and sand bars at the mouth of the Cumberjua canal with Zuari River can be seen in Fig. 4.25.





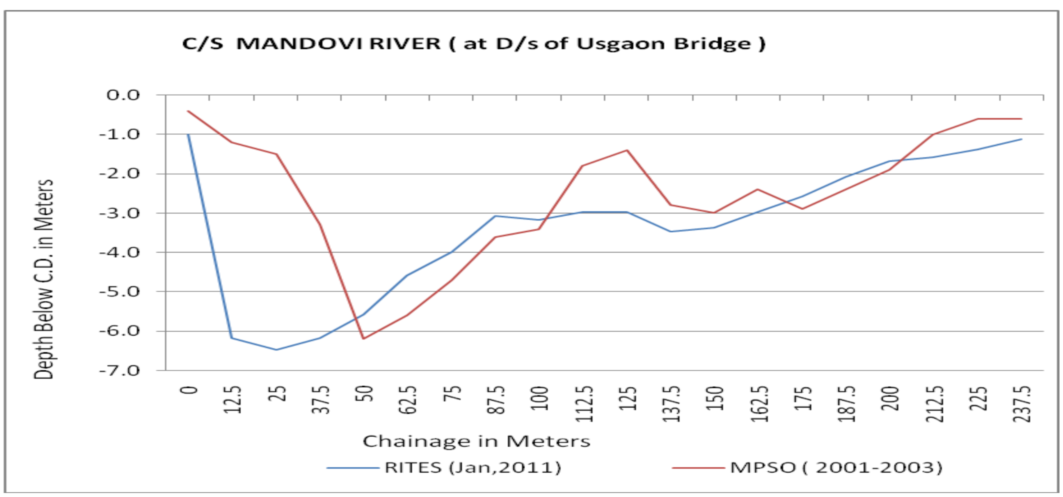
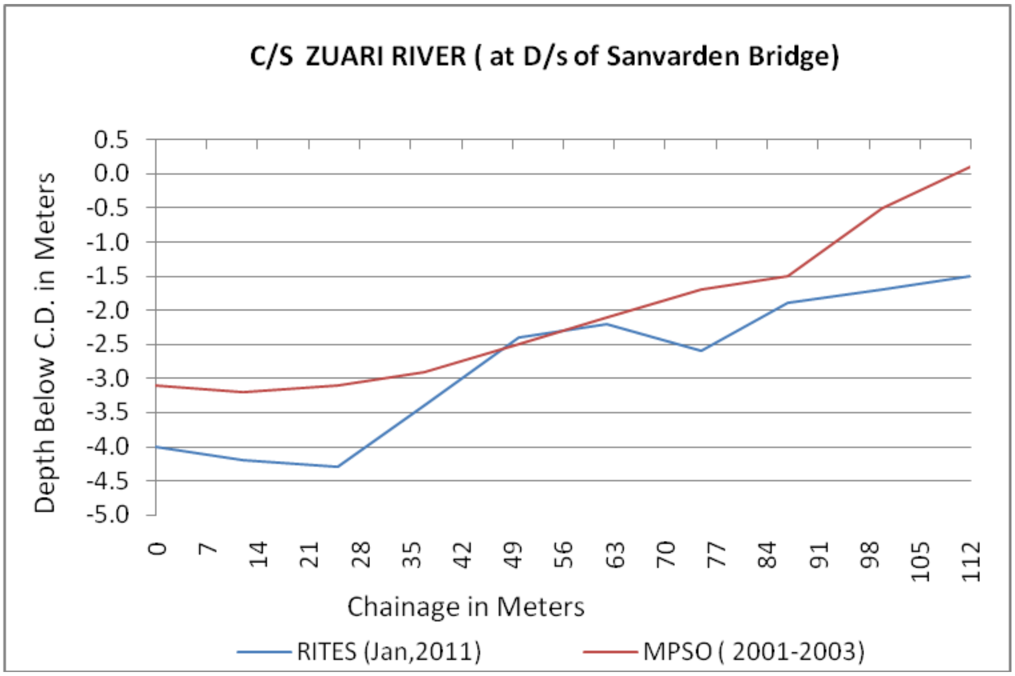


Fig. 4.22: Typical cross sections of river Mandovi waterway



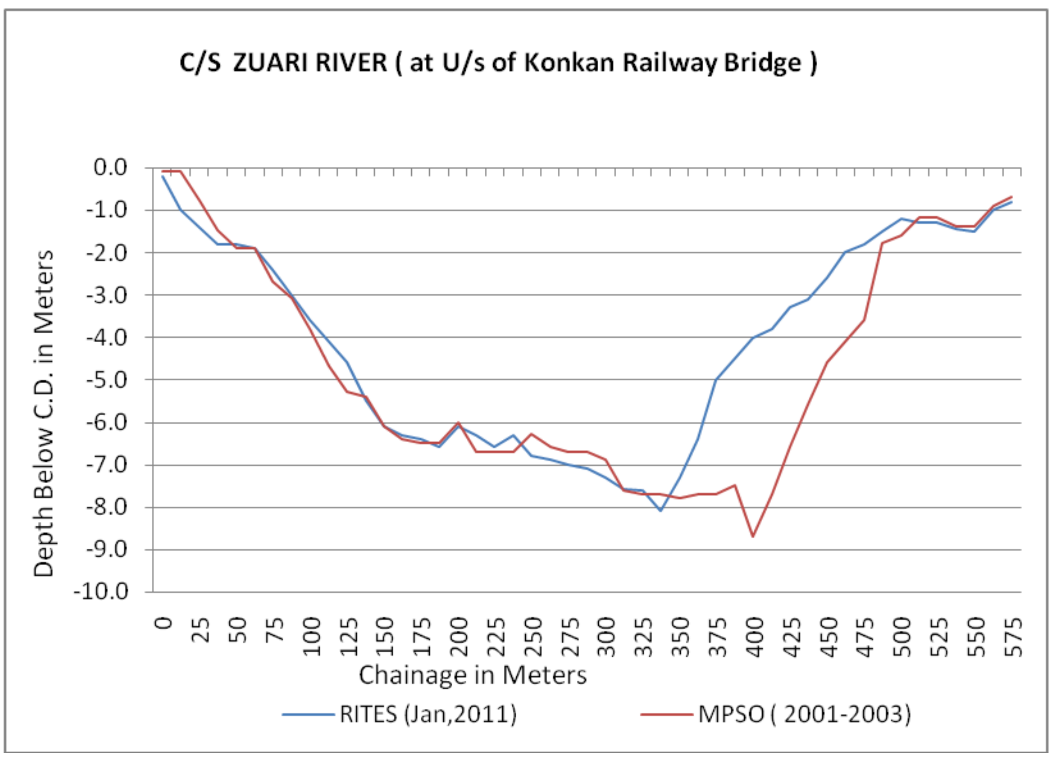
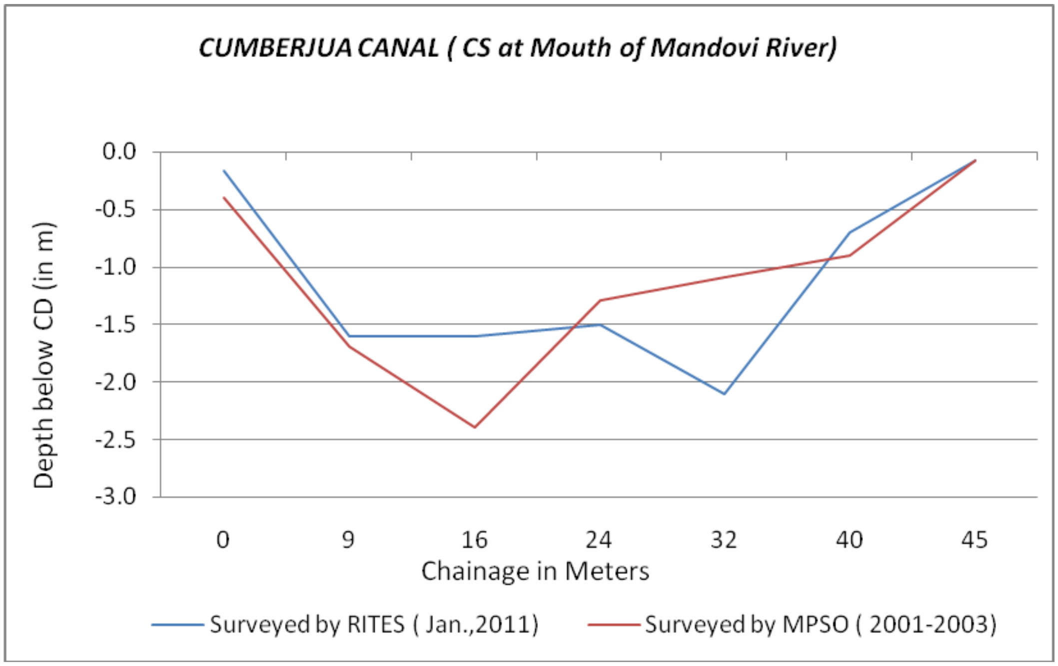


Fig. 4.23: Typical cross sections of river Zuari waterway



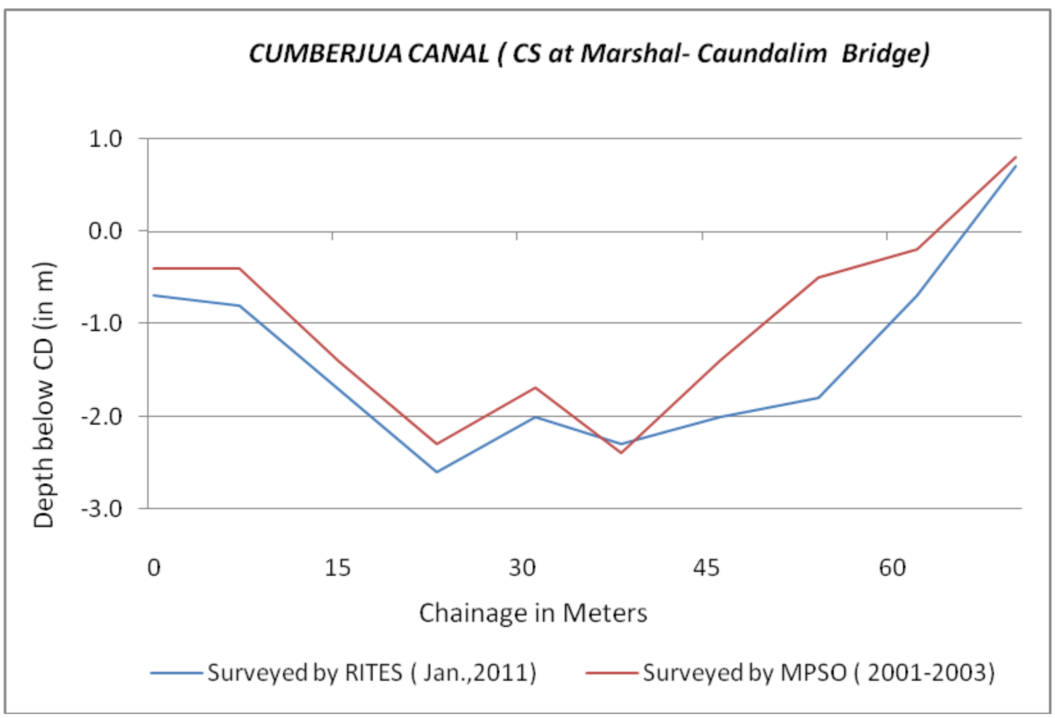


Fig. 4.24: Typical cross sections of Cumberjua waterway

Fig. 4.25: Formation of shoals and sand bars at the mouth of Cumberjua canal with Zuari River

4.5 WATERWAY DEVELOPMENT WORKS

The proposed waterway development works depend upon the proposed barge size that can optimally economize the iron ore transportation from mines to export ports.

The dimensions of the design vessel / barge proposed are:

Length of the vessel	: 78.4 m
Width / Beam	: 14.8 m
Depth	: 4.7 m
Loaded draft	: 3.5 m to 3.7 m
Capacity of the vessel	: 3000 DWT
Depth below CD	: 3.9 m to 4.0 m

The channel dimensions as per the standard practice for the above vessel / barge are:

Bottom width	: 67.5 m
Top width	: 107.5 m
Depth below CD	: 3.9 m to 4.0 m
Side slope	: 1:5
Additional width at bends	: 16 m

4.5.1 WATERWAY DESIGN

Criteria

The basic parameters considered for the fairway design are:

- Depth
- Width
- Side slopes.

Channel Depth:

The fairway channel depth should be good enough to ensure steer-ability of the vessel and to prevent touching of the vessel to the ground To meet this requirement the minimum depth needed in a channel will commonly be the sum of the draught of the vessel and other tolerance factors. The tolerance factors considered are:

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

The keel clearance factor is the prime concern of all the tolerance factors considered. As per the standards laid down by German Code of Practice (EAU 80), adopted for the Mandovi, Zuari and Cumberjua waterways, a 50 cm layer of water column below the keel of the loaded ship is sufficient for free maneuverability of the vessel.

However, investigations in rivers and river models (refer River Engineering by PPh Jansen et al) have shown that the keel clearance should be more than 30% of the vessel's draught for safe maneuvering arid also to negotiate with possible additional squat and ship induced return currents.

Considering the above, a keel clearance of 50 cm has been provided (for a design vessel draught of 3.4 m) in the Mandovi, zuari rivers and Cumberjua canal for the operation of 3000 tonnes barges proposed for future operation in these waterways. However at present the barges plying with maximum capacity in these waterways is about 2500 tonnes having keel clearance of 50 cm with draught of 3.2 m The channel depth requirement for the present barges is (3.2 m+0.5 m) =3.7 m)

Since a total keel clearance of 50 cm in these waterways has already been provided with maximum capacity of 2500 tonnes and the same is proposed for the barges with enhanced capacity of 3000 tonnes plying in these waterways for the 30 . The channel depth for enhanced capacity barges (3000 tones), thus, becomes 3.9 m below standard low water level of these waterways.

Channel Width

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

W= BM+BM1+C+2C1 where,

W — Navigation channel width for two way navigation

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

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

C = Width of separating zone.

C1= Width of the security area, between the maneuvering zone and the channel side which is accounted for environmental and human factors including bank suction. Values recommended by various authorities for the above equation vary within wide limits. Some of the recommended values are presented below.

BM = 1.3B to 3.OB

BM =BM1

C = 0.5B to 1.0 B

C1 = 0.3B to 1.5 B

Where B =.Beam of a design vessel

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

BM = 1.3 B

BM= BMI

C =0.5 B

C1 = 0.95 B

The designed channel width for two way navigation at draft level = 0.95 B+1.3B+0.5B +l.3B+0.95B = 5.0 B m

The channel width at draft level for the present maximum capacity barges (2500 tones) already plying in these waterways is

Option: 5.0B = 5.0 X 14.32 =71.6 m (Bottom width 66.6 m with side slope 1:5) for the

The channel width at draft level for the for the enhanced capacity barges (3000 tones) adopted for study is

Option: 5.0B = 5.0 X 14.5 =72.5 m (Bottom width 67.5m)

The above width allowance will also take care for the additional width required for unloaded ship due to prevailing cross winds along the waterways.

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The channel width at draft level for the present case would be 72.5 m. Thus the channel widths proposed will meet the requirement.

The proposed vessel size for the waterways under present study is 75mx14.5mx3.9 m draft, Self Propelled barges of 3000 t capacity

The minimum vertical clearance as per IWAI norms for 3000 ton capacity should be 9.0 m .The total minimum vertical height to meet the above requirement of the draft would be:

Water cushion below the vessel	= 0.50 m
Draft	= 3.50 m
Vessel Projection above water level (WL)	= 1.50 m
Height of operators cabin	= 2.80 m
Clearance up to lowest portion of bridge	= 1.0 m
Total	= 9.30 m

Thus total waterway including clearances (vertical and horizontal) would be 106.5m wide at waterline x 9.0m from the river/canal bed.

Width Allowance at Bends

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

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

The guidelines for width allowance in bends proposed by Delft Hydraulics are described in Table 4.2:

Table: 4.2 – Navigation Channel Width Allowances

Quality of the cross-section	Minimum radius permitted	At keel level of up going loaded ship	At keel level of down coming unloaded ship.
Normal cross-section	R/L=6	$0.5\ L^2/R$	L^2/R
Narrow cross-section	R/L = 4	$0.5\ L^2/R$	L^2/R

The norms for desirable bend radius as per Dutch guidelines are 4 L for narrow and one-way sections and 6L for normal section (L – overall length of barge unit). The Chinese norms for minimum bend radii are in the range of 4L to 5L. The proposed bend radii for the present waterway are 5L.

The minimum radius of the adopted bend is 400 m. Wherever the radius of the bend is less than 5 times of the length of the designed vessel i.e. 5x80 = 400, additional widths are provided for free maneuverability of the vessel. The additional width provided in the present fairway system for a designed vessel is:

$$\Delta b = L^2/R = 80X80/400 = 16\ m$$

4.5.2 Details of 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 4.3. 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 4.3) 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. As per Chinese Standards, minimum clearance of 11 m has been specified for Waterway of 2000 tons capacity. However, in European classification, the minimum specified vertical clearance is 9.1 m. 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 in Goan waterways are shown in Fig.4.26 and typical bridge on Zuari river is shown in Fig.4.27.

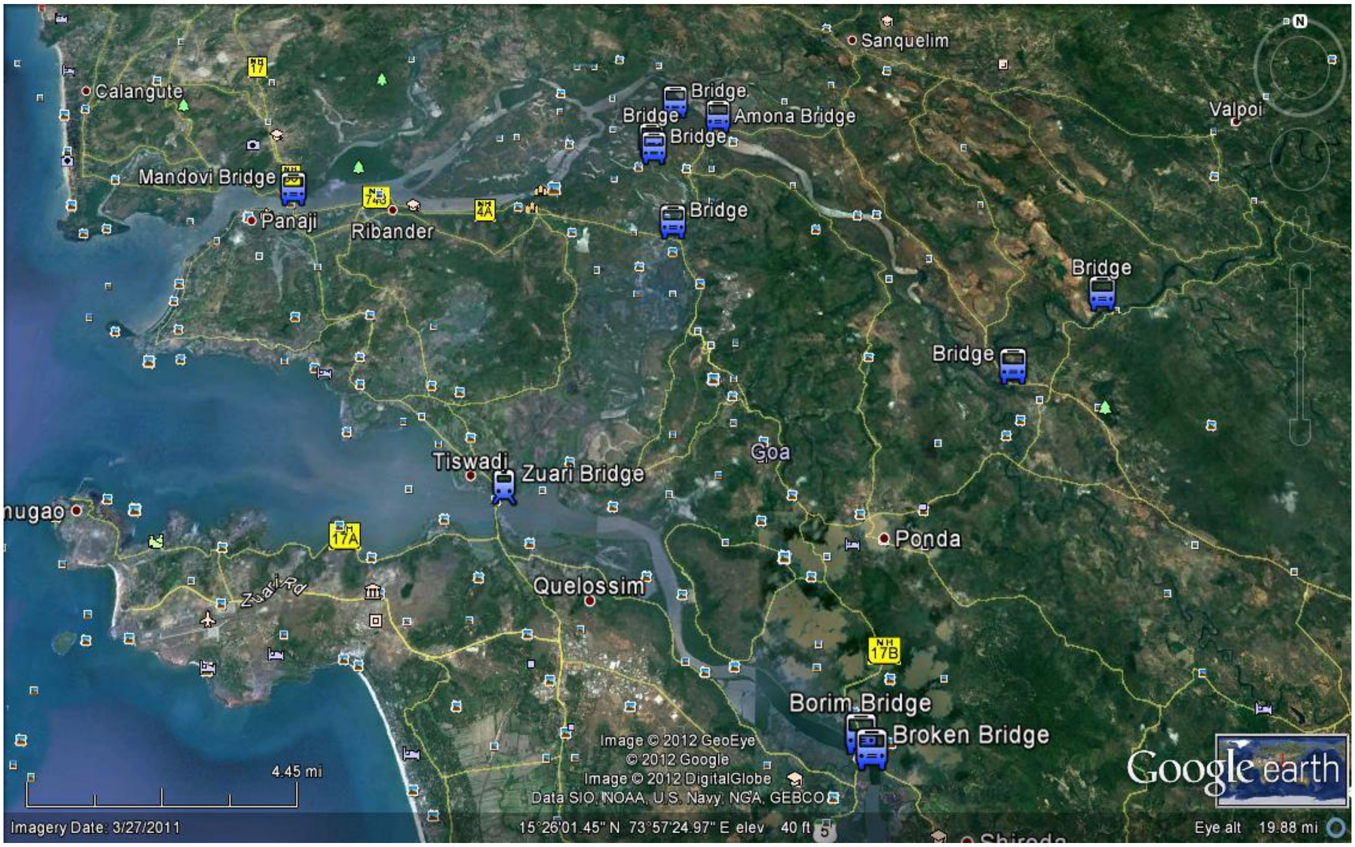


Fig 4.26

Fig.4.27

Table: 4.3 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 loading point

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	

4.5.3 Dredging

Dredging of Navigation channel

The analysis of hydrographic / thalweg survey data has indicated that the availability of depths below the chart datum level (Standard Low Water Level) for navigation vary from location to location in all the three waterways viz., Mandovi, Zuari and Cumberjua canal. Examination of the longitudinal profile of the river bed indicates that the required depths of 4.0 m below the chart datum level are not available. While the predominant least available depths in Mandovi and Zuari rivers are around 2 to 2.5 m at some critical regions, the navigable depths in Cumberjua canal are still less of the order of about 1.5 to 2.0 m. Hence a capital dredging is required to create the navigable channel. The design channel dimensions to estimate the dredging quantities are given below:

Bottom width: 67.5 m
Depth below CD: 4.0 m
Side slopes: 1:5
Additional width at bends: 16 m

The dredging quantities for the above design channel have been worked out based on the detailed bathymetric surveys carried out by Panaji port / MPSO. The abstract of dredging quantities are furnished in Table 4.4. About 6.5 million m^3 of material is required to be removed by dredging to create a channel of 67.5 m width and 4.0 m depth. About 2.6 million m^3 of material is required to be dredged out each from Zuari and Cumberjua canals.

Table: 4.4 Abstract of Estimated Dredging Quantities in Goa waterways

Sl.No	Waterway	Dredging Quantity in m^3
1	Mandovi river	12,08,869
2	Zuari river	26,49,770
3	Cumberjua canal	26,38,001
	Total	64,96,640

Further details of estimated dredging quantities reach wise are provided in Tables 4.5 to 4.7 for the proposed channel (Bottom Width 67.5 m, depth below CD 4.0m and side slope 1:5). Most of the dredging is involved naturally in the upstream reaches of Mandovi and Zuari rivers where the tidal influence is less. About 4.3 lakh m^3 of sand out of 12 lakh m^3 total dredging quantity in Mandovi River, means almost two thirds is required to be dredged out in first three km of the waterway near Usgaon Bridge as shown in the figure 4. 26. Similarly, about 7.2 lakh m^3 of sand is required to be dredged out in the first five km reach of Zuari river near Sanvardem Bridge where the waterway is narrow, shallow and less tidal influence. About 11 lakh m^3 of sand is required to be dredged out in the Zuari river mouth from chaninage 35 km to 45 km (from Konkan rail bridge at Cortalim to towards Marmugao port) where the river bed is shallow as shown in Fig 4.26. However, in this reach the waterway is wide and tidal influence is effective thus the barges of lower draft can negotiate during the high tide. In Cumberjua canal, about 13.5 lakh m^3 of sand is required to be dredged out in the first four km of the canal with its confluence with Mandovi River, that is, almost half of the total estimated dredging quantity in the Cumberjua canal of 26 lakh m^3. In this reach the Cumerjua canal is narrow, shallow and heavily silted up.

Dredgeability of the bed material

The selection of a suitable dredger is however, depends upon the type of material to be dredged and other morphological and physical constraints in a specific waterway. The Goa waterway is a estuarine nature with sea confluence at the river mouths and the inland waterway with tidal influence, bridges across the rivers, narrow and shallow canal of Cumberjua.

The results of the sieve analysis of the riverbed material of rivers Mandovi, Zuari and Cumberjua canal are presented on page 189 to 197 of this report indicate that the material to be dredged is mainly composes of sand.

The earlier data regarding the bottom bed material in the proposed waterways conducted and analysed by MPSO during 2001 to 2003 has been collected and placed in annexure 4.1 of this report. The above collected data of bottom bed profile of the proposed waterways in the study area has been presented chainage and position wise to give clear view of bottom bed material.

Selection of dredging equipment

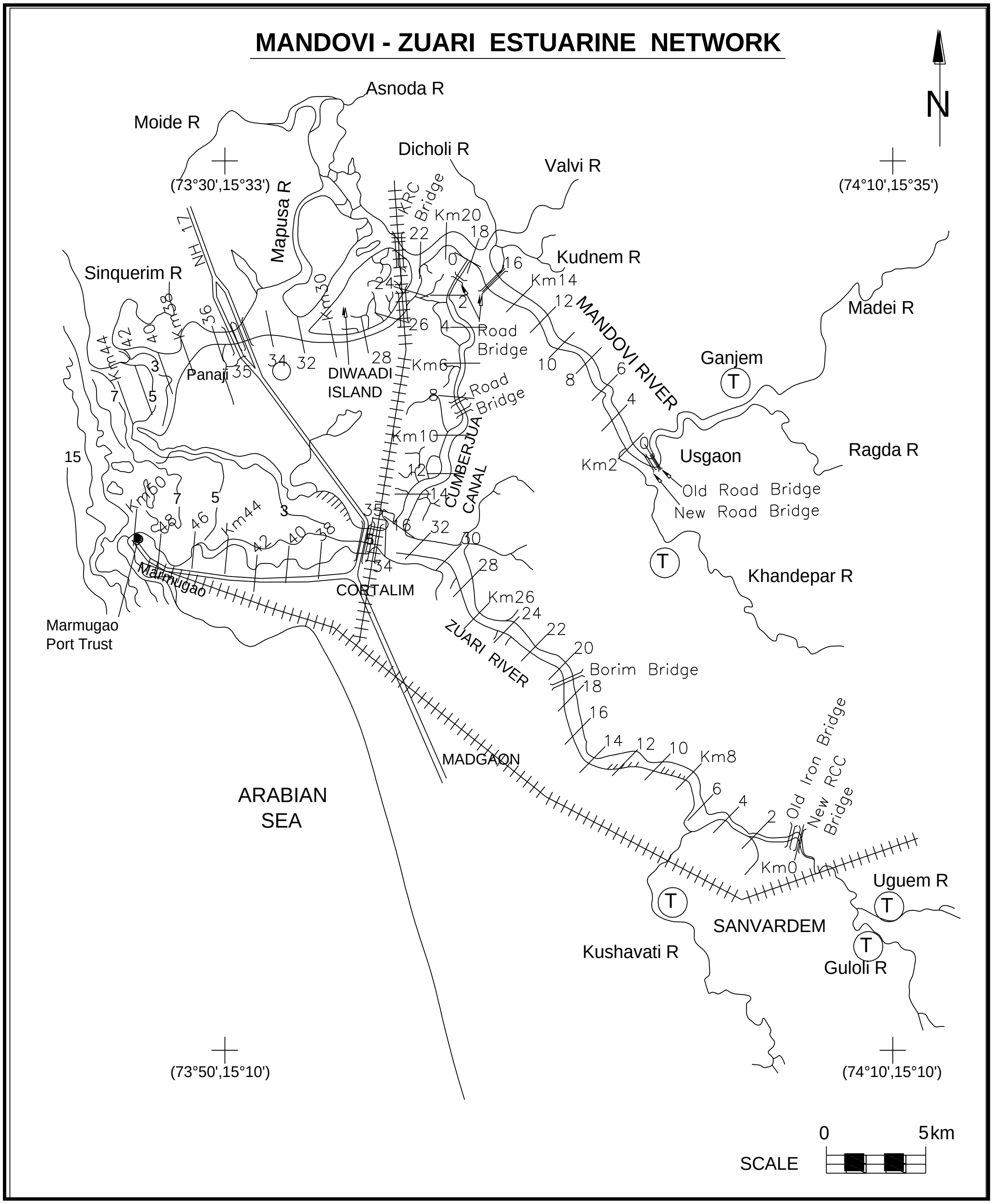
The capital dredging is usually carried out with a cutter-suction dredger whereas maintenance dredging will be carried out with a trailing suction hopper dredger. There are various types of dredgers available in the market viz., suction dredger, bucket dredger, grab dredger, backhoe / dipper dredger, water injection dredger, pneumatic dredger, amphibious dredger etc.

The features of the suitable types of dredgers are briefed below for the present context:

Trailing Suction Hopper Dredger

The TSHD is a sea going self propelled vessel which is equipped with suction pipes (draghead) provided on the sides of the vessel. The suction pipes terminate at the lower end in a draghead which is provided to draw the maximum amount of sea bed material and discharge it into a hopper in the vessel.

The THSD is a very versatile dredging unit. These types of dredger are best used in relatively unrestricted areas. It can work in busy navigation channels and can discharge its load in various ways. It can dredge material ranging from gravel, sand, silt and soft to medium clay. One of the main advantages of a TSHD is that it can operate in exposed locations with wave heights of up to 3 m. The TSHD is generally used in open approach channel of harbours and surrounding sea areas.



(Source - Survey of India Toposheet/ Edited by RITES)

Fig: 4.26 Location of waterway reaches for dredging

Table: 4.5 Estimated Reach wise Dredging Quantity in Mandovi River
Proposed channel (Bottom Width 67.5 m, depth below CD 4.0m and side slope 1:5

Depth 4.0 m, 3000 ton Barge			
Chainage (in Km.)		**Quantity (in Cum)**	**Remarks**
From	**To**		
0	1	118676	Near Ambeshi - Ganjem Bridge
1	2	129626	Near Rumadwada Village
2	3	180611	Near Chavdiwada Village
3	4	35118	Near Waghurme Village
4	5	36759	Near Kanwali Village
5	6	0	
6	7	44048	Near Sawae verem village
7	8	3874	Near Sater bhat village
8	9	25725	Near Tarijawakwada village
9	10	147	Near Valval village
10	11	30785	Near Valval village
11	12	0	
12	13	14275	Near Vetgi village
13	14	506	Near Vetgi village
14	15	58452	Near Amona village
15	16	47437	Near Amona-Khandola Bridge
16	17	755	Near Tonk village
17	18	55430	Near Sarmanas village
18	19	12530	Near Pili village
19	20	0	
20	21	0	
21	22	6464	Near Akhada village
22	23	6641	Near Santa Juva village
23	24	0	
24	25	52212	Near Marjua village /K.R.C. Bridge
25	26	21403	Near Marjua village
26	27	0	
27	28	0	
28	29	86574	Near Raybandar village
29	30	77184	Near Chimbel village
30	31	85977	Near Raybandar village ferry ghat
31	32	41241	Near Raybandar village ferry ghat
32	33	288	Near Mersiwadi village
33	34	0	
34	35	0	
35	36	0	
36	37	0	
37	38	0	
38	39	0	
39	40	0	
40	41	22657	Near Karanjhalen village/Aguda bar
41	42	13474	Near Aguada village
42	43	0	
Total		**12,08,869**	

Table: 4.6 Estimated Reach wise Dredging Quantity in Zuari River
Proposed channel (Bottom Width 67.5 m, depth below CD 4.0m and side slope 1:5

Depth: 4.0 m, 3000 ton Barge			
Chainage (in Km.)		**Quantity (in Cum)**	**Remarks**
From	**To**		
0	1	183079	Near Sanvordem New Bridge Bridge
1	2	151534	Near Digas village
2	3	160190	Near Shelvan village
3	4	117999	Near Panchvadi village
4	5	107305	Near Mouth of Paroda river
5	6	34202	Near Vijra village
6	7	16441	Near Vijra village
7	8	53444	Near Amlay village
8	9	112851	Near Vajangal village
9	10	40113	Near Makazan village
10	11	575	Near Manken Gaval village
11	12	94	Near Sankren Bagh village
12	13	15571	Near Kurtorin village
13	14	15678	Near Mayna village
14	15	9796	Near Rachol village
15	16	19540	Near Shiroda village
16	17	151513	Near Kuray village
17	18	126638	Near Vajen village
18	19	41002	Near Borim Bridge
19	20	341	Near Betki village
20	21	58345	Near Lotli village
21	22	57100	Near Bori village
22	23	13132	Near Karvhol village
23	24	9800	
24	25	0	
25	26	0	
26	27	0	
27	28	11969	Near Agopur village
28	29	43477	Near Kuranjal village
29	30	0	
30	31	0	
31	32	0	
32	33	0	
33	34	0	
34	35	0	KRC Bridge
35	45	1098039	Between K.R.C. Bridge & Mormugao Port Trust
	Total	**26,49,770**	

Table: 4.7Estimated Reach wise Dredging Quantity in Cumberjua canal
Proposed channel (Bottom Width 67.5 m, depth below CD 4.0m and side slope 1:5

Depth: 4.0 m, 3000 ton Barge			
Chainage (in Km)		**Quantity (in Cum)**	**Remarks**
From	**To**		
0	1	338936	Near Jua village
1	2	339628	Near Jua Village/Gaundali road Bridge
2	3	358277	Near Kambhar Juven village
3	4	314144	Near Kambhar Juven village
4	5	173257	Near Gaundali village
5	6	170687	Between Gaundali and Mangadao village
6	7	145324	Near Mangadao village
7	8	136287	Near Banastrim Bridge/ Banastrim Village
8	9	157354	Near Bhama Village
9	10	96550	Near doda Village
10	11	61627	Near Bhama Village
11	12	77888	Near KundaiVillage
12	13	96767	Near KundaiVillage
13	14	60779	Near Dongri Village
14	15	22066	Near KundaiVillage
15	16	48261	Near Sanwada village
16	16.25	40169	Near Adanwada Village
	Total	**26,38,001**	

It is understood that the dredging after independence in Manodovi river had been conducted in 1989-1992 for about 100000 Cum. similarly in Zuari river in 1996-1998 for about 110000 Cum . It is also reported that dredging work awarded in 1996 to 1998 in Zuari river is yet to be completed. Hence it is understood that the dredging had not been carried out in Mandovi and Zuari River since 1998 resulting to siltation takes place in some of the reaches. The dredging quantities has been worked out on the basis of the MPSO survey charts, the hydrographic survey conducted during 2001-2003. The waterways are required to be dredged out for uninterrupted movement of barges immediately.

The agencies working on dredging works in and around Goan waterways are Dredging Corporation of India, Vishakhapatnam and M/s Mitha Dredging, "La Marvel" Dona Paula, Goa.,the M/s Western Dredging , Margao,Goa .

The shoals reported in Goan waterways as per the surveys and based on discussion with Goa Barge Owners association (GBOA) are identified as follows.

Mandovi River – Aguada sand bar, Sen Pedro (old Goa), near Amona and near Kotombi.

Zuari River – near St.Jacinto island (MPT jurisdiction) , undir, Xelvona and Digashi

Cumberjua canal – at present draft restricted to 2.6 m as against 3.3 meters for Mandovi river.

Cutter Suction Dredger

The CSD comprises a rotating cutter head mounted at the end of a suction pipe and connected to a dredging pump in the main body of dredger. The dredger pivots around a spud located at the rear of the dredger by using a system of anchor wires and winches. The cutter head cuts the material on seabed / estuary bed and then the material is sucked up through the suction pipe by the dredger pump and discharged through a pipeline.

The CSD can dredge a variety of different type of soils, ranging from clay and silt to sand and weak rocks. It is very sensitive to wave conditions and therefore is usually deployed in sheltered locations. CSD's can operate in wave swells of up to 0.5 m dependent on the associated wave periods. Long waves and swell are usually a determining factor in deciding if it can operate safely and effectively. As such this type of dredger is not suitable for open channel dredging.

The cutter suction dredger is capable to dredge all kind of material and is accurate due to their movement around spud. The spoil can be transported via pipeline and have barge loading facility as well. Cutter power ranges from 50 KW to 5000 KW,depending on the type of soil to be cut. The powerful cutter suction dredgers are capable to dredge rock.
The cutter suction dredgers are most suitable dredgers for dredging works in the proposed waterways.

Amphidredge with cutter and Pump

This machine has milling cutter suction system designed especially for the dredging of fine sand and silt. The system pumps out the dredged spoil through a discharge pipe line to the dumping site situated at a considerable distance. This dredger is suitable for shallow areas with low draft particularly in inland waterways. The output of the dredger is of order of 100 to 140 cum/hr.

Grab or Clamshell Dredger

It is a simple stationary dredger with or without propulsion.The dredge material can be stored in hopper, otherwise materials can be transported by barges.The capacity of Grab dredger is expressed in the volume of the grab.Grab sizes varies between less than 1 Cum to 200 Cum. The opening of the grab is controlled by the closing and hoisting wire or by hydraulic cylinders.

- The dredging process is discontinuously and cyclic
- Lowering of the grab to the bottom
- Closing of the grab by pulling the hoisting wire
- Hoisting starts when the bucket is complete closed
- Swinging to the barge or hopper
- Lowering the filled bucket into barge or hopper
- Opening the bucket by releasing the closing wire..

Suitable materials are soft clay, sand gravels. The boulder clay can also be dredged by this dredger. In soft soils light big grabs while in more cohesive soils heavy small grabs are favorable.

This type of dredger suitable in Mandovi and Zuari river where bottom bed consist of gravels and pebbles. Similarly in Cumberjua canal it can also be utilized.

Selection of Dredgers

The Cutter suction Dredgers are suitable for the dredging of Mandovi and Zuari river and Cumberjua canal , Since the cutter suction dredgers are suitable for the dredging of bed materials like sand,clay pebbles and gravels and rocks. Wherever any problem in dredging of bed materials like pebbles and gravels with low depth availability grab dredgers may also be utilized. The Cumberjua canal has to be widened needs the cutting /dredging at land as well as in water, the Amphidredge dredgers are suitable for this canal. The grab dredgers may also be utilized at selected locations.

As per the guidelins the dredged material can only be disposed off in the deep sea,the transportation of spoil/dredged material shall be carried out through barges from dredging area to deep sea (disposal area).

Disposal of dredged spoil

As per Government guidelines the disposal of the dredged materials/spoils at the disposal ground, strictly as per the provisions of the Costal Regulation Zone notification 1991. As per the guidelines the dredged material cannot be disposed on banks/shore areas of the waterways and it should be disposed at geographical positions: Latitude 15^0 26’00’’ (North) and longitude 73^0 44’ 30’’ (East) locality.

The dredged material can be disposed of beyond the disposal area of Mormugao Port trust (Lat 73^0 44’ to 73^0 45’ East and Long 15^0 25’ to 15^0 26.2’ North) towards sea side. Otherwise a new area has to identify by conducting hydrographic surveys in the deep sea and water testing of the identified area for the disposal of dredged material.

Besides river conservancy works of dredging as stated above, there are no other river training measures are envisaged for the present waterway in view of the waterways are tidal in nature.

Pre dredge survey is required before the execution of dredging work in the waterways to know the exact bottom bed levels similarly after completion of the dredging a post dredge survey is required for the actual measurement of dredging quantity during execution of the works.

The detailed geotechnical investigations are required in the identified locations of the dredging areas to know the exact bottom bed materials of these locations before execution of the work.

Maintenance Dredging

Even after completion of the capital dredging, 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 cost estimates, the quantity may be taken as 10% of the capital dredging quantities based on past data of similar projects.

Dredging in Aguada Bar

Dredging quantity in and around Aguada bar for the proposed channel has been worked out (refer table 4.5) and its quantity is about 35130 Cum. The dredging quantity for wider channel of 300 m width for the 3000 ton barges for the proposed channel parameters has been also worked out and it comes around 4,50,470 cum.

4.5.4 Bank Protection

During the survey period, it was noticed that certain reaches of the Cumberjua canal banks have undergone erosion. This erosion is due to flood/ebb flows of sea water drainages and thereby removal of material. These problems are, however, routine.

In addition to the above, the canal bed and banks are susceptible to erosion due to the fast moving barges which generate waves and turbulence of different magnitude depending upon the speed of the vessel, its hull form, type and spacing of propellers, draught and channel bed form. The effect of these waves and turbulence on the channel depends upon the width of the channel and the bed and bank materials.

It is reported by Central Water and Power Research Station (CWPRS), Pune, through model studies and found that the vessel of speed 8 km/hr would generate currents of velocity 1.16 m/sec. The maximum waves of height 0.3m would he generated at the bank due to vessel movement.

Since the present barge speed in Goa waterways is about 15 km / hr, it is assumed that the banks up to 0.6m above the water line are required to be protected.

The various type of bank protection works can be provided along the waterways are described below

Types of Bank Protection works:

In bank protection structures, revetments are often used to protect the subsoil from being washed away by the hydraulic loads, such as waves and currents. The various type of bank protection works prevalent are as follows:

The most widely used bank protection works along the rivers include;

Stone rip – rap, concrete block, pavement, articulated concrete mattresses, sheet piles, transverse dikes, vegetation, gabions and bulk heads.

Sheet Piling:

A Sheet pile wall is a permanent structure designed to prevent the type of subsidence that commonly occur adjacent to all waterways. It is a protective covering on an embankment of earth designed to maintain the slope or to protect it from erosion. This type of bank protection is a system of concrete piles driven at closed intervals so that earth behind it can be retained. These concrete piles are pre cast piles and transported through barges to the location of bank protection works. The detailed arrangement of driven sheet pile at site is shown in Fig.4.27 below.

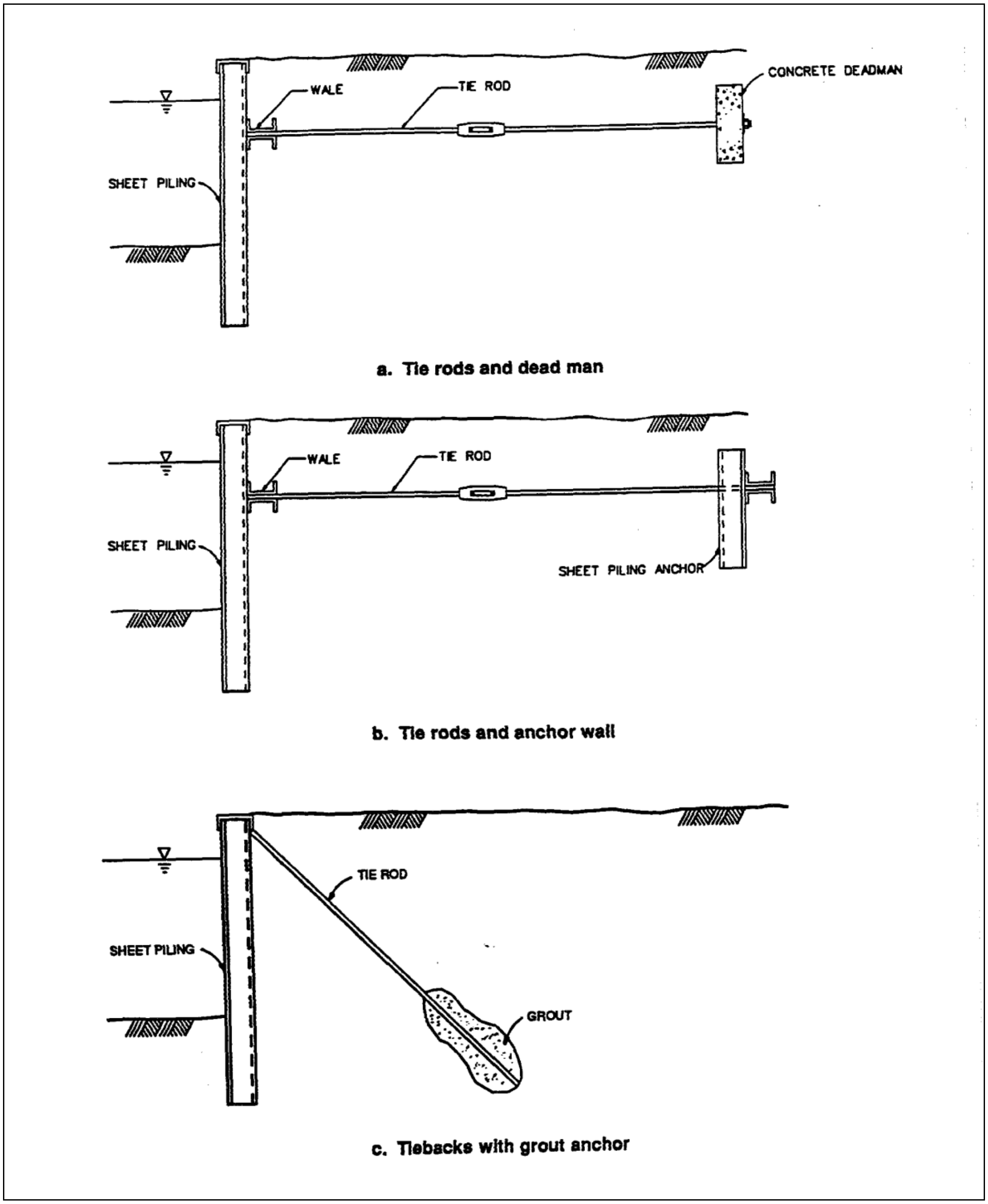


Fig.4.27

Gabions:

Gabions are baskets made of hexagonal woven wire Mesh Type 80, commonly referred to as double twist wire mesh.

Gabions are filled with rock at the project site to form flexible, permeable, monolithic structures such as retaining walls, channel linings and weirs for erosion control projects.

The steel wire used in the manufacture of the gabion is heavily zinc coated. If required, a 0,5 mm nominal thick PVC coating is then extruded over the galvanized wire to provide added protection for use in aggressive environments with acidic soils and water, in salt or fresh water or wherever the risk of corrosion is present.

In order to reinforce the structure, all mesh panel edges are selvedged with a wire having a greater diameter than the mesh wire.

The Gabion is divided into cells by means of diaphragms positioned at approximately 1m centers. The box filled with stones and gabions protection works are shown in Fig.4.28 (a,b).

Specification for Gabion:

The specification is intended to be used for the gabion wall. The specification is suitable for the bank protection purposes. However at the time of actual construction work the work shall be carried out in accordance with the specification and as per approved drawings.

Specification for Materials:

a. **Wire Mesh**:

- The flexible wire mesh shall be hexagonal woven mesh with joints formed by triple – twist which does not unravel if cut.
- All wires used in manufacturing of the gabion units shall conform to BS 1052:1980(1999),in mild steel wire, annealed , having a tensile strength of 38-50kgf/sq.mm before PVC coating and fabrication of netting.
- All wires shall be heavily galvanized to BS443:1982(1990) and conforming to its minimum weight zinc coating weight and zinc coating adhesion requirement which is checked by rigorous wrapping test.
- All edges of the gabion units shall be mechanically selvedged to prevent raveling of the mesh and to develop the full strength of the woven mesh.
- Each gabion units shall have diaphragms at every 1000 mm intervals.

b. **Galvanizing:**

All wires including the PVC coated type shall be heavily zinc coated to BS 443:1982(1990) and class A coating in BS EN 10244-2:2001, with minimum zinc coating weights as shown below:

Wire Diameter (Heavily Galvanized)	Type of Wire	Minimum Zinc coating Weight	Heavily Galvanized with PVC coating
3.4 mm	Selvedge wire	275 g/sqm	3.4 mm (core dia.)

			4.4 mm (overall dia.)
2.7 mm	Mesh wire	260 g/sqm	2.7 mm (core dia.) 3.7 mm (overall dia.)
2.2 mm	Lacing wire	240 g/sqm	2.2 mm (core dia.) 3.2 mm (overall dia.)

The adhesion of the zinc coating to the wire shall be such when wire is wrapped six turns round a mandrel of 4 times the diameter, it does not flake or crack to such an extent that any flakes zinc can be removed by rubbing with bare fingers.

c. Mesh Wire:

- The average mesh width D, measured at right angles between twisted sides over 10 meshes shall conform to the tolerance limits specified in BS EN 10223:1997 part3: Hexagonal steel wire netting for engineering purposes.
- For mesh D = 8 cm or 80 mm, the tolerance limit shall be 8 cm +16%,-4%.

d. Polyvinyl Chloride (PVC) Coating:

- All wires used in fabrication of the gabion cages shall be extruded with a U.V. stabilized poly vinyl chloride (PVC) compound.
- The coating shall be grey colour and having an average thickness of 0.5 mm and not less than 0.4 mm in thickness.
- The PVC compound shall be capable of resisting deleterious effects of natural weather exposure and immersion in salt water without much material changes in its initial properties.
- The PVC coating compound shall have the following initial material properties:

Specific Gravity; Shall be 1.30 to 1.35 in accordance with ASTM D792-91

Durometer Hardness: Shall be 50 to 65 shore D in accordance with ASTM D2240-86

Tensile Strength: Shall not be less than 210 Kg/ sqcm in accordance with ASTM D412

Elongation: Shall not be less than 190% and shall not be greater than 280% in accordance with ASTH D 412-87

Resistance to Abrasion: The loss weight shall not be greater than 0.19 g in accordance with ASTM D 1242-56(75)

e. Stone:

- Stone fill for gabion units shall be clean rough quarry stone or pit or river cobbles or a mixture of any of these materials and shall be essentially free from dust, clay, vegetative matter and other deleterious materials.

- Individual pieces of stone shall have least dimensions not less than 20 mm larger than the gabion mesh openings and greatest dimensions not more than 2/3 of the thickness for gabion.
- The stone shall be hard, tough, durable and dense, resistant to the action of air and water and suitable in all aspects for the purpose intended.

Construction Method:

- Prior to placing gabions, the surface on which they are to be constructed shall have been prepared and finished in accordance with the relevant provisions of the specification.
- Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of engineer before gabions are placed.
- Each gabion basket shall be put in place in its turn, completely fabricated except for the fastening down the lid, stretched to the correct shape and dimensions and fastened securely to all contiguous along each edge with tying wire.
- The basket shall be tightly packed with approved stone by hand in such a manner that voids are kept to a practable minimum and are uniformly distributed in the stone mass.
- The lid of the basket shall be securely fastened down with tying wire along all hitherto unfastened edges, all to the satisfaction of engineer.

Fig.4.28 (a)

Fig.4.28 (b)

Proposed canal bank protection works

The design and selection of proper bank protection works in navigational canals, streams and waterways is based on the forces responsible for erosion of banks as well as the bed materials and the behavior of different material under the action of such destructive forces. Here, the various erosion processes involved and the design principles of bank protection works based on the impact of various barge induced hydraulic loads in combination with natural tidal flow phenomena in the waterway have been dealt with. Also, various bank protection measures, their merits and demerits have been taken into consideration.

The design of bank protection works need good information on the soil characteristics of the bed and banks. The soil investigations carried out on the samples collected on the Cumberjua canal bed indicate that about 77 % sand, 19% silt and 4% clay. Hence, the bed and banks of the canal is mainly composed of sand and silt. So vegetation cover bank protection is not possible on the bed and banks. Considering the types of barges being ply in the waterway and wave action and velocities generated stone pitching over the geo-textile filter on the Cumberjua canal banks is proposed. The Geo-textile filter will have to be spread initially on the recommended bank slopes of 1:1.5 to prevent fine particles from flowing out. The proposed bank protection i.e. stone pitching is cost effective in comparison to sheet piles and gabions. It is recommended stones of weight 15kg (20 cm x 20 cm x 20 cm) are to be laid over the geo-textile filter. A typical sketch showing the proposed bank protection works is in Fig. 4.29.

Cost of bank protection has been included appropriately in the cost of waterway development.

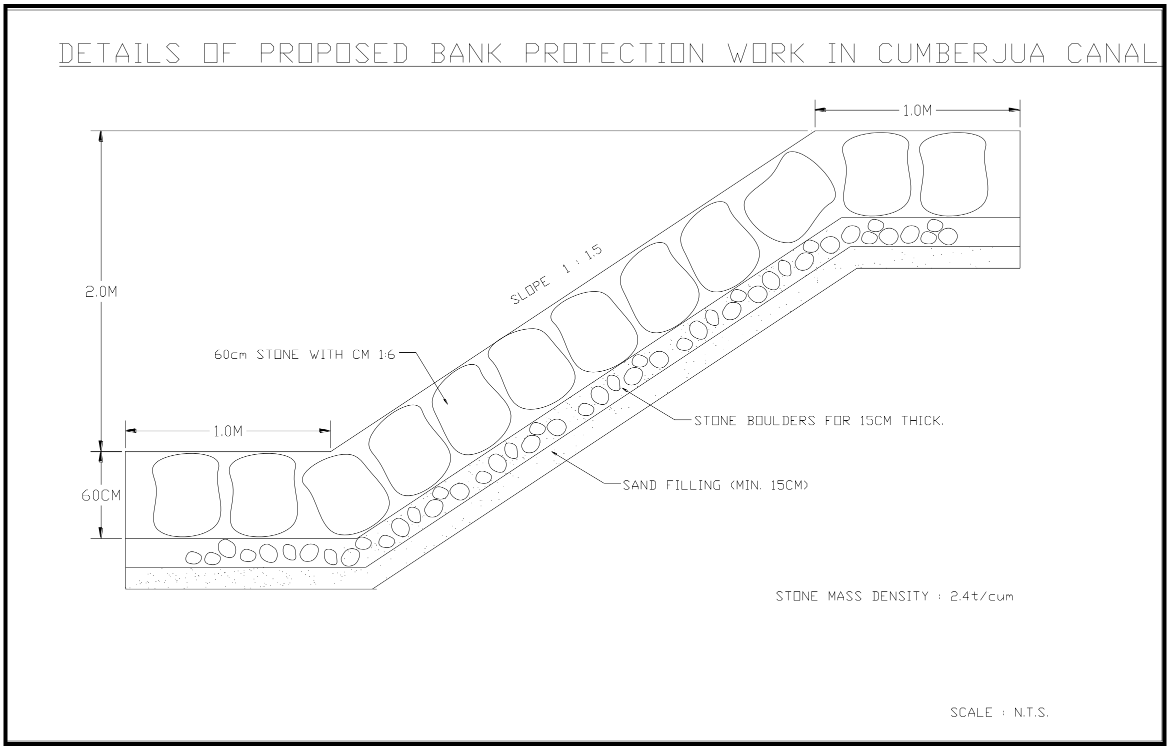


Fig: 4.29 Proposed bank protection works in Cumberjua canal

The identified reaches for bank protection works in respect of Mandovi river,Zuari river and Cumberjua canal have been identified during survey and field data collection at site. The abstract of bank protection works needs to be carried out in proposed waterways are tabulated in Table 4.8.

Table 4.8

S.No.	Name of Waterway / Item of work	Total length of Bank Protection Work (in m.)	Quantity in Cum per m.	Total Quantity (Cum.)
1.	Mandovi River	Nill	Nill	Nill
2.	Zuari River	Nill	Nill	Nill
3.	Cumberjua Canal (Chainage 0km to 8.1 km on both banks)	16200 m		
A	Sand Filling (Base course)	16200 m	0.75	12150
B	Quantity of DR/RR Masonary	16200 m	3.75	60750

4.5.5 Widening of Cumberjua Canal

Cumberjua linking to Mandovi river to Zuari river needs to be widened to meet the requirement for 3000 tons vessel/barges. It is understood that at present there is no barge transportation through this canal except during monsoon season due to non availability of sufficient depth and width. The widening required land acquisition along the canal are presented in the Table 4.9 below:

Table 4.9

Widening Of Cumberjua Canal

S.No.	**Chainage (in Km.)**		**Length (in Meters)**	**Average Width Available**	**Width required for Widening**	***Area (in Sqm)***	***Remarks***
	From	**To**					
1	0	1	1000	50	60	60000	
2	1	2	1000	55	55	55000	
3	2	3	1000	60	50	50000	
4	3	4	1000	60	50	50000	
5	4	5	1000	80	30	30000	
6	5	6	1000	75	35	35000	
7	6	7	1000	85	25	25000	
8	7	8	1000	90	20	20000	
9	9.225	9.75	500	82.5	27.5	13750	
10	11.65	11.75	100	100	10	1000	

Total		**339750**	**Sqm.**
		33.975	**Hectares**

4.5.6 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.

Proposed aids to navigation system on waterways

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 a 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 (Murmagao 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 streamling 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.

The detailed Sketches and description of the navigational marks proposed to be erected have been given in Fig 4.28 (A, B and C).The channel marking as per the regulations of Inland Waterways Authority of India (IWAI) under "National Waterway, Safety of Navigation and Shipping Regulations,2002" are come into force after publication in the official Gazette are placed in the Annexure 4.4 of this report. The channel marks published by IWAI may also be provided for the safety of vessels plying in these waterways in place of channel marks proposed in Fig.4.30 (A, B, C).

Estimates of requirements of aids to navigation in proposed waterways

Based on our recent experience, the navigational marks required in the proposed waterways have been worked out. The cost of Marks also has been taken based on our recent and past experience in similar type of rivers and canals in India. The cost has been worked out for Channel Markers necessarily required and are to be erected on the banks of river. This provision is required for safe and efficient navigation. The numbers of Beacon Stations and buoys and their cost estimate based on consultants experience have been worked out for the safe and efficient navigation during night along the waterways. The Summary of details of the Navigational Marks and beacon stations required to be provided in each waterway are given in table 4.10 as under.

Table: 4.10
Details of Navigation Aids

S.No.	*Location*	*Type of Navigation aids*	*Number of navigational aids required in Waterway*		
			Mandovi River	*Zuari River*	*Cumberjua Canal*
1	*At Bridges*	*Fixed shore Markers*	*4*	*4*	*3*
2	*At Bends*	*Fixed shore Markers*	*15*	*14*	*14*
3	*At Ferry locations, Bifurcations etc.*	*Fixed shore Markers*	*8*	*5*	*4*
		Total	***27***	***23***	***21***
4	*Navigational Channel Marking*	*Lighted Beacons/Buoys*	*36*	*56*	*14*
5	*Intersection Points*	*Traffic Lights*	*12*	*15*	*12*

Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

1. Lateral Marks: To mark the left and right sides of the route to be followed.

(a) **Left:**

Colour: Green

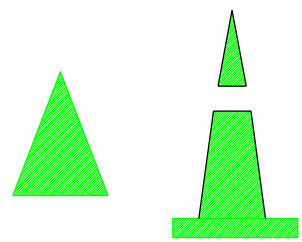
Shape: Conical Pillar or spar

Top Mark: Single,white cone,point upward

Light:

Colour: Green

Rhythm: Single flashing



(a) **Right:**

Colour: Red

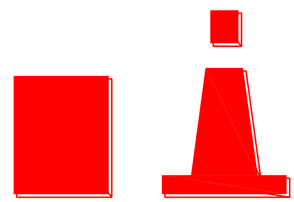
Shape: Cylindrical (Can) Pillar or spar

Top Mark: Singlered cylinder (can)

Light:

Colour: Red

Rhythm: Single flashing



2. Bifurcation Marks: To Mark middle ground,bifurcated channels and isolated dangers in mid-channels.

Colour: Red and White Vertical Strips

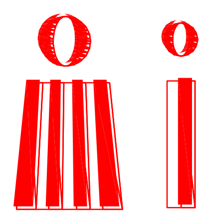
Shape: Truncated Cone , Pillar or spar

Top Mark: Single Sphere with Red and White Vertical Strips

Light:

Colour: White

Rhythm: Group Flashing flashing with three flashes



3. Shore Marks: To indicate the channel at points where it approaches a bank.

3.1 Bank- Wise Marks:

Left Bank Marks:

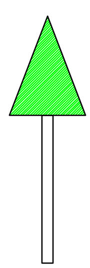
Colour: White

Shape: Post with Top Mark

Top Mark: Conical

Light:

Colour: Green



Right Bank Marks:

Colour: Red/White
top mark red post

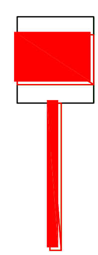
Shape: Post with Top Mark

Top Mark: Cylindrical

Light:

Colour: Red

Rhythm: Single Flashing



Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

(Source – Navigational Aids provided in Mekong River , China)
Fig: 4.30 (A) Typical navigation aids proposed in Goa waterways

Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

4. Crossing Marks: To indicate crossing & alignment of the channel from one bank to another.

Left Bank:

Colour: White top mark , White/Black Post.

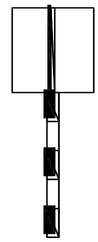
Shape: Post with Top Mark

Top Mark: Two squares facing upstream & Downstream.

Light:

Colour: White

Rhythm: Morse Code "A"



Right Bank:

Colour: Red top mark , Red/White Post.

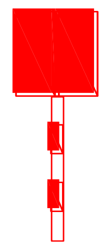
Shape: Post with Top Mark

Top Mark: Two squares facing upstream & Downstream.

Light:

Colour: White

Rhythm: Morse Code "N"



5. Marks of Prohibited Areas: To indicate no permission of entry.

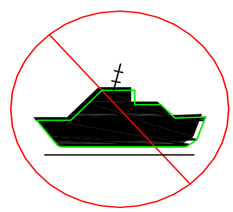
Colour: White with Red tborder & slant, and black ship figure.

Shape: Circular

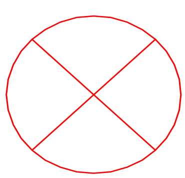
Light:

Colour: Green

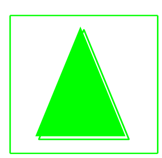
Rhythm: Quick Flashing Light.



6. Marks on Bridges: To indicate passage through Bridges..



No Pass



Pass

Pass with attention.

Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

(Source – Navigational Aids provided in Mekong River , China)

Fig: 4.30 (B) Typical navigation aids proposed in Goa waterways

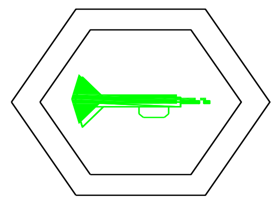
Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

7. Sound Signal Marks:

To indicate use of horning or other sound signal.

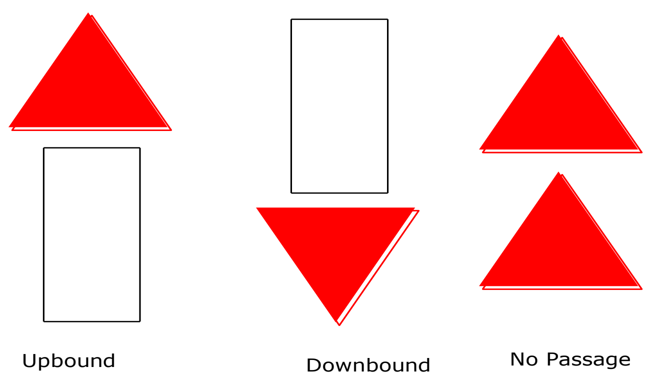
Colour: White board with black horn figure.
Shape: Hexagon

Light:
Colour: Green
Rhythm: Quick flashing light.



8. Marks for Traffic Control:

To upbound or downbound vessels in oneway or sequential passage or to prohibit navigations.



Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

(Source – Navigational Aids provided in Mekong River , China)

Fig: 4.30 (c) Typical navigation aids proposed in Goa waterways

4.5.7 Parking Bay

As discussed above about 400 barges of various sizes regularly ply 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 190 barges move in the waterway between mining points and harbours (Mormugao and Panaji) for transportation of iron ore. The iron ore barges are required to be wait long time at barge unloading points particularly at Murmagao port. A suitable site selection and creation of parking bay is necessary for barges to anchor and wait till they get their turn. At present barges are anchored and waiting in the open sea conditions around the Mormugao port. During rough weather conditions i.e., during peak monsoon and cyclone periods it is difficult to anchor in the open sea conditions and also unsafe for the barges. In front of the Iron ore berth (Berth No. 9) of Mormugao port, mooring dolphins are there for sea going vessels to anchor. Similar, mooring Dolphins arrangement is also required for inland water transport barges in a suitable location.

The suitable site selected for parking bay for the barges is the Cumberjua canal, at the intersection Point of Zuari River as shown in Fig. 4.31. The selected location is adequate and sufficient to cater the requirement of parking of the barges. The parking bay will cater to the barges plying in both Mandovi and Zuari waterways. The site is selected considering the following merits:

- The area is sheltered from the open sea conditions to avoid rough sea conditions and strong swell
- The Cumberjua canal at the proposed parking bay location is relatively wide
- The proposed location is close to the Mormugao port, about 10 to 12 km away. Most of the iron ore barges reach the Mormugao port via., the proposed parking bay location particularly during peak monsoon season

About 50,000 m^2 area is required to be acquired for the proposed parking bay. Some of the area will be acquired and some will be reclaimed by sand filling of the dredged material. In the parking bay, a series of 25 numbers of Dolphins will be provided for mooring 25 numbers of barges. The Dolphins are single piled structures designed to take care of the tension on a mooring line. The mooring Dolphins are used for securing the vessels by using ropes as shown in the above figure.

For approximate assessment of the sub soil classification of the proposed parking bay area for construction of Mooring Dolphins, the geotechnical properties of the bore-hole data of the nearby available site was obtained from the published information and provided in table 4.11. As per the sub soil classification, the pile length for Mooring Dolphins shall be around 30 m.

Table 4.11: Sub soil stratification from published information (Amona jetty site, Goa)

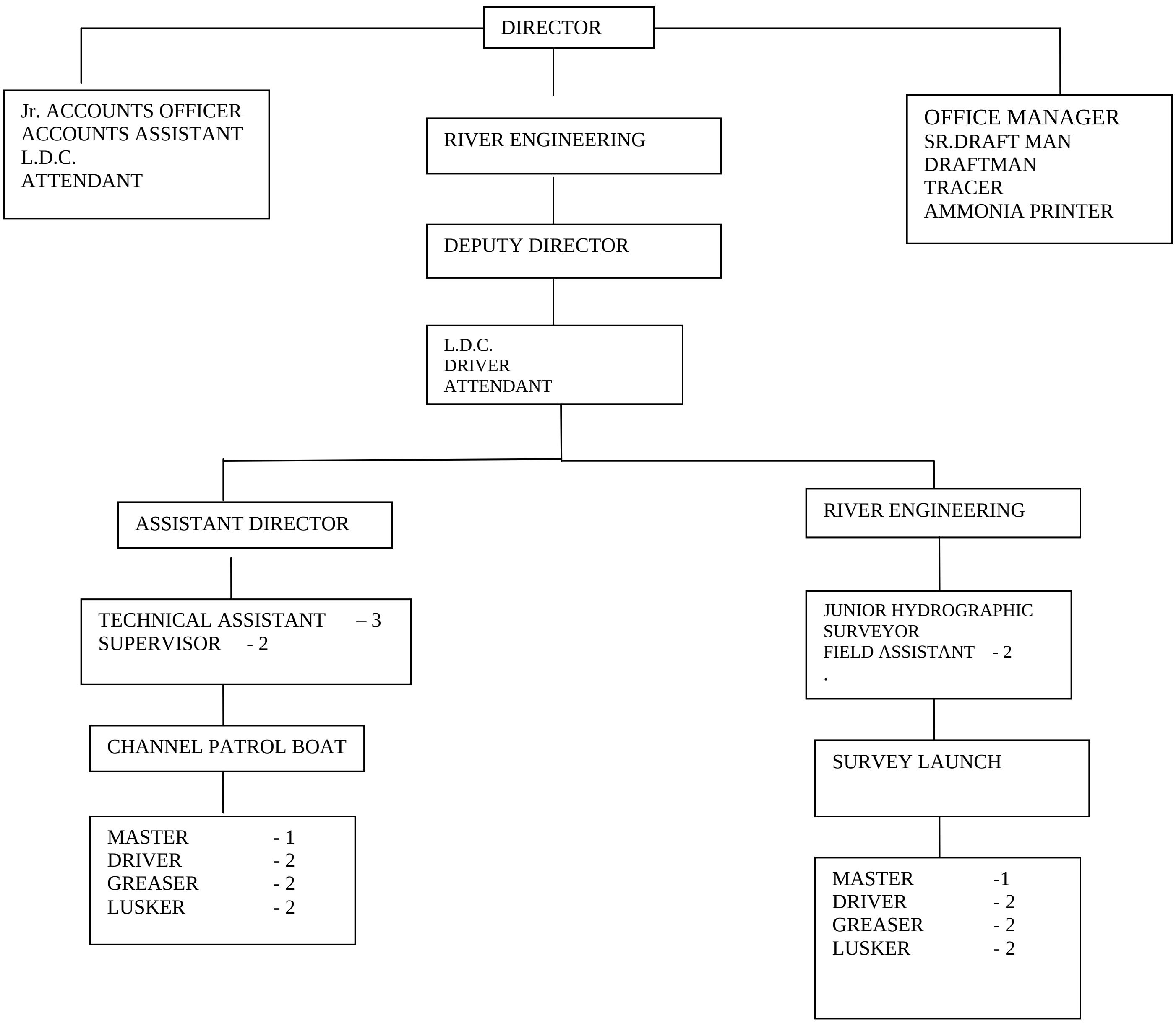
Layer / Strata	Description of soil	RL in 'm'	SPT, 'N'	Geotechnical classification	Lab Cu and □
I	Brown Lateritic clayey fill	57 to 50	7 to 10	MH / MI	
II	Very soft black marine clay	50 to 42	1 to 4	MH	Cu = 0.5 T / m^2 □ = 5.5
III	Yellow stiff lateritic silt	42 to 30	14 to 25	MI	Cu = 2.18T / m^2 □ = 22
IV	Dense silty sand	30 to 28	>50	SM	
V	Hard lateritic clayey silt	28 to 20	>50	MI	
M – Silt; S – Sand; I – Medium compressibility; H – High compressibility					

4.6 ORGANISATION AND MANAGEMENT:

The major activities involves for the development of the proposed waterways are dredging, navigational aids and bank protection works along the proposed waterways. The staff requirement for the execution of work for the proposed developmental works is summarized in organized chart.

Director shall be the overall in charge for various activities of works involved in the development of waterways. The major items involved are planning works, monitoring the functions, study and phasing of expenditures etc. Director shall be assisted by Deputy Directors, senior Hydrographic Surveyors and their staff etc. The detailed organization chart for the proposed development works is given as under.

ORGANISATION CHART FOR GOAN WATERWAYS



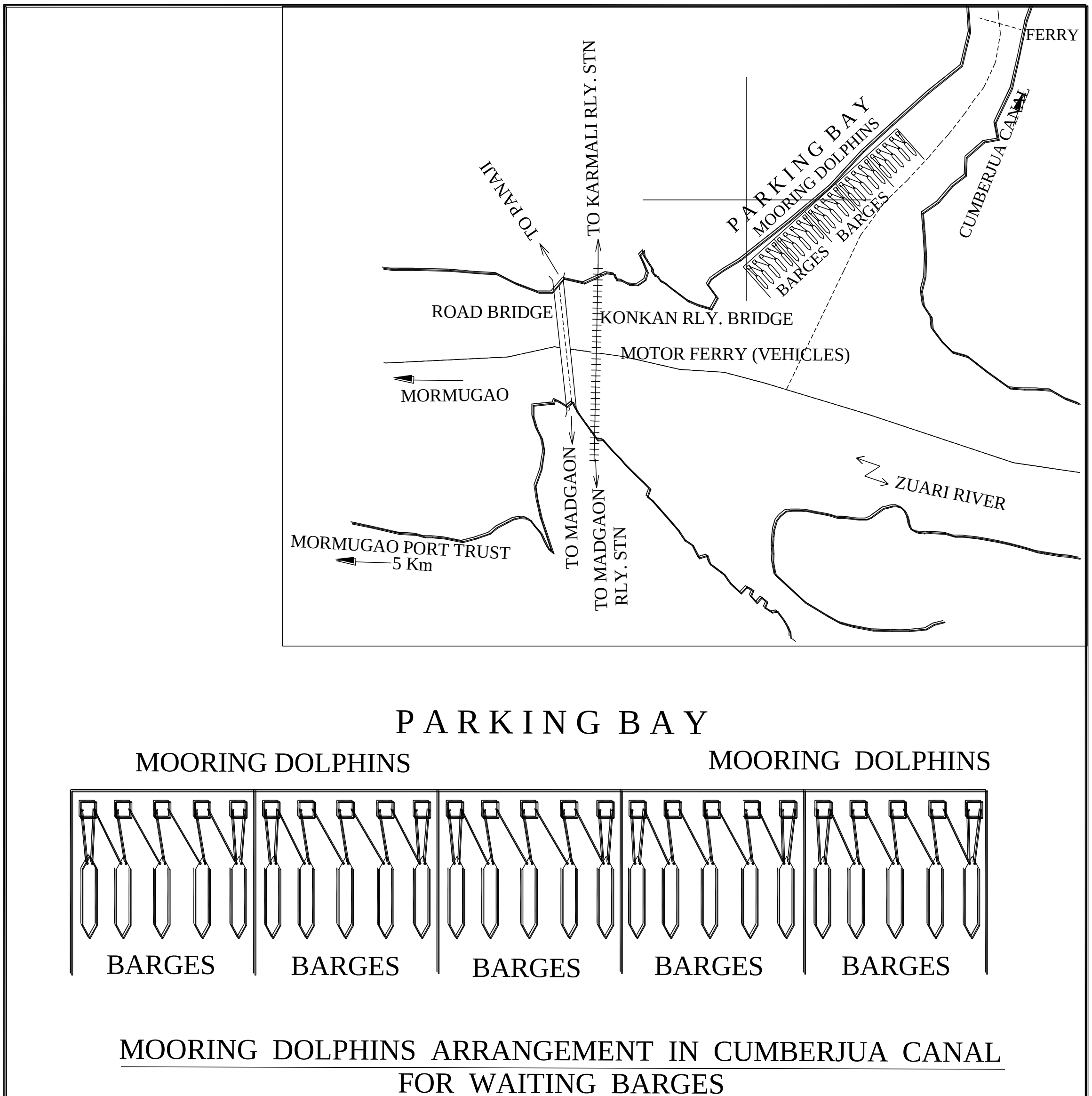
4.7 CONSTRUCTION SCHDULE:

The development works included dredging, bank protection works, channel marking and construction of parking bay etc. The bar chart for the construction schedule is given below:

Activity	Year 1	Year 2	Year 3
Land Acquisition along Cumberjua Canal			
Dredging works			
Bank Protection Works			
Construction of Parking Bay			
Installation of Vessel Tracking System Etc.			

4.8 COST ESTIMATE:

The capital cost estimate for waterway development is worked out to Rs 306.70 crores. The breakup details are furnished in table 4.12. The major waterway development cost is deepening of the waterways suitable to ply 3000 ton iron ore barges. Since, the Goa waterways have been operating for the last six decades by private operators and are under the administrative control of Department of Captain of ports, Government of Goa all the necessary infrastructure is available as discussed. The operating cost is generally considered as 2% of the capital cost for waterway development to increase the draft suitable to 3000 tons barges from the existing draft.



DETAILS OF PARKING AREA	
AREA	500 m x 100 m = 50,000 sq. m
BARGE SIZE FOR PARKING	80 m x 15 m
NO. OF BARGES CAN PARK AT A TIME	25 BARGES

Fig. 4.31: Parking bay for iron ore transport barges

Table 4.12 : Capital cost for Development of Waterways in Goa					
S.No.	**Description**	**Quantity**	**Unit**	**Rate (Rs.)**	**Capital cost Amount (Rs)**
A	***MANDOVI RIVER***				
1	Capital Dredging for 3000 ton Barge including mobilization and demobilization of dredgers	1208869	Cum	200	241773800
2	Disposal of Dredged materials in Deep sea at designated area, as per the provisions of the C.R.Z.notification,1991.	1208869	Cum	200	241773800
3	Aids to Navigation				
	(i)Channel markers	27	Nos.	50000	1350000
	(ii)Beacons / Floating Buoys (Basic cost + Installation)	36	Nos.	800000	28800000
	(iii) Traffic lights (Basic cost + Installation)	12		500000	6000000
	TOTAL of A				519697600
		Say			52 Crores
B.	***ZUARI RIVER***				
1	Capital Dredging for 3000 ton Barge including mobilization and demobilization of dredgers	2649770	Cum	200	529954000
2	Disposal of Dredged materials in Deep sea at designated area, as per the provisions of the C.R.Z.notification,1991.	2649770	Cum	200	529954000
3	Aids to Navigation				
	(i)Channel markers	23	Nos.	50000	1150000
	(ii)Beacons / Floating Buoys (Basic cost + Installation)	56	Nos.	800000	44800000
	(iii) Traffic lights (Basic cost + Installation)	15		500000	7500000
	TOTAL of B				1113358000
		Say			112 crores

C	***CUMBERJUA CANAL***				
1	Capital Dredging for 3000 ton Barge including mobilization and demobilization of dredgers	2638001	Cum	200	527600200
2	Disposal of Dredged materials in Deep sea at designated area, as per the provisions of the C.R.Z.notification,1991.	2638001	Cum	200	527600200
3	Bank Protection Works (total line metres: 16200 m)				
	i) Sand Filling (Base Course)	12150	Cum	225	2733750
	ii) Stone Masonary	60750	Cum	2500	151875000
4	Aids to Navigation				
	(i)Channel markers	21	Nos.	50000	1050000
	(ii)Beacons / Floating Buoys (Basic cost + Installation)	14	Nos.	800000	11200000
	(iii) Traffic lights (Basic cost + Installation)	12		500000	6000000
5	Land Acquisition	33.975	Hectare	1500000	50962500
5	Cost of Mooring Dolphins for waiting barges including installation and accessaries	25	Nos	5000000	125000000
	Total of C				1,40,40,21,650
		Say			141 Crores
D	Manpower cost for the execution of project (for Project period 2 year)		LS		40000000
E	Cost for vessel tracking system		LS		10000000
		GRAND TOTAL			**308,70,77,250**

Say Rs.310 Crores

* Goa Barge Owners Association (GBOA) needs the requirements of 16 nos. of slipway/dry dock facilities over and above to the existing 16 nos of slipway / dry dock facilities to meet the future requirement. The cost of one slipway/dry dock facility is about 6 crores i.e for 16 nos. Rs. 96 Crores. However cost of additional slipway/dry dock has not been considered as it is beyond the preview of the present scope of services. Since the existing slipway/dry-docks had been constructed and maintained by private owners the same practice may be followed for the additional facilities.

Annexure 4. 1

MANDOVI RIVER

Sl No.	Chainage (in Meters)	Depth(m)	WIDTH (in Meters)
1	0	0.9	137
2	525	2.4	142
3	1025	2.7	137
4	1300	4.1	113
5	1525	2.1	275
6	2025	2.7	187
7	2525	2.8	100
8	2550	2.6	165
9	3025	6.6	75
10	3050	6.1	125
11	3525	3.2	137
12	4025	4.4	175
13	4525	2.4	182
14	5025	9.7	187
15	5525	7.7	135
16	6025	13.9	147
17	6525	2.0	208
18	7025	3.8	227
19	7525	6.9	107
20	8025	2.3	182
21	8525	2.5	222
22	9050	4.6	225
23	9575	2.6	187
24	10075	4.7	172
25	10600	3.2	292
26	11100	6.7	225
27	11600	6.9	125
28	12100	5.6	252
29	12600	4.0	252
30	13100	7.3	177
31	13525	4.2	270
32	14025	4.6	292
33	14525	1.4	402

34	15025	3.0	482
35	15525	3.4	458
36	16025	1.9	275
37	16525	6.6	230
38	17025	2.2	400
39	17525	4.6	345
40	18025	3.6	558
41	18525	4.5	327
42	19025	6.7	320
43	19525	10.2	187
44	20025	7.8	222
45	20525	6.0	285
46	21050	4.2	337
47	21550	3.4	415
48	22050	5.8	438
49	22550	5.6	220
50	23050	6.6	242
51	23550	10.2	167
52	24050	3.6	250
53	24550	1.9	445
54	25050	1.5	375
55	25550	3.5	412
56	26050	4.4	375
57	26425	6.1	337
58	26725	5.8	260
59	27225	4.1	280
60	27725	5.0	263
61	28225	2.7	450
62	28725	3.1	492
63	29200	3.4	530
64	29700	3.0	575
65	30200	3.2	540
66	30725	2.8	550
67	31225	3.4	330
68	31725	3.6	1112
69	32225	5.0	612
70	32725	8.7	620
71	33225	6.5	712
72	33725	4.7	800
73	34225	4.7	930
74	34725	9.8	1040
75	35250	6.6	620
76	35750	6.9	530

77	36250	5.7	512
78	36750	8.0	405
79	37250	5.0	862
80	37750	6.7	1185
81	38250	5.2	1000
82	38750	3.0	720
83	39250	6.0	612
84	39750	5.5	707
85	40237	7.7	1170
86	40837	8.3	2835
87	41437	7.2	2840
88	42037	6.0	3570
89	42637	6.4	4125
90	43237	7.8	3900

ZUARI RIVER

S.No.	Chainage (in m)	Depth (m)	Width (m)
1	0	1.5	80
2	500	1.6	85
3	1000	3.9	150
4	1500	4.8	115
5	2000	1.8	115
6	2500	4.9	125
7	3000	3.0	150
8	3500	2.3	150
9	4000	3.4	175
10	4500	2.7	100
11	5000	8.1	125
12	5500	3.5	150
13	6000	4.4	120
14	6500	5.7	155
15	7000	3.4	175
16	7500	2.3	185
17	8000	2.9	200
18	8500	2.6	235
19	9000	3.2	200
20	9500	3.6	215

21	10000	5.7	130
22	10500	8.1	175
23	11000	6.1	150
24	11500	8.1	150
25	12000	4.3	240
26	12500	3.9	240
27	13000	7.6	240
28	13500	4.2	260
29	14000	3.9	220
30	14500	8.4	125
31	15000	11.7	165
32	15500	4.8	110
33	16000	2.6	360
34	16500	2.2	375
35	17000	2.2	450
36	17500	2.5	460
37	18000	3.2	400
38	18500	3.5	335
39	19000	5.5	280
40	19500	11.0	175
41	20000	6.6	310
42	20500	2.9	425
43	21000	3.1	125
44	21500	3.7	330
45	22000	4.5	325
46	22500	4.9	460
47	23000	8.8	375
48	23500	8.8	290
49	24000	5.5	340
50	24500	6.1	310
51	25000	7.5	225
52	25500	8.9	185
53	26000	7.8	125
54	26500	5.4	290
55	27000	5.8	360
56	27500	4.5	465
57	28000	3.2	510
58	28500	3.6	440
59	29000	6.5	300
60	29500	8.4	410

61	30000	7.8	345
62	30500	7.8	425
63	31000	6.1	580
64	31500	4.5	495
65	32000	4.5	545
66	32500	4.3	1125
67	33000	4.4	800
68	33500	5.6	680
69	34000	7.7	1080
70	34500	7.0	1240
71	34875	5.8	1040
72	35000	5.1	900
73	35500	4.9	780
74	36000	3.7	660
75	36500	3	1080
76	37000	2.6	2040
77	37500	2	2580
78	38000	1.7	2640
79	38500	2.9	2220
80	39000	2.8	4260
81	39500	2.7	4500
82	40000	2.7	5100
83	40500	2.5	4550
84	41000	2.5	4050
85	41500	2.3	4525
86	42000	2.2	5125
87	42500	2.2	5425
88	43000	2.3	4775
89	43500	2.3	4600
90	44000	2.4	4725
91	44500	2.8	5875
92	45000	3.5	5450
93	45500	4.4	4600
94	46000	4.9	4550
95	46500	5.2	4700
96	47000	6	4750
97	47500	7.1	5300
100		Open sea	

CUMBERJUA CANAL

S.No.	Chainage (in m)	Depth (m)	Width (m)
1	0	3.2	45
2	500	2.4	50
3	1000	1.9	55
4	1500	2.3	55
5	2000	3.1	55
6	2500	3.0	55
7	3000	3.0	60
8	3500	3.2	65
9	4000	3.4	53
10	4500	3.8	70
11	5000	2.6	90
12	5500	3.3	80
13	6000	4.0	95
14	6500	6.1	87
15	7000	7.8	87
16	7500	4.4	80
17	8000	3.6	80
18	8500	2.4	117
19	9000	3.4	125
20	9500	8.0	90
21	10000	6.3	75
22	10500	5.7	95
23	11000	5.0	150
24	11500	4.1	150
25	12000	6.4	110
26	12500	6.2	125
27	13000	4.3	200
28	13500	3.9	205
29	14000	6.6	200
30	14500	5.2	170
31	15000	4.5	177
32	15500	4.3	257
33	16000	2.6	300
34	16250	2.8	350

Annexure 4.2

CRIETRICAL BENDS IN GOA WATERWAYS

CUMBERJUA CANAL

S.No.	Chainage (in Km.)	Radius of Curvature (in m)
1	0.32	109
2	1.02	358
3	2.00	104
4	2.50	75
5	3.03	119
6	3.80	188
7	4.35	304
8	5.52	738
9	7.00	548
10	7.90	614
12	9.05	472
13	10.03	521
14	12.00	351
15	14.45	419

ZUARI RIVER

S.No.	Chainage (in Km.)	Radius of Curvature (in m)
1	0.90	325
2	1.45	441
3	2.40	420
4	4.10	429
5	5.20	285
6	6.80	782
7	7.50	560
8	12.40	337
9	15.80	570
10	20.90	659
12	28.00	1600
13	31.70	1256

MANDOVI RIVER

S.No.	Chainage (in Km.)	Radius of Curvature (in m)
1	0.20	316
2	3.00	690
3	3.80	576
4	5.00	257
5	5.90	222
6	6.80	271

7	9.10	1078
8	11.00	995
9	12.05	1022
10	15.40	928
12	19.00	670
13	22.00	294
14	22.90	338
15	31.90	1067
16	37.20	381

Annexure 4.3

RECORD OF BOTTOM SAMPLE MANDOVI RIVER

S. No.	Sample No.	Date	Chainage In Km.	Position in U.T.M. Easting in mtrs.	Coordinates Northing in mtrs	Equipment used	Geological description
1	00	02.02.2001	0.45	398575.0	1707532.5	DNTI GPS 5012 Reciever & Sampler A Type	Sand Mud
2	1	02.02.2001	1.1	397732.5	1707695.0	do	Pebbles
3	2	02.02.2001	2.075	397125.0	1708487.5	do	Pebbles
4	3	02.02.2001	3.225	396562.5	1709317.5	do	Coarse Sand
5	4	02.02.2001	4.4	396285.0	1710192.5	do	Coarse Sand
6	5	02.02.2001	5.35	395737.5	1710882.5	do	Sand Mud
7	6	02.02.2001	6.5	395900.0	1711423.8	do	Coarse Sand
8	7	02.02.2001	7.625	395250.0	1711887.5	do	Sand Mud
9	8	02.02.2001	8.55	395090.0	1712855.0	do	Pebbles
10	9	02.02.2001	9.7	394312.5	1713425.0	do	Coarse Sand
11	10	02.02.2001	10.725	393330.0	1713600.0	do	Sand Mud
12	11	02.02.2001	11.8	392680.0	1714240.0	do	Sand Mud
13	12	02.02.2001	12.35	392390.0	1715180.0	do	Sand Mud
14	13	02.02.2001	13.375	391557.5	1715767.5	do	Sand Mud
15	14	02.02.2001	14.875	390630.0	1716137.5	do	Coarse Sand
16	15	02.02.2001	15.9	389712.5	1716540.0	do	Sand
17	16	02.02.2001	16.8	389320.0	1717475.0	do	Coarse Sand
18	17	02.02.2001	18.25	388635.0	1718190.0	do	Sand Mud
19	18	02.02.2001	19.1	387957.5	1718932.5	do	Sand Mud
20	19	02.02.2001	20.125	387070.0	1719.012.5	do	Sand Mud
21	20	02.02.2001	21.075	386325.0	1718337.5	do	Coarse Sand
22	21	02.02.2001	22.05	385462.5	1717837.5	do	Coarse Sand

RECORD OF RIVER BED SAMPLES
SURVEY: CUMBERJUA CANAL
EQUIPMENT USED: BY GRAB

SURVEY LAUNCH :MAHALAKSHMI YEAR:2003 SHEET NO. 1 TO 6

S. No.	DATE	CHAINAGE IN Km.	LATITUDE (N)	LONGITUDE (E)	REDUCED DEPTH IN METERS	CLASSIFICATION
1	19.04.03	0.1	$15^0$31'18".40	$077^0$55'46".40	3.00 m	Fine Sand & Mud
2	19.04.03	0.8	$15^0$30'58".70	$073^0$56'18".40	2.20 m	Mud
3	19.04.03	2.1	$15^0$30'47".96	$073^0$56'42".70	3.10 m	Coarse Sand
4	19.04.03	3.05	$15^0$30'15".10	$073^0$56'46".60	3.30 m	Mud & Fine Sand
5	19.04.03	4.125	$15^0$29'55".60	$073^0$57'15".40	5.10 m	Sand
6	19.04.03	5	$15^0$29'26".98	$073^0$57'21".90	5.50 m	Coarse Sand
7	19.04.03	5.55	$15^0$28'57".50	$073^0$57'13".80	3.20 m	Mud & Sand

8	19.04.03	6.625	15^{0}28’27”.80	073^{0}57’08”’.20	8.00 m	Mud
9	19.04.03	8.15	15^{0}27’59”.80	073^{0}57’29”.90	2.40 m	Gravel
10	19.04.03	9.125	15^{0}27’36”.80	073^{0}57’09”.10	4.60 m	Gravel
11	19.04.03	10.75	15^{0}26’59”.50	073^{0}56’44”.30	4.20 m	Stone
12	19.04.03	12.375	15^{0}26’13”.90	073^{0}56’40”.90	7.00 m	Gravel
13	19.04.03	13.85	15^{0}25’58”.60	073^{0}55’54”.70	3.50 m	Mud
14	19.04.03	14.825	15^{0}25’28”.20	073^{0}55’39’’.99	4.60 m	Mud
15	19.04.03	15.475	15^{0}25’11”.30	073^{0}55’32’’.70	1.00 m	Mud

RECORD OF RIVER BED SAMPLES
SURVEY: ZUARI RIVER
EQUIPMENT USED: BY GRAB

SURVEY LAUNCH :MAHALAKSHMI YEAR:2003 SHEET NO. 1 TO 13

S. No.	DATE	CHAINAGE IN Km.	LATITUDE (N)	LONGITUDE (E)	REDUCED DEPTH IN METERS	CLASSIFICATION
1	17.01.03	19.35	15^{0}20’50”.00	074^{0}00’19”.70	6.5	Sand
2	17.01.03	22.075	15^{0}21’22”.60	73^{0}59’17’’.10	3.1	Fine Sand
3	17.01.03	22.9	15^{0}21’22”.90	73^{0}58’48’’.5	3.3	Fine Sand
4	17.01.03	23.85	15^{0}22’04”.40	73^{0}58’04’’.40	5.7	Fine Sand & Gravel
5	17.01.03	24.95	15^{0}22’36”.60	73^{0}57’28’’.40	6.8	Mud & Fine Sand
6	17.01.03	27.6	15^{0}23’15”.97	73^{0}57’21’’.60	3.1	Mud & Fine Sand
7	17.01.03	28.375	15^{0}23’39”.80	73^{0}57’13’’.80	3.5	Mud & Shells
8	17.01.03	29.325	15^{0}24’06”.50	73^{0}56’56’’.30	8.0	Soft Mud
9	17.01.03	30.25	15^{0}24’20”.20	73^{0}56’31’’.90	6.9	Mud & Shells
10	17.01.03	31.05	15^{0}24’20”.70	73^{0}55’55’’.40	4.9	Sticky Clay
11	17.01.03	32.6	15^{0}24’24”.90	73^{0}55’16’’.90	5.6	Sticky Clay
12	17.01.03	33.95	15^{0}24’33”.40	73^{0}54’36’’.30	7.9	Shells & Gravel
13	17.01.03	34.2	15^{0}24’36”.10	73^{0}54’21’’.90	5.7	Mud
14	17.01.03	34.8	15^{0}24’40”.08	73^{0}54’02’’.70	3.8	Sticky Clay
15	01.02.03	9.75	15^{0}17’53’’.80	74^{0}02’49’’.90	1.9	Fine Sand
16	01.02.03	10.8	15^{0}18’17’’.60	74^{0}02’26’’.80	4.7	Fine Sand & Mud
17	01.02.03	12.55	15^{0}18’03’’.60	74^{0}01’37’’.90	3.1	Fine Sand & Mud
18	01.02.03	13.825	15^{0}18’04’’.50	74^{0}01’03’’.10	4.0	Sand
19	01.02.03	15.3	15^{0}18’37’’.00	74^{0}00’44’’.60	6.2	Stone & Gravel
20	01.02.03	16.275	15^{0}19’10’’.60	74^{0}00’33’’.90	2.4	Fine Sand & Mud
21	01.02.03	17.275	15^{0}19’42’’.40	74^{0}00’27’’.70	2.1	Fine Sand & Mud
22	01.02.03	18.275	15^{0}20’14’’.80	74^{0}00’21’’.00	3.1	Sand & Mud
23	10.02.03	8.675	15^{0}17’56’’.70	74^{0}03’24’’.60	3.0	Gravel & Mud
24	10.02.03	7.7	15^{0}17’46’’.70	74^{0}03’56’’.60	3.3	Gravel
25	10.02.03	6.625	15^{0}17’16’’.80	74^{0}04’14’’.00	4.1	Gravel & Stone
26	10.02.03	5.6	15^{0}16’45’’.30	74^{0}04’22’’.40	2.3	Gravel & Stone
27	10.02.03	4.25	15^{0}16’32’’.80	74^{0}04’48’’.99	1.5	Gravel
28	10.02.03	3.275	15^{0}16’23’’.90	74^{0}05’14’’.30	1.8	Gravel
29	10.02.03	2.175	15^{0}16’03’’.10	74^{0}05’36’’.20	1.6	Gravel
30	10.02.03	0.325	15^{0}15’58’’.10	74^{0}06’31’’.60	2.1	Gravel & Stone
31	22.02.03	Beyond Survey Limit	15^{0}16’00’’.30	74^{0}06’58’’.80	2.5	Gravel
32	22.02.03	Beyond Survey Limit	15^{0}15’32’’.50	74^{0}07’19’’.40	5.8	Stone
33	22.02.03	Beyond Survey Limit	15^{0}15’12’’.90	74^{0}07’42’’.80	2.2	Coarse Sand

Annexure 4.4

Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

Annexure - I

(See regulation 3)

A. BUOYAGE AND MARKING OF THE WATERWAY:

(i) DIRECTION OF BUOYAGE:

The direction of buoyage shall be defined as follows

(a) The general direction taken by the mariner when pproaching,river or estuary or waterway from seaward

(b) In case of non tidal rivers the direction against the flow of the river

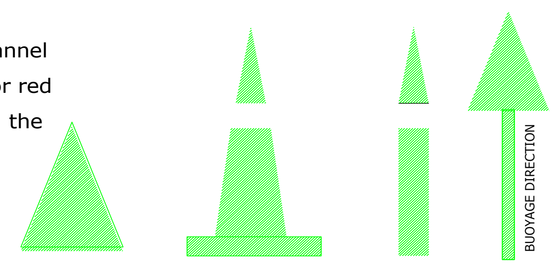
(c) The direction in which the kilometer chainage increases in case of estuary

(ii) **PORT HAND MARKS :**

these marks indicate the left hand side of the channel

BY DAY: Red Buoys,preferably cylindrical (CAN),or red spars,red cylindrical top marks is compulosory on the spars and on thebuoys if they are not cylindrical.

BY NIGHT: Rhythmic red lights of any type

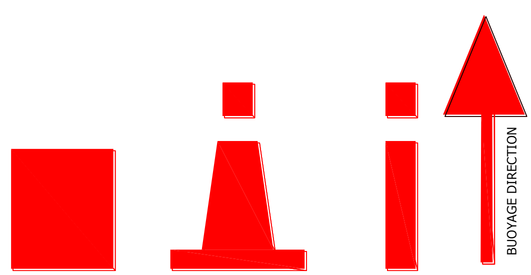


B. STARBOARD HAND MARKS

These marks indicate the right side of the channel

BY DAY: Green buoys preferably conical,or green spars A green conical top mark point upward is complusory on the spars and on the buoys if they are not conical.

BY NIGHT: Rhythmic green lights, of any type



Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

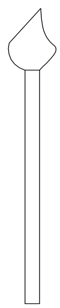
(Source – Inland Waterways Authority of India)

Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

(iii) **Bamboo marks in between and marks**

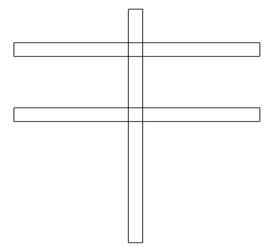
Right Hand Marks

(Ball mark)

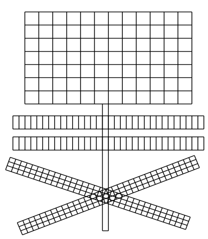


Left Hand Marks

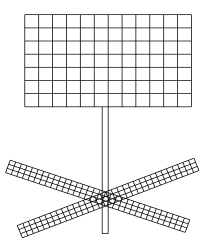
(Bamboo strips; mark)



(IV) **Under water snag marks (painted with lime)**

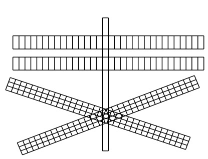


a) To indicate snag which can be crossed from either side

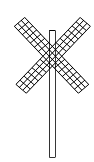


b) Snag to be kept on left

(V)**Closing of Channel**



c) Snag to be kept on right



Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

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Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

Annexure - II

(See regulation 4)

C. Signs and Signals

1. Day and Night marking

Where the prescribed mark consists of:-

(a) Light only , the lights may be used by day and by night;

(b) Boards only , the boards may be used as night marks if illuminated.Boards shall be rectangular in shape of 1.5 meter x 1 meter size minimum;

(c) Boards and lights, by day , either boards or lights may be used; by night either lights or illuminated boards may be used.

2. Lighting

Lights may be provided at night for lighting of the lower parts of a bridge, of the piers of a bridge, of the approaches to a lock, of a section of small canal etc.

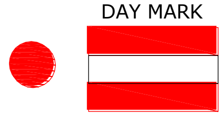
3. Intensity of lights

The lights recommended in this rules shall be visible for a distance of at least 2 kms, and shall be distinct from the surrounding lights.

4. Fixed lights

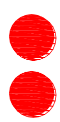
(i) Single red light

DAY MARK



"No passage"
Either to some of the channels or arms of the waterway, or to the whole of the waterway

(ii) Two red light placed one above the other



Complete and prolonged stoppage of navigation (blockage) of water -way bridges or locks out of service)

(ii) Two ror more red lights set apart

"No passage" (between the lights)

Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

(Source – Inland Waterways Authority of India)

Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

(iv) Single green light

"Go ahead" (the green light is always placed at side of the navigable channel). The use of this signal shall however, be restricted to cases where a single green light is sufficient clearly to indicate the clear passage. In other cases, the use of two green lights set apart, and indicating the passage is recmmended.

(v) Two green lights set apart

"Go ahead" between the lights

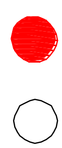
(vi) Single yellow light, along or between green lights

"Go ahead" but look out for traffic coming the other way".Vessels may steer towards the light which is placed above the navigable channel

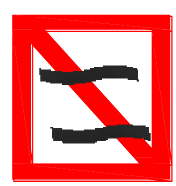
or

Proceed with caution.

(vii) A red light above a white light



"Do not cause wash"



(viii)

Do not exceed the speed indicate (In km/hour)

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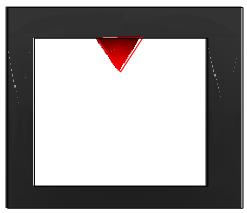
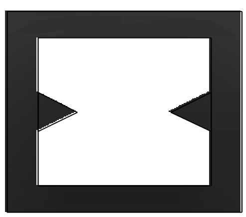
Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

(ix)  Clearance above water level limit

(x)  Width Of fairway or Channel Limit.

Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

(Source – Inland Waterways Authority of India)

Navigational Aids Proposed in Mandovi River, Zuari River and Cumberjua Canal

Annexure - III

(See regulation - 10)

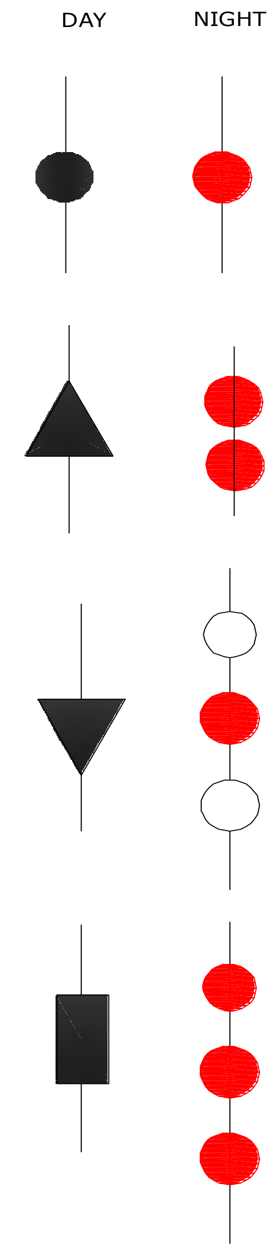
STORM WARNING SIGNALS

1. WARNING: A storm may affact you shortly

2.DANGER: A storm will soon strike you

3.DANGER: The port is threatened by a Bore tide or flash flood; sudden rise in water level and strong current expected.

4. GREAT DANGER: A violent storm will soon strike you.



Detailed Project Report for development of Mandovi River, Zuari River and Cumberjua Canal in Goa

(Source – Inland Waterways Authority of India)

CHAPTER – 5

ENVIRONMENTAL STUDY

5.1 GENERAL

The Mandovi, Zuari and Cumberjua canal system in Goa is actively being used for transportation of iron ore by barges. Ore extraction is carried out in the riverine belt and the transport of ore is done by barges plying the inland waterways of Mandovi-Cumberjua canal – Zuari estuaries system. The location of iron ore mines in the waterway belt of Mandovi and Zuari estuaries is shown in Fig. 5.1 . Extraction of ore generates large amount of mining rejects. Ore produced and processed at mines is transported by 10 ton tippers to river jetties using public roads, for loading in to barges. These barges take the ore to Murmagao harbour for loading in to ships. Most of the barge-loading jetties are away from mines about 13 to 15 kms from mine, on an average. Depending upon shipment program and tide timings, ore from mine is either stacked or loaded in to barges. For barge loading, tipper and wheel loader combination is deployed. The pollution of environment occurs in each stage of iron ore transportation right from mining, stacking, loading, unloading, transportation from mines to river jetties by trucks and transportation from river jetties by barges to export loading point at port and transshipers.

5.2 IMPACT OF IRON ORE MINES ON WATERWAYS

Mining and associated activities have quantitative and qualitative impacts on the water regime in and around the mines. These are briefly outlined hereunder:

- Water in the nearby water bodies gets polluted due to leaching from the overburden dumps, discharge of pumped mine water, and other activities in the vicinity of the water bodies
- During rainy season the runoff water from the areas surrounding the mines carries with large quantity of the suspended solids into the nearby water bodies.
- All the aquifers, including the water–table aquifer, above the mineral deposit are damaged

It is evident from the above that the mining and associated activities changes in ground water flow patterns, lowering of water table, changes in hydrodynamic conditions of river/underground recharge basins, reduction in volumes of subsurface discharge to water bodies/rivers, disruption and diversion of water courses/drainages pattern, contamination of water bodies, affecting the yield of water from bore wells and dug wells etc. Therefore, it is necessary to plan the mining and associated activities in such a manner that their impacts on the water regime are as minimum as possible.

Mandovi River, has 37 loading points from where Iron ore is transferred to ships. There are about 27 mining sites in the catchment area of Mandovi. The mines around Mandovi generate 1.0 lakh tones of mining reject annually and about 70,000 cubic tones of mining particles are deposited in the river every year.

Fig. 5.1 : Map showing iron ore mines along rivers Mandovi, Zuari and Cumberjua canal in Goa

5.2.1 Impact on Water Quality

Mining activities in Goa contribute to water pollution mainly due to the following three activities:

- Dewatering of the mining pit water to enable to proceed the mining below the ground water level
- Unloading of iron ore by trucks at river jetties
- Loading of iron ore in to barges at jetties
- Iron ore stacking at jetty yards
- Transportation by barges
- Effluent discharge from plants/iron ore jetties
- Storm water run-off from mine dumps and surroundings at jetties

Accidental spillages of oil by the barges during ore transportation are also source for water pollution in Mandovi and Zuari rivers.

Erosion of waste dumps due to heavy rainfall leads to turbidity of natural drainage system because of the suspended solids carried by the run-off. Currently, however its impact on the receiving streams and rivers is invariably detrimental but varies in degree. At its worst the water course can be rendered lifeless and virtually unusable. At best the mineral solids present will cause a hazard to the river biology which would otherwise flourish. It would appear most likely however that marine plants, fish, crusticans, smaller creatures and micro organisms must have suffered and the food chain might have been thus disrupted.

During the thalweg survey, water and surface soil samples from the river bed have been collected and analyzed in the laboratory. Three water and soil samples have been collected in each of the waterway viz., Mandovi, Zuari and Cumberjua canal and are subjected to test the various environmental parameters. The results are furnished in Tables 5.1 to 5.13.

The calcium and magnesium are two of the major constituents of sea water contributing significantly to the biological and geochemical processes in the sea. High concentrations of these elements in the sea, relative to their biogeochemical reactions tend to make them conservative elements especially in the open sea. However, in the coastal, estuarine and lagoon waters the concentration variations specially for calcium are quite significant due to land drainage, high rates of biological uptake, precipitation and dissolution processes characteristic of shallow systems. The calcium (Ca) and magnesium (Mg) concentrations in the samples collected at Zuari river mouth are high of the order of 1600 mg/l and 1040 mg/l whereas at the head of the estuary, that is, near Sanvarden bridge, the respective concentrations are of the order of 8 mg/l and 12 mg/l only as shown in the above tables. Similarly, the calcium and magnesium concentrations at Mandovi estuary mouth are 1590 mg/l and 1047 mg/l when compared the river waters at the head of the estuary near Usgaon Bridge and are respectively 12 mg/l and 152 mg/l as shown in the above tables.

Table: 5.1
Water sample analysis

Location: Zuari River (at Sanvarden bridge)

Sr. No.	**Parameter**	**Unit**	**Observed Values**
1	pH		6.62
2	Alkalinity	mg/l	28
3	TSS	mg/l	<5.0
4	TDS	mg/l	62
5	Sulphate (as SO_4)	mg/l	12.75
6	Calcium (as Ca)	mg/l	8
7	Magnesium (as Mg)	mg/l	11.66
8	Chloride (as Cl)	mg/l	13.2
9	Fluoride (as F)	mg/l	1.33
10	Nitrate as Nitrogen	mg/l	1.45
11	Total Iron (as Fe)	mg/l	0.28
12	Dissolved Oxygen	mg/l	6.5
13	Sodium (as Na)	mg/l	8
14	Total Phosphate (as PO_4)	mg/l	0.014

Table 5.2: Water sample analysis
Location: Zuari river (at mouth of the Zuari river with sea)

Sr. No.	**Parameter**	**Unit**	**Observed Values**
1	pH		7.32
2	Alkalinity	mg/l	96
3	TSS	mg/l	166
4	TDS	mg/l	23900
5	Sulphate (as SO_4)	mg/l	2402
6	Calcium (as Ca)	mg/l	1600
7	Magnesium (as Mg)	mg/l	1040
8	Chloride (as Cl)	mg/l	16109
9	Fluoride (as F)	mg/l	1.38
10	Nitrate as Nitrogen	mg/l	1.10
11	Total Iron (as Fe)	mg/l	1.36
12	Dissolved Oxygen	mg/l	8.7
13	Sodium (as Na)	mg/l	7798
14	Total Phosphate (as PO_4)	mg/l	0.024

Table 5.3: Water sample analysis

Location: Mandovi River (at Usgaon bridge)

Sr. No.	Parameter	Unit	Observed Values
1	pH		7.01
2	Alkalinity	mg/l	40
3	TSS	mg/l	<5.0
4	TDS	mg/l	2348
5	Sulphate (as SO_4)	mg/l	192.58
6	Calcium (as Ca)	mg/l	12.2
7	Magnesium (as Mg)	mg/l	152.40
8	Chloride (as Cl)	mg/l	1244
9	Fluoride (as F)	mg/l	1.42
10	Nitrate as Nitrogen	mg/l	0.45
11	Total Iron (as Fe)	mg/l	0.82
12	Dissolved Oxygen	mg/l	2.2
13	Sodium (as Na)	mg/l	610
14	Total Phosphate (as PO_4)	mg/l	0.15

Table 5.4: Water sample analysis

Location: Mandovi River (at sea mouth)

Sr. No.	Parameter	Unit	Observed Values
1	pH		7.15
2	Alkalinity	mg/l	104
3	TSS	mg/l	176
4	TDS	mg/l	27000
5	Sulphate (as SO_4)	mg/l	2386
6	Calcium (as Ca)	mg/l	1590
7	Magnesium (as Mg)	mg/l	1047
8	Chloride (as Cl)	mg/l	16982
9	Fluoride (as F)	mg/l	1.66
10	Nitrate as Nitrogen	mg/l	1.50
11	Total Iron (as Fe)	mg/l	0.82
12	Dissolved Oxygen	mg/l	6.8
13	Sodium (as Na)	mg/l	8112
14	Total Phosphate (as PO_4)	mg/l	0.027

Table 5.6: Water sample analysis

Location: Cumberjua canal (at mouth of Mandovi River)

Sr. No.	Parameter	Unit	Observed Values
1	pH		7.03
2	Alkalinity	mg/l	52
3	TSS	mg/l	54
4	TDS	mg/l	8006
5	Sulphate (as SO_4)	mg/l	612.72
6	Calcium (as Ca)	mg/l	30.42
7	Magnesium (as Mg)	mg/l	395.98
8	Chloride (as Cl)	mg/l	4174
9	Fluoride (as F)	mg/l	1.50
10	Nitrate as Nitrogen	mg/l	1.41
11	Total Iron (as Fe)	mg/l	0.76
12	Dissolved Oxygen	mg/l	9.3
13	Sodium (as Na)	mg/l	2160
14	Total Phosphate (as PO_4)	mg/l	0.04

Table 5.7: Water sample analysis

Location: Cumberjua canal (at mouth of Zuari River)

Sr. No.	Parameter	Unit	Observed Values
1	pH		7.01
2	Alkalinity	mg/l	92
3	TSS	mg/l	150
4	TDS	mg/l	21600
5	Sulphate (as SO_4)	mg/l	1972.73
6	Calcium (as Ca)	mg/l	1280
7	Magnesium (as Mg)	mg/l	913.68
8	Chloride (as Cl)	mg/l	14087
9	Fluoride (as F)	mg/l	1.46
10	Nitrate as Nitrogen	mg/l	0.38
11	Total Iron (as Fe)	mg/l	0.17
12	Dissolved Oxygen	mg/l	7.9
13	Sodium (as Na)	mg/l	6798
14	Total Phosphate (as PO_4)	mg/l	0.029

Table 5.8: Soil sample analysis

Location: Mandovi river (at Usgaon bridge)

Grain Size Analysis

IS:SIEVE SIZE (MM)	2.0	0.600	0.425	0.300	0.150	0.075
% OF PASSING	100	99.20	97.50	95.60	68.90	6.9

Test Parameter	Units	Observed value
Gravel	%	Nil
Sand	%	93.10
Silt	%	5.5
Clay	%	1.4

2. Atterbergs Limit Test

Sr. No.	Test Parameter	Unit	Observed value
(i)	Plastic Limit	%	Non Plastic
(ii)	Liquid Limit	%	22.0
(iii)	Plasticity Index	%	Non Plastic
3.	Soil Classification (as per IS:1498)	---	S.P, Fine Sand
4.	Natural Moisture Content	%	21.70
5.	Natural Dry Density	gm/cc	1.512
6.	Specific Gravity	---	2.62
7.	CC	---	0.09
8.	D50	mm	0.140
9.	Unconfined Compressive Strength (at N.D.D & N.M)	Kg/cm²	0.01
10	Cohesion Angle of InternalFriction at 90% Proctor Density(M.D.D.)		
(i)	Cohesion ©	Kg/cm²	0
(ii)	Angle of internal friction	φ	31º
11	Free Swell index	%	Nil
12	pH	---	7.98
13	Moisture Content	%	21.70
14	Available Nitrogen as N	mg/100g	21.40
15	Sodium	Meq/100g	1.304
16	Calcium	Meq/100g	2.8
17	Magnesium	Meq/100g	1.2
18	Available Potassium as K	Meq/100g	0.256
19	Organic Matter	%	0.72
20	Electrical Conductivity	µmhos/cm	210
21	Total Phosphate	ppm	65.0

Table 5.9: Soil sample analysis

Location: Mandovi river (at Sea mouth)

Sr. No.	Test Parameter	Unit	Observed Value
1.	pH	---	7.5
2.	Moisture Content	%	16.50
3.	Available Nitrogen as N	mg/100g	17.90
4.	Sodium	Meq/100g	1.410
5.	Calcium	Meq/100g	2.60
6.	Magnesium	Meq/100g	1.18
7.	Available Potassium as K	Meq/100g	0.28
8.	Organic Matter	%	0.60
9.	Electrical Conductivity	µmhos/cm	308.0
10.	Total Phosphate	ppm	52.0

Table 5.10: Soil sample analysis

Location: Zuari river (at Sanvarden bridge)

Sr. No.	Test Parameter	Unit	Observed Value
1.	pH	---	8.10
2.	Moisture Content	%	18.5
3.	Available Nitrogen as N	mg/100g	18.60
4.	Sodium	Meq/100g	1.320
5.	Calcium	Meq/100g	2.63
6.	Magnesium	Meq/100g	1.22
7.	Available Potassium as K	Meq/100g	0.210
8.	Organic Matter	%	0.66
9.	Electrical Conductivity	µmhos/cm	312.0
10.	Total Phosphate	ppm	58.0

Table 5.11: Soil sample analysis

Location: Zuari river (at Sea mouth)

Sr. No.	Test Parameter	Unit	Observed Value
1.	pH	---	7.60
2.	Moisture Content	%	28.6
3.	Available Nitrogen as N	mg/100g	19.20
4.	Sodium	Meq/100g	1.230
5.	Calcium	Meq/100g	1.980
6.	Magnesium	Meq/100g	1.100
7.	Available Potassium as K	Meq/100g	0.110
8.	Organic Matter	%	0.69
9.	Electrical Conductivity	µmhos/cm	280.0
10.	Total Phosphate	ppm	40.0

Table 5.12: Soil sample analysis

Location: Cumberjua canal (at Mandovi crossing)

1. Grain Size Analysis

IS:SIEVE SIZE (MM)	4.75	2.0	0.600	0.425	0.300	0.150	0.075
% OF PASSING	100	92.50	66.50	43.50	23.50	12.40	10.90

Test Parameter	Units	Observed value
Gravel	%	Nil
Sand	%	89.10
Silt	%	8.10
Clay	%	2.8

2. Atterbergs Limit Test

Sr. No.	Test Parameter	Unit	Observed value
(i)	Plastic Limit	%	Non Plastic
(ii)	Liquid Limit	%	22.0
(iii)	Plasticity Index	%	Non Plastic
3.	Soil Classification (as per IS:1498)	---	S.W, Coarse sand
4.	Natural Moisture Content	%	16.70
5.	Natural Dry Density	gm/cc	1.543
6.	Specific Gravity	---	2.63
7.	CC	---	0.108
8.	D50	mm	0.500
9.	Unconfined Compressive Strength (at N.D.D & N.M)	Kg/cm²	0.01
10	Cohesion Angle of InternalFriction at 90% Proctor Density(M.D.D.)		
(i)	Cohesion ©	Kg/cm²	0
(ii)	Angle of internal friction	φ	30º
11	Free Swell index	%	0.50
12	pH	---	7.80
13	Moisture Content	%	16.70
14	Available Nitrogen as N	mg/100g	18.80
15	Sodium	Meq/100g	1.310
16	Calcium	Meq/100g	2.40
17	Magnesium	Meq/100g	1.16
18	Available Potassium as K	Meq/100g	0.190
19	Organic Matter	%	0.840
20	Electrical Conductivity	µmhos/cm	205
21	Total Phosphate	ppm	68.0

Table 5.13: Soil sample analysis

Location: Cumberjua canal (at Zuari crossing)

1.Grain Size Analysis

IS:SIEVE SIZE (MM)	0.600	0.425	0.300	0.150	0.075
% OF PASSING	100	98.70	97.10	58.5	23.40

Test Parameter	Units	Observed value
Gravel	%	Nil
Sand	%	76.60
Silt	%	19.2
Clay	%	4.2

2.Atterbergs Limit Test

Sr. No.	Test Parameter	Unit	Observed value
(i)	Plastic Limit	%	Non Plastic
(ii)	Liquid Limit	%	22.5
(iii)	Plasticity Index	%	Non Plastic
3.	Soil Classification (as per IS:1498)	---	S.P, Silty Sand
4.	Natural Moisture Content	%	23.95
5.	Natural Dry Density	gm/cc	1.522
6.	Specific Gravity	---	2.65
7.	CC	---	0.100
8.	D50	mm	0.145
9.	Unconfined Compressive Strength (at N.D.D & N.M)	Kg/cm^2	0.025
10	Cohesion Angle of Internal Friction at 90% Proctor Density(M.D.D.)		
(i)	Cohesion ©	Kg/cm^2	0
(ii)	Angle of internal friction	φ	30º
11	Free Swell index	%	1.20
12	pH	---	8.00
13	Moisture Content	%	23.95
14	Available Nitrogen as N	mg/100g	24.50
15	Sodium	Meq/100g	1.50
16	Calcium	Meq/100g	2.90
17	Magnesium	Meq/100g	1.23
18	Available Potassium as K	Meq/100g	0.280
19	Organic Matter	%	0.860
20	Electrical Conductivity	µmhos/cm	212.0
21	Total Phosphate	ppm	72.0

The high Ca and Mg concentrations in the estuary mouth and low concentrations in the head of the estuary can be attributed that the gradual decrease of sea water incursion into the upstream reaches of the river. The high concentrations of Ca and Mg at the sea end are due to more saline content of the sea water. Similarly the chloride (Cl) content is also high in the samples collected at the mouth of the estuary when compared to the head of the estuary as shown in the above tables due to sea water influence. The Ca, Mg and Cl concentrations in Cumberjua canal are also relatively high as shown in the above tables due sea water incursion into the canal. The total dissolved solids (TDS) are noticed high in the mouths of Zuari and Mandovi rivers when compared to their upstream reaches as shown in the above tables due to the influence of the sea.

The nitrate and phosphate are important elements especially as nutrients for phytoplankton and phytobenthos, of the biogeochemical system of an estuary. The earlier studies carried out by various workers on Mandovi and Zuari estuarine system had revealed that these nutrients in decreases from head to mouth in the dry season. It is also examined that the behavior of nutrients in the Mandovi estuary during the pre monsoon season can be attributed to mining rejects form the source for nitrates.

5.3 ENVIRONMENTAL IMPACT

The mining industry in Goa has witnessed a number of positive and significant impacts on the economic development of the state. There are, however, also been several environmental impacts, some of which are due especially to the unique features of mining in Goa and some due to bad mining practices and poor environmental management. The Iron ore industry operates under certain difficult conditions specific to Goan iron ore mines. Mining will lead to all associated activities such as ore transportation, dry/wet screening, beneficiation and loading operations and all these operations will continue at the present levels. All these operations would impact on the environment of the area.

Mining in Goa is concentrated in four talukas namely, Bicholim in North Goa district and Salcete, Sanguem and Quepem in South Goa district. Some 400 mining leases had been granted in Goa till 2002-03, covering approximately 30,325 Ha. Since June 2007, 120 mining projects came up for clearance with the Ministry recommending clearance for an overwhelming 48 per cent of the projects. The remaining 52 per cent of the projects are still pending with the Ministry**.** A typical excavation of iron ore mine is shown in Fig. 5.2. On an average 2.5 to 3 tonnes of mining waste have to be excavated to produce tones of iron ore and approximately 55 million tonnes of waste will be generated every year. This is a huge quantity. The impact would be much more significant as most of the mining leases are surrounded by the rivers and since rainfall in the region is very high, overflow of mining waste will cause extensive damage to water bodies.

Fig 5.2: A typical open cast iron ore mine in Goa

River Mandovi is the largest river in Goa and is known as the lifeline of Goa. There are more than 27 large mines operating in its catchment area with numerous loading points to load barges with iron ore for shipment. A typical iron ore mining area along the banks of Mandovi river and loading points are shown in Fig. 5.3. These mines together generate about 1,01,250 tonnes of rejection per year (Centre for Science and Environment). According to studies conducted by Dr. Sen Gupta, from the National Institute of Oceanography, 70,000 cu tons of iron particulates get deposited in river Mandovi every year. With rainfall of more than 120 inches and open cast mining on the hills, huge mountains of mining rejections reach this river, which is getting heavily silted.

If Mandovi is the most important river of North Goa, Zuari is the lifeline of South Goa. This river has a basin of 973 sq km and also emerges from the Western Ghats. There are more than 10 large mines operating along the river and playing havoc with it. These mines are generating 3330 tonnes of rejection/day, which ultimately find place in the river during monsoon, get deposited on the river bed and affect the riverine ecosystem very severely. The river banks are dotted with numerous loading points, destroying its riparian belt. Typical iron ore mines along the banks of river Zuari and loading stations are shown in Fig. 5.4.

Fig.5.3: Iron ore mines along the banks of river Mandovi and adjacent loading points

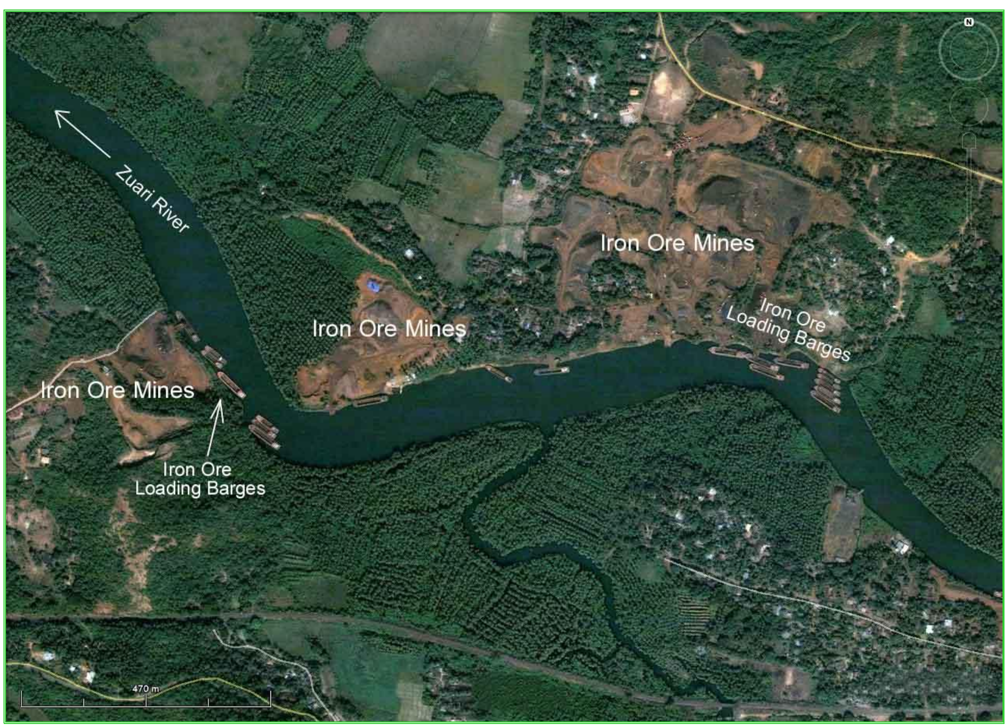


Fig.5.4: Iron ore mines along the banks of river Zuari and adjacent loading points

The iron ore mining rejects while loading and unloading into barges along the banks of Mandovi and Zuari estuaries lead to environmental degradation of the rivers. The iron ore rejects may also possible while transportation of ore by barges from the loading stations to the unloading ship at the port for further export. The iron ore rejects from the transportation barges are due to wind action. The iron ore rejects caused due to transportation by barges can be seen in Fig. 5.5 and Fig. 5.6. The studies of NIO (Parulekar A.H., and Ansari Z.A., 1986) have revealed that the benthic fauna like clams in Mandovi and Cumberjua canal estuarine system (estuarine bottom) of Goa have been severely affected by massive inputs of mining rejects and the resulting environmental stress has caused irreversible ecosystem instability. Reduced dissolved oxygen concentration; high suspended solids and blanketing of bottom deposits by mining rejects, has resulted in more than 70% reduction in clam production; near extinction of resident fauna and the appearance of a low diversity bottom fauna, comprising of tolerant but vagrant species. Ever increasing entry of mining rejects, which has reduced the healthy and highly productive estuarine environment of into an impoverished biotope, which unless prevented will result in the total extinction of estuarine life in the near future.

Due to heavy monsoon the ore rejects get washed and transported downstream by strong bottom currents. The mining rejects settle in the benthic environment of the estuarine system, thus blanketing the bottom deposits. A substantial damage of benthic system is also caused by the excavation and extraction of sand by dredging from the riverine belt. The studies spatial and temporal studies carried out by Zakir A Ansari and S.A.H Abidi (1993) had revealed that the deposition of red clay particles from iron ore rejects in the estuarine system present both in suspension as well as settled on the bottom and the massive inorganic inputs in the form of mining rejects had resulted in considerable reduction of benthic community. This leads to severe environmental stress on biological parameters of density, biomass and diversity.

As per the studies carried out by National Institute of Oceanography there are about 10 large mines in the estuarine basin which generate 1000 to 4000 tons of iron ore rejects per day per mine of which a good portion is expected to reach the Goa estuary.

Fig. 5.5 : Iron ore rejects at loading station

Fig. 5.6: Transportation of Iron ore by barge

5.3.1 Impacts on Air Quality

The existing levels of air quality in the mining regions of Goa as per the air quality monitoring from different studies conducted by agencies like IBM, CMRI, TERI, CPCB etc., are discussed. The annual average total dust “Suspended Particulate Matter (SPM) and “Respirable Particulate Matter” (RPM) concentration observed in the ambient areas in the region were 323 µg/m^3 and 117 µg/m^3 respectively. The maximum SPM and RPM concentration observed in the ambient, was 1615 µg/m^3 and 518 µg/m^3 during summer season. The annual 98 percentile values of SPM and RPM were calculated to be 992 µg/m^3 and 381 µg/m^3, respectively. The annual variation of SPM & RPM is shown below in the graphs (Figs 5.7 and 5.8).

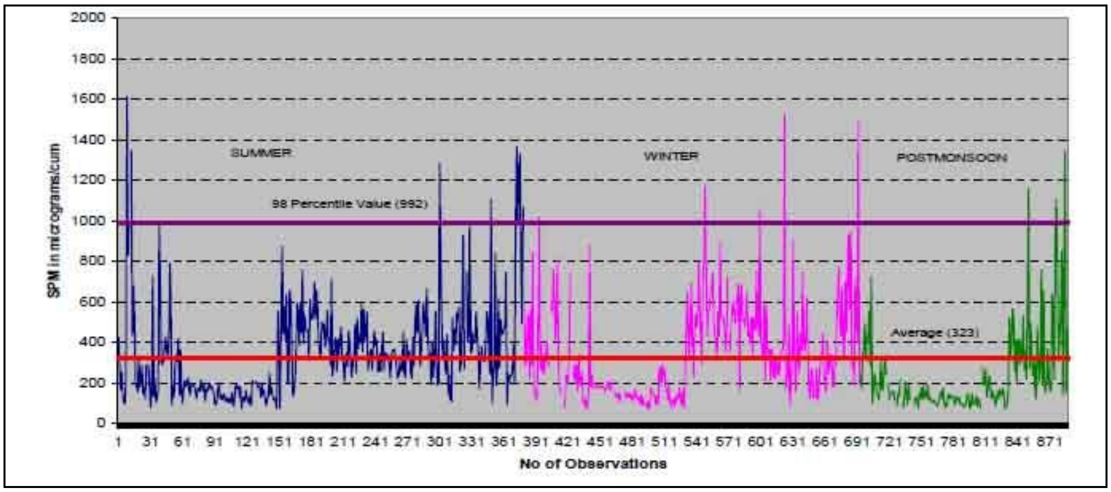


Fig. 5.7: SPM Variation during different seasons at mining area in Goa
(Source: CPCB, 2007)

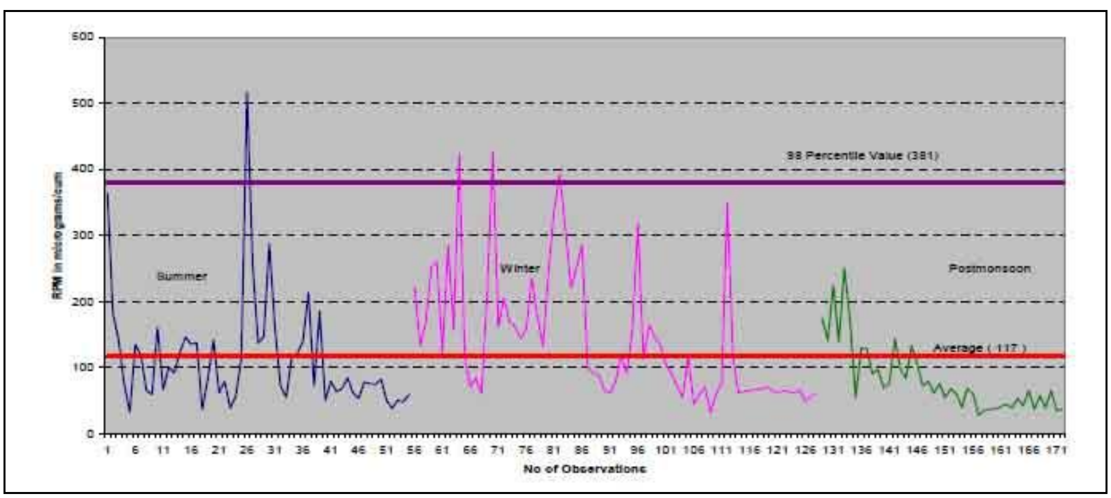


Fig .5.8: SPM Variation during different seasons at mining area in Goa
(Source: CPCB, 2007)

The concentration of SO_2 and NOx were observed to be insignificant, though the maximum value of SO_2 and NOx were 99 µg/m^3 and 67.5 µg/m^3 during winter and summer, respectively. The annual average value of SO_2 and NOx were 14 µg/m^3 and 9 µg/m^3, respectively. Lead and CO in ambient air was also found to be insignificant. The annual variation of SO_2 & NO_x is shown below in the graphs (Figs 5.9 and 5.10).

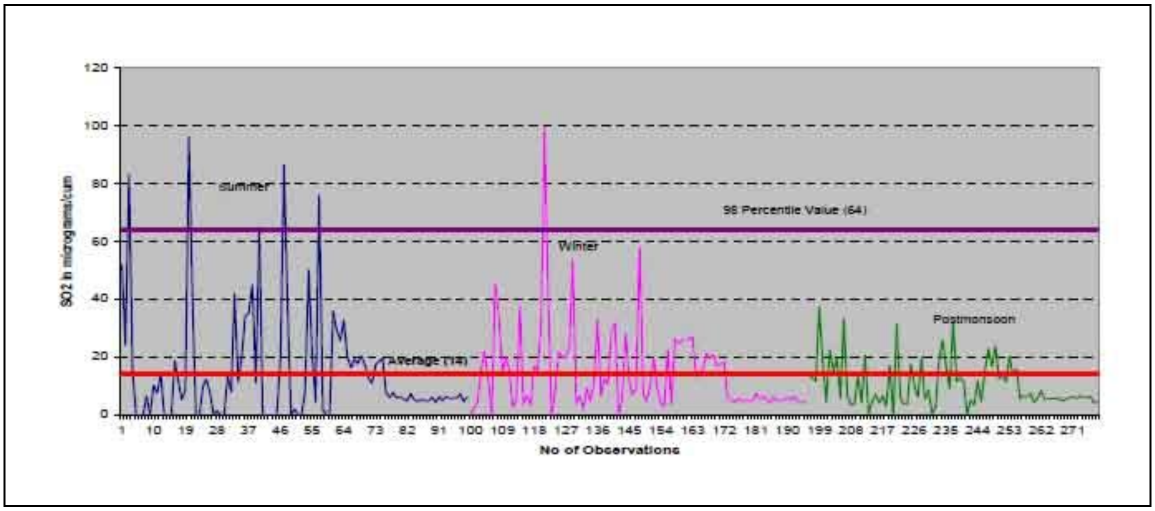


Fig. 5.9: SO_2 Variation during different seasons at mining area in Goa
(Source: CPCB, 2007)

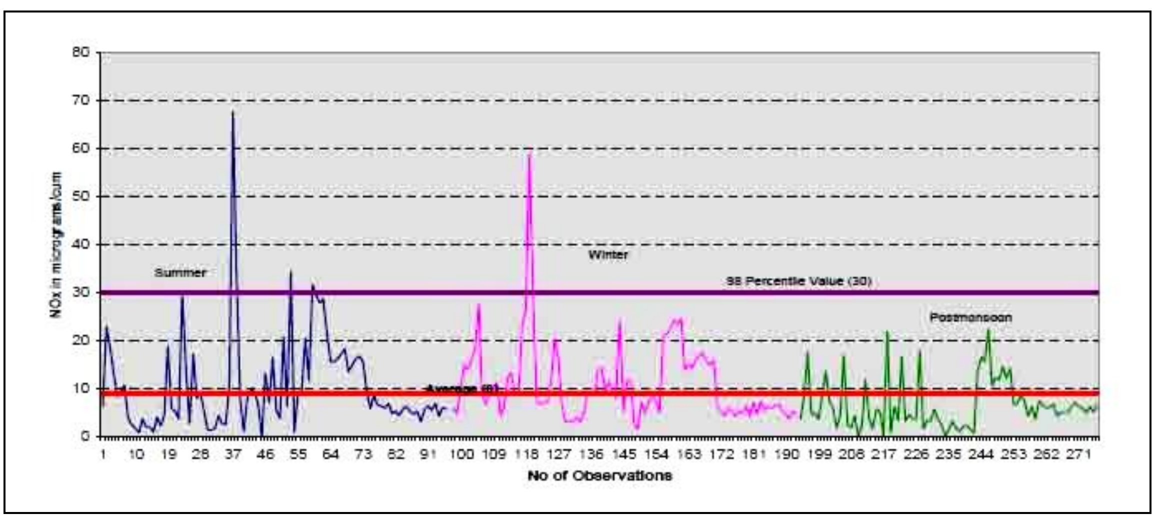


Fig. 5.10: NO_x Variation during different seasons at mining area in Goa
(Source: CPCB, 2007)

5.4 ENVIRONMENTAL MANAGEMENT PLAN

5.4.1 Pollution Prevention and Control

Pollution prevention and controls are needed to be incorporated during the design phase of the mine operation. The underlying principle for effective pollution prevention and control is to contain contaminants on the site itself. This can include covering chemicals, avoiding unplanned equipment maintenance, etc. Air quality controls include the use of water tankers for dust suppression, water sprays on conveyors and ore stock piles, controls on blasting and limiting freefall distances while stockpiling the ores and overburdens. The design and maintenance of haul roads and navigational routes is also an important consideration in dust control. Similar control measures need to be integrated to each operation of the mine during the planning stage. Control measures are to be implemented at jetty locations along the waterways. One of the critical factors in successful pollution prevention and control is through proper training of the workforce. It is no matter how sound the plant designs or committed the mine management, and management of the transport corridors, ultimately environment protection can only be achieved with the understanding and commitment of the every person involved in ore mining and transportation net work. An untrained or thoughtless dumper operator can cause significant harm and expose the environment to severe pollution.

5.4.2 Biophysical Impacts

Climate, soils and the rehabilitation strategy are important considerations in minimizing impacts on native flora and fauna. Soil erosion can be minimized by a proper understanding of soil structure, conservative landform design, utilizing complex drainage networks, incorporating runoff silt traps and dry detention ponds in the rehabilitated landform. A dry detention pond is designed to hold water over a short period and allow its later controlled release. Careful use of topsoil can promote vegetation cover if the topsoil material is structurally appropriate and contains propagates of native vegetation. Selection of native floral species can be desirable in promoting a stable and robust vegetation cover. Where possible, species endemic to the area should be used, preferably those from the site itself.

5.4.3 Socio-economic Issues

Mining of iron ore affect the local and national economics in a variety of ways. Mines are built to exploit the mineral resources of the country to provide economic benefit to the community and the government, while earning profit for the share holders of the mining company. Some people will get direct benefit via the creation of employment and business opportunities, while other people may feel aggrieved by the project proceeding. Where communities exist at a potential mine site, mining impacts on the host environment can significantly influence community attitude to the operation. Measures are available to promote positive aspects of mining while recognizing and addressing potentially adverse side effects. This applies to community infrastructure, employment and land use planning.

5.4.4 Environmental Monitoring

Ongoing operational environmental monitoring provides factual information to test environmental performance, demonstrate compliance with environmental legislation, refine operational practices and safeguard the interests of both the mining company and the surrounding community. A well conceived monitoring programme must give attention to what is being measured and the ultimate use of the data. Monitoring within the mine site can be checking source emissions, but it gives little information on the environmental effects on surrounding communities and the region. Environmental monitoring, including physical, chemical and biological elements, needs to be extended to areas that may be affected around the mine site and transportation corridors.

5.5 ENVIRONMENTAL MITIGATION MEASURES

Most of the major big mining companies like M/s Sesa Goa and M/s Dempo are taking proper care for the dust suppression inside the mines. As the drilling and blasting in the mines are limited only during the monsoon, the dust generations are limited to the fair weather because of transportation and beneficiation (dry process). During excavation, the dust generation is much less because of high in-situ moisture content in the ore itself. Fixed water sprinklers are installed by the side of the road to suppress the ore laden air as shown in Fig. 5.11. The haul road dusts are normally being suppressed by using normal hired water tankers by the companies as shown in Fig. 5.12.

The drilling machines of M/s Sesa Goa at their Codli mines were fitted with proper and effective wet drilling arrangements. But, still dust generation is identified as a key issue, and is mainly due to the clustered nature of the mines, the narrow uncovered gravel roads and the fact that ore is transported in open trucks normally of 10 ton capacity running thousands of round-trips per day between the mines and the beneficiation plants or loading points. This causes a direct nuisance for the nearby villagers. The situation is worse in the mining area of north Goa in comparison to South Goa.

It is reported that the use of covered trucks to transport iron ores in the public road as shown in Fig. 5.13. Similar coverage of the iron ore is also required to be extended to barge transportation units. The measures taken by some mines operating in North Goa to suppress dust by spraying water some time worsen the situation by making the roads slushy and slippery. The maintenance of these roads is also generally poor. The problem is most alarming in the 6 km stretch of Guddemol-Capxem road handling 5.4 million tonnes of ore and the 8 km stretch of Sanguem-Curchorem road. The major cause of dust generation is overloading and over speeding of trucks. As per the estimates of TERI (AEQM, November 1997), the estimated annual ore spillage is 1385-2770 tonnes per year for handling of 5.4Mt of ore in the Codli-Sanvordem stretch and a consequent fugitive dust generation of 139 – 277 t/year (7.4 – 12.3 g/s), leading to an ambient dust concentration of 850 – 1500 $\mu g/m^3$ in the surrounding areas. In the Ugem-Xelvona stretch, the ore spillage is estimated to be 655-1310 t/yr for handling 1.5Mt of ore, and dust generation of 66 – 131 t/yr (3.5 – 5.8g/s) leading to a dust concentration of 400 - 500$\mu g/m^3$.

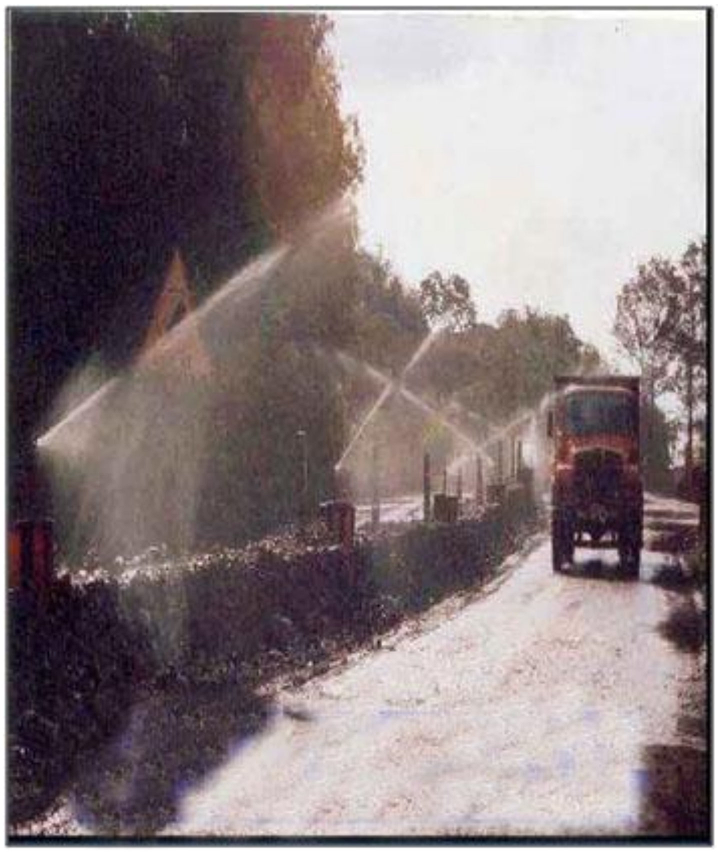


Fig. 5.11: Fixed Water Sprinklers alongside the road as dust suppression measures

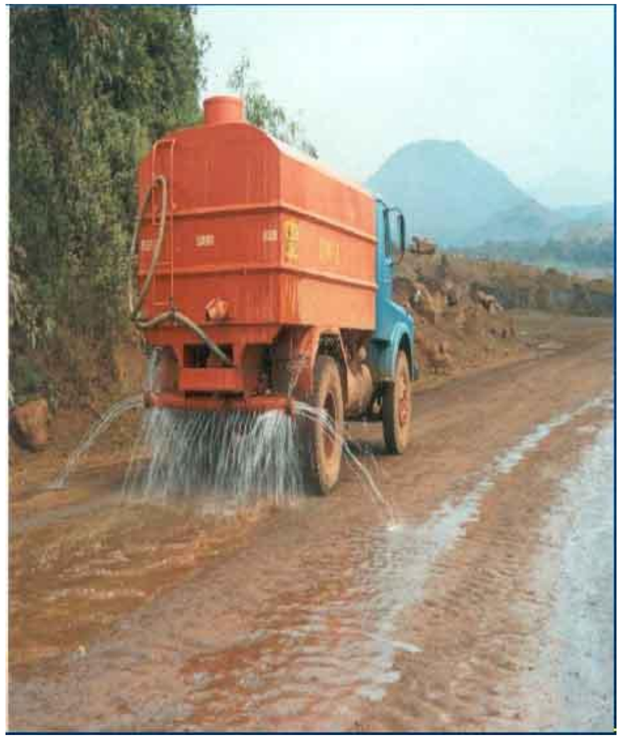


Fig.5.12: Suppress the road dust by sprinkling water

Fig. 5.13: Coverage of the iron ore with tarpaulins

5.6 ENVIRONMENTAL ASSESSMENT OF IMPACTS DUE TO WATERWAY DEVELOPMENT WORKS

5.6.1 INTRODUCTION:

The environmental assessment of the project the potential impacts on the natural environment as well as physical impacts on the human population. The assessment involves laboratory testing and the review of available documentation on the local environment. The physical impact of operation of the waterways on local population has been also taken into care. Such impacts includes destruction of bunds and protect agricultural fields due to erosion caused by the wash created by passing vessels specially in Cumberjua canal where width of canal is less.

This Chapter deals with anticipated positive as well as negative impacts due to the implementation of the recommendations of the proposed DPR of the project waterways.

5.6.2 IMPACTS ON LAND ENVIRONMENT

a) Collection & testing of Soil samples of project waterways

Requisite nos of soil samples collected from the project waterways during field investigation period i.e. January,2011 and get tested for the environmental parameters and enclosed in Annexure . The results shows that pH is about 8 in all the waterways, which reflects that soil is saline in nature.The samples were also tested for available Nitrogen, Sodium, Calcium,Magnesium Potassium, organic matter, electrical conductivity and for total phosphate (PO4). However in the analysis the consultant has also reviewed the available reports and published data in the present context of the study.

b) Implementation phase

Impacts during project execution stage

Pre-construction activities generally do not cause significant damage to environment. Preparatory activities like the use of existing access road, construction of storage sheds, etc. being spread over a large area, would have no further significant impact once the land is acquired and its existing use changes. Clearing, stripping and leveling of sites, construction of bunds for protection from flooding for bank protection works, earth filling and dredging of river / canal bed, will lead to some disturbance to the habitat. Since, the proposed project site is spread in large area, hence during the execution activities in the proposed project area is of such level and nature, to cause significant adverse impact on this account. The natural drainage in the area is such that the entire water would outfall in the waterways. This could lead to marginal increase in turbidity levels. However, based on experience in similar projects, this impact is not expected to be significant.

a) **Operation phase**

Generation of garbage at the iron ore terminals

The problem envisaged during operation phase could be the disposal of garbage or solid waste generated from various sources. The various sources of solid waste are the waste various berths and the project office. The solid waste generated from various sources shall mainly comprise of floating materials, packaging, polythene or
plastic materials, etc. Therefore, a system needs be devised whereby undue quantity of garbage is not permitted to accumulate in the project area and the same could be disposed off at designated sites in a proper manner.

5.6.3 WATER ENVIRONMENT

a) **Collection & testing of Water samples of project waterways**

Requisite nos of water samples collected from the project waterways during field investigation period i.e. January,2011 and get tested for the environmental parameters and enclosed in Annexure . The results shows that pH varies 6.6 to 7.3 in the project waterways, which reflects that water is neither saline nor alkaline in nature. The samples were also tested for alkalinity ,TSS ,TDS, Sulphate as SO4,Chloride,Fluoride,Nitrate as Nitrogen, Total Iron, Dissolved Oxygen, Calcium, Magnesium Sodium, and for total phosphate (PO4). However in the analysis the consultant has also reviewed the available reports and published data in the present context of the study.

b) Project Execution phase

Impacts due to effluents from labour camps

The average and peak labour strength likely to be deployed during construction phase of the proposed construction activities / dredging activities will be about 100 and 200 respectively. There are quite a few villages situated in vicinity of the project area. It is assured that the labour force engaged by the contractor could come from outside areas. It is assumed that about 50% i.e. 100 labourers will stay in labour site camps close to the project site. The balance labour population would come from nearby settlements. Based on this the total water requirement for the labour population congregating in the area for the execution of the proposed project that will stay during the construction phase
are estimated as below:

- Peak labour strength : 200
- Labours likely to stay at construction site (50%) : 100
- Married families (75% of 100) : 75

- Single : 25
- Husband and wife both working (75% of 75) : 38
- Families (38/2) : 19
- Families where only husband is working (50% of 19) : 10
- Family size (assumed) : 5
  Total number : 19x5+10x5+25
- =170 --- (A)
- Add 5% for the persons who will be service provider : 9
- like shops, repairing facilities, etc.
- 50% of service providers will have families : 5
- Total number : 5x5+5=30 --- (B)
- Total population (A+B) = (A + B) = 170+30=200

Water requirement: 70 lpcd
Total water requirement: 14 m3/day

About 200 labours would stay at the construction site, only during working hours. The water requirement for such labour shall be 9.0 m3/day @ 45 lpcd. Thus, total water requirement works out to (14.0 + 9.0) about 23 m3/day.

The sewage generated is normally taken as 80% of the total water requirement i.e. (0.8 x 23) 18.40 m3/day. The domestic water normally contains high BOD, which Needs proper treatment and disposal, otherwise, it can have an adverse impact on the DO levels of the receiving body.

The disposal of sewage without treatment can cause problems of odour and water Pollution which ultimately confluences into the waterways. However, these natural drains are seasonal in nature and are likely to remain dry in the non-monsoon months. During this period, the flow of untreated sewage from the labour colonies in these drains can lead to development of anaerobic conditions, with associated water quality problems.However, in the present case it must be mentioned that the total quantity of sewage (23 m3/day) generated by the labour during construction phase is quite small and is not expected to cause any adverse impact on the marine water quality. However, it is proposed to treat the sewage from labour camps before disposal.

. **Water requirement for domestic use**

The water requirement for domestic use includes requirement for drinking, cleaning, etc. in the project area. Assuming a population of 100 in the project waterways area at peak hours and per capita water requirements of 75 lpcd, the total water requirement works out to 7.5 m3/day. The sewage generation shall be of the order of 6 m3/day.Suitable measures for treatment of sewage shall be commissioned,

5.6.4 IMPACTS DUE TO DREDGING

The tentative volume of dredging works out to be waterway wise is as follows

1. Mandivi river
2. Zuari river
3. Cumberjua Canal

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The potential environmental effects of dredging can be categorized as impacts due to dredging process itself and those due to disposal of the dredged material. During the dredging process effects may arise due to the excavation of sediments at the bed, loss material during transport to the surface, overflow from the dredger whilst loading and loss of material from the dredger and/or pipelines during transport.Various potential impacts are outlined in the following sections:

Impacts on benthic organisms

During all dredging operations, the removal of material from the river/canal bed also removes the animals living on and in the sediments (benthic animals). With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in complete removal of animals from the excavation site.

In areas to be covered under dredging well-developed benthic communities are not expected to occur in or around the area. Since, the significant macro-and meio-fauna is not developed in the area, hence dredging is not expected to lead to significant adverse impacts.

The recovery of disturbed habitats following dredging ultimately depends upon the nature of the new sediment at the dredge site, sources and types of re –colonising animals, and the extent of the disturbance. In soft sediment environments recovery of animal communities generally occurs relatively quickly and a more rapid recovery of communities has been observed in areas exposed to periodic disturbances, such as maintained channels. Thus, in area under maintenance dredging in subsequent years, the recovery of benthic organisms is not expected to be significant.

Impacts on Suspended sediments and turbidity levels

When dredging and disposing of non-contaminated sediments, the key impacts are the increase in suspended sediments and turbidity levels. Any dredging method releases suspended sediments into the water column, during the excavation itself and during the flow of sediments from hoppers and barges.

Increase in suspended sediments and turbidity levels from dredging operations may under certain conditions have adverse effects on marine animals and plants by reducing light penetration into the water column and by physical disturbance. The increase is likely to last for a period of 10-15 days after the cessation of dredging activities. This trend is noticeable under flood as well as ebb conditions.

Increased suspended sediments can effect filter feeding organisms, such as Shell fish, through clogging and damaging feeding and breathing process. Similarly, young fish can be damaged if suspended sediments become trapped in their gills and increased fatalities of young fish have been observed in heavily turbid water.Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites.

The increase in turbidity results in a decrease in the depth that light is able to penetrate the water column which may affect submerged plants, by temporarily reducing productivity and growth rates. Since, the benthic fauna is moderately
developed in the areas, hence impacts on this account are not expected to be significant. The degree of resuspension of sediments and turbidity during dredging and disposal depends on:

- Sediments being dredged (size, density and quality of the material),
- Method of dredging (and disposal),
- Hydrodynamic regime in the dredging and disposal area (current direction and speed, mixing rate, tidal state), and
- Existing water quality and characteristics (background suspended sediment and turbidity levels).

In most cases, sediment resuspension is only likely to present a potential problem if it is moved out of the immediate dredging location by tidal processes. In general, the effects of suspended sediments and turbidity are generally short term (<1 week after activity) and near-field (<1km from activity). These are of concern only, if sensitive species are located in the vicinity of the maintained channel. Since, no sensitive species are observed in the areas to be dredged, hence, no adverse impacts are anticipated.

Impacts on water quality

Redox potential (eH) and pH are two variables that control the characteristics of chemicals and heavy metals in water and sediment. As long as the pH remains around 8 and eH < 150 mV , most of the chemicals and metals will remain bound to the solid phase without being released into the surrounding water. Only anoxic conditions reduce the eH below this level and hence if dissolved oxygen level is within the normal range, no leaching of chemicals and heavy metals is expected to occur.

In the present project sites pH is around 6.6 to 7.3 and dissolved oxygen was 6.0 -8.5 mg/l which is normal for a ecosystem where there are no sources of pollution. Dissolved oxygen levels are not reduced to anoxic conditions until and unless there is significant increase in organic pollution loading. In future, significant increase in organic pollution loading is not expected. Under these circumstances, there is no possibility of any of the chemicals or metals being leached into the water. Moreover,sediment samples collected from all the sites were uncontaminated. As such no adverse impact due to dredging on the chemical characteristics of water or sediment is expected.

Impacts due to dredging and disposal of organic matter and nutrients

The release of organic rich sediments during dredging or disposal can result in the localised removal of oxygen from the surrounding water. However, removal of oxygen from the water is only a temporary phenomenon, as tidal exchange would quickly replenish the oxygen supply. Therefore, in most cases where dredging is taking place in open coastal waters, this localised removal of oxygen has little, if any,effect on marine life.

Impacts due to contaminated sediments

Another possible impact is the release of toxicants from the sediment if the sediment is contaminated. In the case of contaminated sediment acute toxicity, chronic toxicity and bioaccumulation are the possible effects. But all these are short-term and insignificant and no serious effects have been reported from any earlier instances or experimental studies. In all the sites surveyed, the sediment samples analyzed did not show the presence of any appreciable levels of contamination and hence may not pose any such problems.

Impact on phytoplankton and primary productivity

Biomass of phytoplankton depends mainly on the availability of light in nutrient rich waters. Dredging and disposal may lead to increased turbidity and consequent reduction of light penetration for short periods. This may affect primary productivity and plankton biomass. However, turbidity due to dredging and dumping will be observed only in a localised area and only for a very short duration. Hence these impacts are not expected to be significant in nature.

Impacts on benthos

The dredging and dumping generally affect the benthos. These are related to removal of the benthic organisms from the dredging site and burial of benthic organisms at the dumping site. The dredged material takes away most of the benthos along with it and while dumping it most of the organisms present are buried under the deposited material. This will result in reduced number and diversity of benthic organisms at the dumping site. However, earlier studies show that the dredged site will be colonized by benthic organisms within a very short time. Benthic fauna did not contain any rare or endangered species and consisted of common species only. It can be expected that these species will colonize within a short time from dislodging.

Impacts on fisheries

The most important impact on fishes may be suspended solid load or changes in the food chain. The high turbidity due to heavy suspended solid load during dredging or disposal of dredged materials results in clogging of gills of fishes thereby causing asphyxiation. But since fishes are free swimming they very well avoid such areas and move to safer areas. Once the turbidity is over due to currents, they come back to the area. Due to this capability of the fishes there is no significant adverse impact on fishes and fisheries is expected on fisheries as a result of dredging. Moreover, in the proposed area including the marine area proposed to be dredged, fisheries are not very well developed. Hence, significant adverse impacts are not anticipated.

(c) Operation phase

Impacts due to iron ore handling

Iron ore handling operations lead to entrainment of dust, which can have an adverse impact on ambient air quality. In the proposed project, the iron ore will be loaded unloaded through barge loaders and unloaders. . Thus, entrainment of iron ore dust during barge loading and unloading shall be minimal.

5.6.5 IMPACTS ON ECOLOGY

The direct impact of during project execution activity is generally limited in the vicinity of the project execution sites only. The project execution sites include villages, towns , cities, agricultural fields and forest areas. Since there is no major construction activities , hence, no significant impacts are envisaged on terrestrial flora as a result of the proposed project.

5.6.6 IMPACTS ON SOCIO-ECONOMIC ENVIRONMENT

The process of social assessment encouraged informed public participation in project planning including involvement of the potential project affected groups and local Governments bodies. The assessment results were considered with technical and economic feasibility findings in the final determination of waterway improvements.The assessment also contribute to the preparation of social action plans governing project implementation and the mitigation of adverse social impacts.

CHAPTER - 6

PROJECT APPRAISAL

6.1 BACKGROUND

Goa has witnessed a growth in Iron ore industry heralded with a quantum jump in exports during the last ten years. Iron ore mining is currently the major attractive industry and is concentrated along north and south Goa spanning about 700 sq km area spread along the banks of rivers Mandovi and Zuari.

The Goan iron ore industry is wholly dependent on exports. All the iron ore produced in Goa is exported to China, Japan, Korea, Taiwan and some European countries. This is because the iron ore produced from Goa is less suitable for steel production (lower the iron content and higher the quantum of fines) in the country at the present level of technology. Goa produces comparatively of low grade iron (Fe content ranges from 50% to 62%) which requires elaborate process of beneficiation is required to make it fit to use by the steel industry. But there is a huge demand for Goan iron ore globally as it is often used as a product blend to make up for the optimal Silica. Due to lack of technology in India to use iron ore fines, the mine operators / exporters prefer to export to other countries where there is a demand.

Moreover, Goa uses the logistic advantage of inland water transport to move iron ore from mines to the nearest ports for export. The cost of transporting ores to ports by inland waterways works out to be a more efficient and less expensive mode of transportation when compared to by rail and road. Thus IWT provides cost competitiveness to exports of even low Fe content / fines of iron ore.

6.2 IRON ORE MARKET ANALYSIS

6.2.1 Iron ore demand

Recent economic development drives steel demand in the world market, and thus demand for its raw materials. Scrap availability and technology choices determine the final demand for the various iron ore products. Demand for seaborne ore tends to grow at a faster rate than total ore demand, due to quality and availability issues of local ores, particularly in China.

In the last decade, the industry consolidation in the seaborne iron ore market has increased significantly. As a result, real prices have been constant, as opposed to average real annual price declines of 2% – 3% during most of the eighties and early nineties.

6.2.2 Iron Ore Demand Analysis

Demand for Steel: Steady growth of steel demand is expected until 2025. Critical assumptions are:

The Chinese economy has been continuing to grow (but slower than currently) at a healthy rate until 2009 – 2010. Post 2010 growth rates in the 4% – 6% range were assumed, similar to those observed in Japan, after its phase of rapid economic expansion. The urbanisation rate in China of 1% p.a. is foreseen to be sustained for the next 20 – 25 years.

Relatively slow economic growth in the developed world is anticipated, with negative implications for steel consumption, due to relocation of manufacturing capacities to emerging markets.

No major "world-wide" crisis that would either destabilize the economy of the developed regions or induce a 'hard landing' for the Chinese economy.

No immediate 'boom' of the Indian economy is expected, but a rather moderate short- and medium-term growth path, only taking off beyond 2011.

Continued moderate growth in Common Wealth of Independent States (CIS) and South America, not assuming any major setbacks in these regions, was assumed.

Demand for Iron Ore: The iron ore market is expected to remain attractive in the next two decades, based on positive underlying fundamentals. These include steady growth of iron ore demand at least up to 2020 (about 30% increase from today's levels), particularly in the seaborne market (growth of more than 45%). China will represent close to 50% of total iron ore demand in 2025 (up from 31% in 2004). In 2004, China accounted for 34% of the 600 m t seaborne demand. Eventually, the market becomes predominantly Chinese, representing close to 80% of total seaborne demand of 880 m t in 2025.

One of the key factors boosting the iron ore market is a developing scrap shortage. The ratio of scrap to finished steel has reduced over the last years to a low of 46% versus historical levels of 50% – 55%. These lower levels should prevail until 2015 – 2020. This long period of relative scrap shortage will help to fuel an iron ore boom. As of 2015 – 2020, more scrap is expected to become available again which will limit further iron ore growth.

6.2.3 Iron Ore Supply Analysis

What had been mostly the terrain of relatively cheap brown fields' expansion for two decades, now demands significant green fields expansions. This capacity expansion is expected to be led by the three largest producers (CVRD, Rio Tinto and BHP-Billiton), who will continue to use the modularity and flexibility of their production systems to avoid overcapacity coming in and putting undue pressure on prices. The largest producers are also uniquely involved in price setting and have long-term volume contracts with major customers, creating entry barriers for newcomers.

The combined (controlled or influenced) market share of the three dominant producers is projected at approximately 75% to 2025; today they also control over 80% of the relevant port capacity, as well as 6 out of 7 major railway systems. The CIS is also expected to play a major role in the supply of iron ore/metallics. As far as iron ore exports are concerned, the CIS is expected to focus only on pellets for the European market. In order to fully capture this market, and at the same time satisfy growing local demand (CIS steel consumption and steel exports), CIS will need to increase iron ore production by 30 – 50 m t between 2004 and 2025, without increasing its deep-sea exports.

India could increase iron ore production in the medium term from 135 m t in 2004 to around 160 m t in 2010. As a result, seaborne exports will increase to 80 m t in 2010 (up from 65 m t in 2004). Beyond 2010, seaborne exports are expected to strongly decrease, as the Indian Government wants to preserve iron ore to the maximum for the domestic steel industry, serving local and export demand. This decline could come even earlier if the Government starts enforcing environmental and other mining-related legislation.

The current high iron ore prices might lead to short term increases in Chinese domestic iron ore production (and hence reduce Chinese seaborne demand). In the longer run, a decline in domestic ore production is projected. China will become more and more dependent on seaborne iron ore due to the increase in iron ore needs on one hand and limited economically viable domestic reserves on the other hand. As a result, overall share of domestic ore over total ore consumption in China is expected to drop from about 50% in 2004 to some 20% in 2025.

Increasing vertical integration by major steel makers (e.g. Mittal), leading to somewhat reduced seaborne demand, is forecast in the longer term.

6.2.4 Iron Ore Supply and Demand Balance

The currently announced and fully committed expansion plans should be sufficient to satisfy the expected increase in demand up to 2010 – 2012. Longer term, there is a need for new green fields iron ore systems. From a logistics, operational cost and quality point of view, projects in Australia, Brazil and Africa (both South and West) are most likely. None of these “second expansion wave” projects are likely to be realised before 2012, due to infrastructure limitations or geo-political risks.

6.2.5 Iron ore price forecasts

The factors affecting iron ore prices are:

- Grades of Iron Ore
- Export Demand for iron ore
- Steel industry growth
- Sea Freight rates
- Govt. Regulations (EXIM and Mining)
- Big Players(Big -Trio) Decision in Pricing Mechanism
- Growth of BRICI

In economics, BRICI is a grouping acronym that refers to the countries of Brazil, Russia, India, China and Indonesia, which are all deemed to be at a similar stage of newly advanced economic development.

In the 1960s and early 1970s, under the impetus of materials-intensive Japanese economic expansion, iron ore prices increased well above inflation rates, as new capacities were required to satisfy Japanese iron ore demand. Most likely, a similar scenario will develop, now driven by Chinese demand.

Historically, iron ore price levels correspond to 'incentive pricing' levels with regard to industry cost curves, allowing existing players to earn attractive returns on brown field expansion projects. Recently, both spot and contract prices have 'detached' from the cost curves, which is considered a short-term anomaly. Current high price levels, driven by short-term supply constraints, should be short lived and should come down in the near term to more economic price levels, to avoid overcapacity build-up. The full green field cost of new potential iron ore systems (e.g. West Africa and Australia) has increased recently due to the current commodity price boom and the consequent equipment and skill shortages (at least for the short and medium term).

Now iron ore is priced according to an index (of which there are a few: Metal Bulletin and Platts both maintain them), the most popular of which is the 62% China CFR (cost and freight) which is most commonly viewed as the closest to an iron ore 'spot' price. There are two other popular indices, the lower grade 58% index, and the index for higher grade 63.5% Indian fines. Both are quoted in a similar fashion to the 62% index as CFR China. A Typical iron ore pricing chart for 62% and 58% of 'Fe' in the world market (China) is shown in Fig. 6.1. The Indian iron ore price quoted in the market is around US $ 180 in January / February 2011. This includes ocean freight. The freight from India to China is around US$ 40/ton. Australian ore fines with 62 percent iron content were quoted during the same period at US$ 176 – US$ 178 a ton, including freight. The ocean freight from Brazil to China is around US$ 80 / ton.

Fig: 4.1 A typical Iron ore pricing chart in the world market (China market)

It has always been clear that for a product of variable quality, a variable price will be received, and annual contract negotiations took this into account. What have changed with the move to index-driven prices are the dynamism of the received price (which now moves daily rather than annually) and the transparency of this mechanism. Whereas previously the contracted prices were well kept secrets, we can now extrapolate a received price for a product in relation to the index if we know the product specifications (or at least make a good estimation).

Iron ore with Fe content more than 65% are categorized as high grades while those with Fe content less than 62% are categorized as low grades. Goa's iron ore is comparatively low grades (Fe content ranges in between 50% to 62%). Goa ore being more friable generates a higher quantum of fines. An elaborate process of beneficiation/concentration is required to make it fit to use by the steel industry. Goan ore does not have enough Fe content to justify a steel plant based on it. Finally there is a huge demand for Goan Ore globally as it is often used as blend to make up for the optimal Silica, Alumina content with ore from other parts of the world.

6.3 GOA'S ECONOMY

Goa's economy has undergone a considerable structural change after its formation in 1987, more specifically after 1999-2000. The estimates of Gross State Domestic Product (GSDP) and the Net State Domestic Product (NSDP) of Goa based on recent Economic Survey of Goa (2009-10) are shown in Fig. 6.2. The GSDP and NSDP at constant prices and current prices of the state can be seen in the above figure. The GSDP at constant prices has registered a compound annual growth rate of 7.5% during the period 1999-2000 to 2008-09 while the GSDP at current prices is 13.5% during the same period. The GSDP starts spurting from 2005-06.

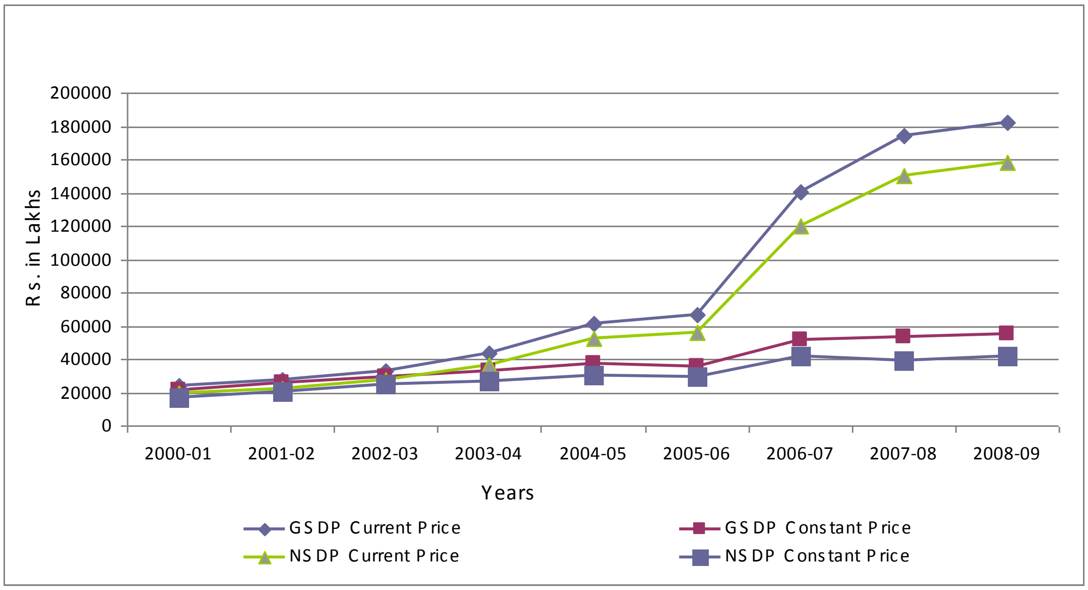

Fig. 6.2 : The GSDP and NSDP of Goa State
(Source: Economic Survey 2009-10, Government of Goa)

The industry sector recorded a constant growth in the share of GSDP at current prices, from 38.6% in 1999-00 to 52% in 2007-08. Within the industry sector, it is surprising to observe that the increase in share of the 'mining and quarrying' sector that recorded a significant increase after 2003-04 as shown in Fig. 6.3. Its contribution of 4.1% in 1999-00 grew marginally to 4.7% in 2003-04. However, by 2007-08 its share jumped up to 10.1%. This increase is due to increase of iron ore demand and its prices in the international market.

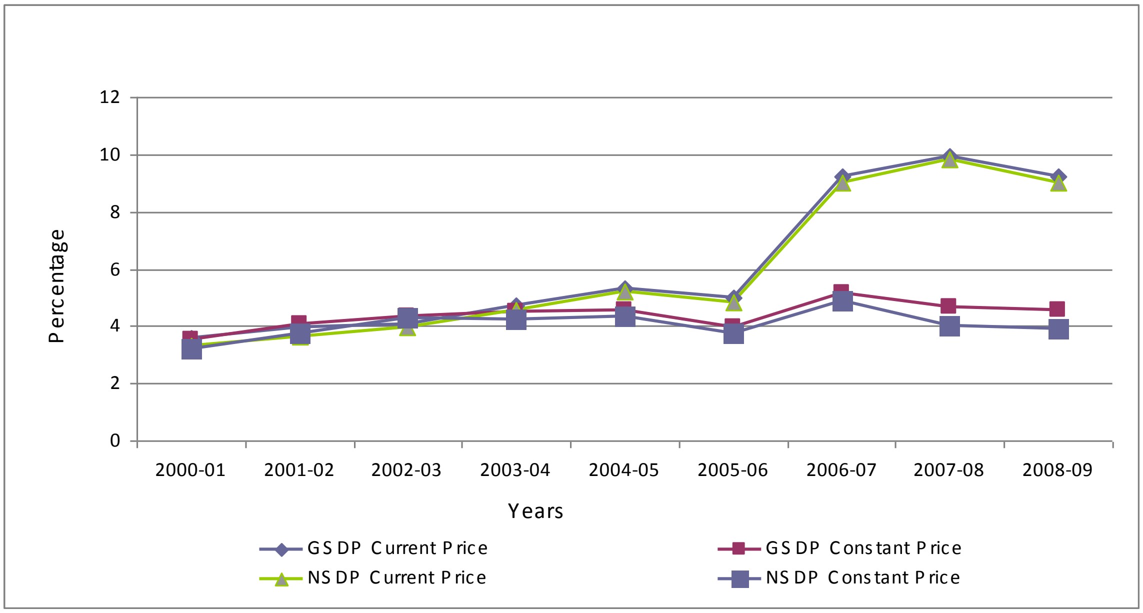

Fig 6.3: Percentage share of 'Mining and Quarrying' industry in GSDP of Goa

(Source: Economic Survey 2009-10, Government of Goa)

6.3.1 Iron Ore Industry Contribution to Goan Economy

The iron ore industry to the Goan economy has been the second most import industry next to tourism industry. Its contribution to Goan GDP, export and employment has been substantial. The contribution of Iron ore industry to Goan economy particularly during the last 10 years period is phenomenal due to world market demand with special reference to China. Though there is a market demand, the exports of iron ore from Goa vary annually due to various factors of transport logistics viz., loading, unloading, barge net work, repair facilities of barges, waterway conditions etc. Hence, the annual predictions of iron ore export are volatile and subject to not only market driven but also existing transport logistics. The five yearly averages of export figures may closely represent the true scenario. The actual five yearly average exports and the projected figures are shown in figure 6.4.

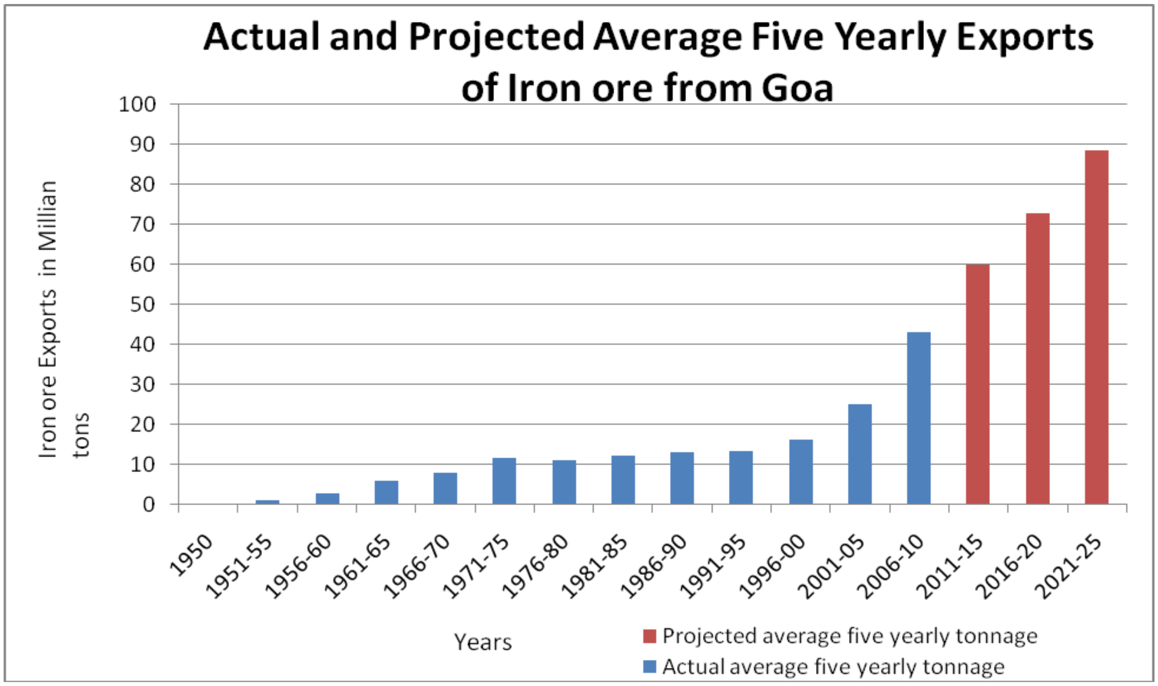

Fig.6.4 Exports of Iron ore from Goa since 1950

6.4 COST BENEFIT ANALYSIS - GOA'S IRON ORE INDUSTRY

Cost-benefit analysis (CBA), sometimes called benefit-cost analysis (BCA), is an economic decision-making approach, used particularly in government and business. CBA is used in the assessment of whether a proposed project, programme or policy is worth doing, or to choose between several alternative ones. It involves comparing the total expected costs of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

In CBA, benefits and costs are expressed in money terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their "present value." This is often done by converting the future expected streams of costs and benefits into a present value amount using a suitable discount rate.

6.4.1 Revenues

Taxes paid by the Goa mining industry

Iron ore industry contributes a significant amount to the State and Central revenue in the form of taxes. In the year 2008-09, Central government collected over Rs 1,600 crores from corporate tax, Rs 250 crores export duty (paid @ 5% towards fine and 10% to lumps, effective only in April 29, 2010) from Goa's mining and quarrying industry as shown in table 6.1. In the same year, the industry paid a total tax of Rs. 500 crore to the State government in terms of Royalty paid at 10% ad valorem tax plus barge tax, road tax and road infrastructural cess. Royalty paid to state government is around Rs 250 per ton.

According to GMOEA up to February 2011 (2010-11), the state government had earned an unprecedented INR 763 crore in royalty on iron ore exports. It may touch INR 900 crore by March 31st 2011.

Table: 6.1 Taxes paid by Mining Industry to State and Centre

Details of taxes	Amount (Rs crores)
	2008-09
a) Central Government	
Export duty at 5% towards fines and 10% to lumps	250
Corporate tax	1,600
Major port charges (Mormugao port)	150
Sub total (a)	2,000
b) State Government	
Royalty paid at 10% ad valorem tax	300
Barge tax	12
Road tax	12
Road infrastructure cess	50
VAT, CST	50
Others (Minor port, Panchayats, Deadrent, Surface rent etc)	76
Sub total (b)	500
Total (a+b)	2,500

The NCEAR has made an assessment exclusively for Mining and Quarrying industry's contribution in Goa to corporate tax considering corporate tax differential. The corporate tax differential is obtained as difference of tax that the firms pay out of their profit from Mining and Quarrying industry and the tax the firms would have otherwise paid had they been in some industry, other than Mining and Quarrying. The net corporate tax benefit due to the Mining and Quarrying industry is estimated by them is Rs. 748 crores.

6.4.2 Benefits

6.4.2.1 Foreign exchange earnings

The iron ore export industry in Goa contributes to India's export earnings. The major buyer of Goa's iron ore is China. The other importers of Goa's iron ore are Japan, Italy, Pakistan, Dubai, Turkey, UAE, Kenya Netherlands, Belgium, Qatar, Saudi Arabia, Rumania, South Korea, Kuwait and Oman. Due to high demand of iron ore in China in past few years Goa's contribution towards India's Iron ore exports have been significantly high. In quantity terms, share of Goa's export in India has been around 40% for the last 5 to 6 years. And in value terms the contribution of Goa's iron ore exports have gone up from 6,606 crores in 2006-07 to Rs 9,173 crores in 2008-09.

According to the Indian Customs and tariffs and DGCI&S for imports, 2009, the weighted tariff of imports in India is 9.9%. In other words the foreign exchange is valued as 9.9% premium which brings the demand for foreign exchange in equilibrium to supply. The study conducted on Goan Iron ore mining contribution to Indian economy in 2010 by NCEAR has assumed that 9.9% of value of exports adds on to the social benefits of the economy. Based on this assumption the estimate of social benefits due to exports of iron ore from Goa is estimated to be 9.9% of Rs. 9,173 crores in 2008-09. Thus the social benefits to the economy due to foreign exchange earnings work out to Rs. 908 crores.

6.4.2.2 Carbon Credit Benefit

Transportation of iron ore from the mining site is primarily carried out using barges instead of road transport via trucks. Transport using barges is much cheaper compared to using trucks and other mode of road transport. This additional effort by the iron ore mining industry to reduce pollution is translated into carbon credit benefits. Every time a barge is used instead of road transport, fuel is saved to the order of 0.027 litres per ton transported per kilometer as per the study carried out by National Council of Applied Economic Research (NCAER, 2010) for Goa Mineral Ore Exporters Association (GMOEA).

Distance of waterways

Iron ore is transported in the Mandovi, Zuari and Cumberjua waterways by using the following leads:

Mandovi River: 45 km

Zuari River: 45 km

Cumberjua canal: 16 km

It is considered that the full lengths of the waterways viz., Mandovi, Zuari and Cumberjua canal are used for transportation of barges. The effective distance of waterways in use for transporting iron ore are as follows:

Mandovi River: The Mandovi waterway is used more for transportation of iron ore. Some of the barges travel from their respective loading point to either Panaji port or Marmugao port. Most of the barges travel up to Marmugao port since large quantity gets export through Marmugao port. The effective length of the waterway considered is 45 km. The usage of Mandovi River by barges for transportation of iron ore is around 64% of the total transportation. Hence, the Mandovi waterway from mines to Mormugao port via., Aguada bar is a busy route for barge movement.

Zuari River: The Zuari waterway is used less when compared to Mandovi River for transportation of iron ore. The effective length of the waterway considered is 45 km. The share of the Zuari River for transportation of iron ore by barges is around 34%.

Cumberjua canal: The Cumberjua canal is used very less only during severe monsoon season of about 2 to 3 months by barges sail from Mandovi river to reach Marmugao port when it is difficult to travel through Aguda bar area. The effective length of the waterway is 16 km. The waterway is used only for about 2% by barges for transportation of ore.

It is assumed that about 98% of the iron ore cargo is being transported using Mandovi and Zuari rivers and only about 2% of the iron ore is being transported using Cumberjua canal.

Fuel savings

This is the fuel saved by transporting iron ore using barges over road transport (trucks). It is measured in litres saved per every ton of iron ore transported over every kilometer. The total tones of iron ore transported and distance it is transported over to determine the total litres of fuel saved.

Factors considered for conversion of

- The total fuel save is estimated to be 0.027 litre / t km
- The density of diesel is 0.832 kg / litre (0.000832 tons per litre)
- CO_2 equivalent fuel savings per ton of fuel saved in ton is 3.2 ton of CO_2 / ton of fuel
- Euros saved per ton of CO_2 is 12 Euro / ton

The fuel saved due to usage of barges by inland water transport are converted into monetary terms and furnished in the following table 6.2. In the year 2009-10 about 14.14 crores of rupees are saved due to usage of barges in place of trucks by road transport.

Table: 6.2 Fuel savings in terms of monetary terms due to use of barges

Year	Tonnage of Iron ore transported by barges	Ton Kilometres transported	Fuel saved in litres	Amount saved in Rupees
2003-04	30773690	1366967310	37077621	8,17,25,010
2004-05	32607957	1448445450	39287634	8,65,96,232
2005-06	36271650	1611186693	43701828	9,63,25,821
2006-07	40536674	1800639059	48840534	10,76,52,351
2007-08	39679458	1762561524	47807719	10,53,75,861
2008-09	45929961	2040208868	55338625	12,19,75,184
2009-10	53237278	2364799889	64142832	14,13,81,065

Subsidy saved on diesel due to inland water transport

The fuel prices in India are still controlled by the Government through a policy called the Administered Price Mechanism (APM), which in turn controlled by inflation rather than free hold on market forces. Hence, the government has a scheme of providing budgetary subsidies on the sale of domestic LPG. In the current fiscal (2011-12) Government of India has made a budgetary provision of fuel subsidy of Rs. 23,640 crores. Since, global crude oil prices have been constantly increasing; government is likely to provide Rs. 30,000 crores to state owned oil firms in 2011-12 to help meet part of their losses. According to TERI, 2010, almost 80% of the domestic crude oil demand was met from oil imports. In view of this huge exchequer of oil import bill and subsidies any savings of oil due to use of inland water transport system has a major role to play.

Based on the studies on NCEAR and views of energy economy consultants it is estimated that the real price per litre of diesel is Rs 51.40 per litre while the market price per litre on sale is Rs. 43.40 (July, 2011). Thus the implicit subsidy that the government pays on diesel is assumed as Rs. 8.

In iron ore transportation in Goa waterways, barges are used instead of trucks, a certain amount of diesel subsidy that the government would bear is saved. Hence, the amount of fuel (diesel) saved due to use of barges can be converted in to monetary terms using the Rs 8 subsidy that the government provides. This is the cost to government avoided by not using trucks.

The amounts of savings by the government in subsidies for diesel by using barges instead of trucks are provided in the following table 6.3.

Table: 6.3 Savings in subsidies of fuel due to use of barges instead of trucks

Year	Tonnage of Iron ore transported by barges	Ton Kilometres transported	Fuel saved in litres	Amount saved in subsidies (Rupees)
2003-04	30773690	1366967310	37077621	29,52,64,939
2004-05	32607957	1448445450	39287634	31,28,64,217
2005-06	36271650	1611186693	43701828	34,80,16,326
2006-07	40536674	1800639059	48840534	38,89,38,037
2007-08	39679458	1762561524	47807719	38,07,13,289
2008-09	45929961	2040208868	55338625	44,06,85,115
2009-10	53237278	2364799889	64142832	51,07,96,776

6.4.2.3 Employment benefits due to mining industry

The mining industry is one of the largest employments generators in the Goan economy. The inland waterways operators constitute roughly 70% of total transportation and are dependent on the iron ore sector as the prime mover. This sector generates considerable employment opportunities for the skilled as well as the unskilled labour. Besides, considering the prevailing high unemployment rate of 8.7% of Goa's population, the iron ore mining sector makes a crucial industry segment in Goa's context (National Sample Survey Organization). As per the NSSO (2004-05) the population of Goa is 14, 63,000. The work force of Goa is 4, 54,993. Out of this about 77,500 workforce is employed in Mining and Quarrying industry as shown in table 6.4. About 8,500 workforce is exclusively involved in barge industry.

6.4.3 Costs

The social costs due to iron ore industry is mainly on account of degradation of environment. These environment costs are basically of two types – air pollution due to iron ore mining and deforestation due to iron ore mining.

6.4.3.1 Air pollution due to iron ore mining

The Integrated Research and Action for Development (IRAD), New Delhi has estimated the pollution load for each firm and industrial sector I n Goa. The total industrial air pollution that was estimated refers to environmental degradation that causes loss of income due to industrial air pollution. The total value estimated was Rs. 517 crores for 2008-09. Air pollution due to Iron Ore mining is considered to be approximately 10% of the total industrial air pollution in Goa. According to National Council of Applied Economic Research (NCEAR), New Delhi, the loss of income due to air pollution caused by Iron ore mining industry is Rs. 51.7 crores.

Table: 6.4 Mining and Quarrying related employment distribution in Goa
(*Source: GMOEA: 2009-10*)

Serial No.		Number of people employed
1	**Mining and Quarrying (Iron Ore)**	
	Direct	15,000
	Indirect (Trade, Hotel & Restaurant, Samplers, Ship agents, Ports, Finance, International business etc)	15,000
	Sub total	30,000
2	**Transportation specific to Mining and Quarrying**	
	Employed in trucks @ 3 persons per truck x 12,000 trucks	36,000
	Employed in barges @ 18 persons per barge x 325	5,850
	Supervision staff for barges	650
	Employed in truck repair garages	3,000
	Employed in barge repair docks	2,000
	Sub total	47,500
	Total employment	**77,500**

6.4.3.2 Deforestation costs:

The Integrated Research and Action for Development (IRAD) study reveals that the economic value of forests in Goa excluding eco tourism value, carbon sink and watershed benefits as the cost to environment due to deforestation. The economic value of forests in Goa on account of benefits such as carbon storage, timber production, non-timber forest products and other values of biodiversity including eco-tourism associated with forests to compute the net economic value. This does not take into account the afforestation made by the mining companies for lack of authenticated data. The total value of Goa forest comes out to be Rs. 2,925.93 crores as per the IRAD study in 2004-05 prices. The total economic value of Goa forest less the indirect benefits of the eco-tourism value, carbon, sink, watershed benefits the value comes to Rs. 363.26 crores in 2004-05 prices. The NCEAR study has estimated the economic value of forests at 2008-09 prices at Rs. 467.62 crores by using the GDP deflators.

6.4.4 Social costs and benefits

The estimates of social cost and benefits of mining industry in Goa per annum as per the NCEAR (2008-09) study with some modifications with the present study are as follows:

Table: 6.5 Details of Social Benefits and Costs of Goa's Iron ore industry

1	**BENEFITS**	Rs Crores (2008-09)
	Premium on foreign exchange earnings due to export of iron ore from Goa	908
	Carbon credit benefit (Fuel savings due to use of barges instead of trucks)	12.2
	Subsidy saved on diesel due to use of barges instead of trucks	44.1
	Revenues: Taxes paid to State and Central governments	
	State Government taxes	
	Royalty paid at 10% ad valorem tax	300
	Barge tax	12
	Road infrastructure cess	50
	Central Government taxes	
	Export duty at 5% towards fines and 10% to lumps	250
	Corporate income tax differentials	748
	Total Benefits	**2324.3**
2	**COSTS**	
	Loss of income due to Environmental degradation	
	Unaccounted costs of land fill sites	14.1
	Avoidance cost solid waste management	0.5
	Air pollution due to iron ore mining	51.7
	Accumulated depreciation of environmental capital due deforestation	467.6
	Total environmental costs	**533.9**
	Net Benefits (1-2)	**1790.4**

The above table indicates that the benefits due to the Goa's mining industry exceed the social costs by about Rs 1,790 crores. It can be interpreted that the costs associated with giving up the iron ore industry in Goa (Opportunity cost) would be greater by Rs. 1,790 crores per year than the cost to the environment associated with running the industry. In addition to this the employment provided by the iron ore industry to a tune of 77, 500 personnel which is about 17% of the total workforce of Goa.

6.5 BARGE ECONOMICS - CURRENT SCENARIO

It is time and again to note that the entire movement of iron ore export in Goa is by barges, even though historically there was rail movement of iron ore right up to the port on the meter gauge railway system. When this was dismantled, barge movement emerged as the primary mode. 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. Apart from the lack of a proper unloading interface at the port, a bottleneck was the line capacity on the rail line section leading to Goa. This has led to the emergence of a dedicated set of barges and loading/unloading infrastructure at several loading points on the Mandovi and Zuari and at Mormugao port and Panaji ports. Perhaps, the inland water transport system in Goa is the first and foremost IWT system in the world which has replaced the other two competitive modes viz., road and rail on commercial and operational aspects. The barge economics for various sizes of barges are furnished in the following table 6.6.

Table: 6.6 Barge Economics for Iron ore transportation – Existing scenario

Item	Unit	Barge Economics – Present scenario			
Barge size	Tons	750	1000	2000	2500
Draft	metres	2.5	2.8	3.2	3.5 to 3.6
INCOME					
Effective loading	Tons	700	900	1800	2300
Trips	Number / annum	200	180	160	150
Throughput per barge	Tons / annum	140000	162000	288000	345000
Rate	Rs / ton	70	70	70	70
Total income	Rupees	9800000	11340000	20160000	24150000
EXPENDITURE					
HSD	litres / trip	408	480	720	960
HSD rate	Rs / litre	43.4	43.4	43.4	43.4
Lubricants	litres / trip	8	10	12	14
Lube rate	Rs / litre	100	100	100	100
HSD cost	Rs	3541440	3749760	4999680	6249600
Lube cost	Rs	160000	180000	192000	210000
Crew size	Number	12	14	18	20
Wage cost	Rs / annum	2880000	3360000	4320000	4800000
Annual repair	Rs	1400000	1800000	1050000	1100000
Running repairs and consumables	Rs	350000	480000	350000	275000
Insurance	Rs	140000	240000	700000	1100000
Taxes and Port charges	Rs	280000	324000	576000	690000
Administration cost	Rs	400000	500000	600000	700000
Total Expenditure	Rupees	9151440	10633760	12787680	15124600
Cost per ton	Rs / ton	65.37	65.64	44.40	43.84
Operating surplus (before interest and depreciation)	Rupees	6,48,560	7,06,240	73,72,320	90,25,400
Operating surplus per ton	Rs / ton	4.63	4.36	25.60	26.16

Assumptions / factors in working out barge economics

- HSD consumption for the barge sizes is based on 12 hours of engine running hours (ERH) per trip. The consumption of HSD is 17, 20, 30, 40 and 50 litres per ERH respectively and twin engines of 200, 220, 300, 400 and 500 BHP respectively for the barge sizes 750, 1000, 2000, 2500 and 3000 tons
- Crew wages: Rs 20000/month/person (Wages are based on agreements between GBOA and GMOEA and the unions)
- Cost of Barges: 750 tons (very old): Rs 70 lakhs; 1000 tons (old) Rs 120 lakhs; 2000 tons (new) Rs. 350 lakhs; 2500 tons (brand new) Rs. 600 lakhs; 2800 tons (recently introduced) Rs. 750 lakhs; 3000 tons (yet to introduce) Rs. 795 lakhs
- Annual repair: 750 tons (very old; 20%), 1000 tons (old; 15%), 2000 tons (new; 3%), 2500 tons (brand new: 2%), 3000 tons (to be introduced 1.5%): The 2000, 2500 and 3000 ton barges are classified and need dry docking twice in 5 years. (Under IV Act, the requirement of dry docking is once a year. However, with special request from the Captain of Ports, Goa, this has been relaxed) Hence their annual repair costs are lower.
- Running repairs and consumables: 750 tons (very old; 5%), 1000 tons (very old; 4%), 2000 tons (old; 1%), 2500 tons (recent: 0.5%), 3000 tons (to be introduced 0.5%)
- Taxes and Port charges: Rs 2 / ton
- Round trips: According to GBOA the barges can make maximum 17 to 18 round trips per month and accordingly the possible barge round trips have been considered

The above table shows that there is an operational surplus for all sizes of barges as the income exceeds the expenditure. The success behind the economic viability of the barge industry in Goa is perfect planning and better interface of transportation of iron ore from the mines till loading into sea vessel for export to international market. Iron ore moves from the mines located by the side of Mandovi and Zuari waterways to barge loading river jetties by trucks. The inland water mode, together with its interfacing costs, offers a cost competitive way of moving material to the next step in the supply chain (the ocean going vessel that carries bulk cargo for export). The Mormugao port is specifically designed to handle iron ore for export through barge shipments in three different ways; by stacking on the ground and loading on to ships via conveyors, by transferring ore from barges to ships anchored at points called mooring dolphins at the port and finally, by transhippers or own equipment of ships docked at anchorage in deep water locations at Panaji port or Mormugao port limits.

While the movement of iron ore by barge on the river system has been successful, the cargo movement is only one way from mines to port without any return cargo. The reason is that the lack of return flow from the port to points upstream. Further the shippers are also reluctant for other commodities to use this mode. For some years now, at least one bulk commodity, coal, has been moving by rail and truck in the reverse direction. Railway wagons, after dropping iron ore at barge loading points at

Sanvordem go empty to Mormugao Port to carry coal in the reverse direction. Coal loading facilities are present at the port and can be designed for barges as well. A possible reason for the unidirectionality of traffic and commodity concentration is the fact that the barges are designed and used for a single commodity and so do not require operations between trips to clean and get the vessel ready for other commodities. Here, the short leads and the barge sizes make it uneconomical for anything other than dedicated commodity vessels with quick turnarounds. In fact, the turnaround is more important for better economics in view of the existing bulk iron ore commodity and its market demand.

The barge economics indicate that the small size barges of 750 tons and 1000 tons capacity barges are less profitable when compared to higher capacity barges (2000 to 2500 tons) due to various reasons besides low throughput. The smaller size barges being used in Goa waterways for transportation of iron ore are age old and require periodical maintenance. The cost of repair and loss of time at dry docks are quite high. For better economics the higher capacity barges are more suitable for better throughput and operational convenience. To operate higher capacity barges and to improve the turnaround time and number of trips, the waterway has to be developed suitable to ply higher draft vessels. Thus, it is proposed to introduce 3000 DWT barges by improving waterway and other related developmental works.

6.6 PROJECT APPRAISAL

Project appraisal has been carried out with a view to assess the overall impact of proposed development of Zuari River, Mandovi River and Cumberjua Canal in Goa for Iron Ore movement from mining areas to the Mormugao Port. Appraisal has been carried out both in financial and economic terms, using base year (2011) market prices/costs to generate cost and benefit series. Project life of 15 years has been considered after completion of the development works. Entire development expenditures are considered as the capital costs where after annualized maintenance expenditure is added in the cost series. Proposed development process (Dredging and other waterway development works) is assumed to take 18 months and accordingly capital costs have been apportioned. Benefits are considered only after completion of the developmental processes.

On advantage side, Consultants are fully aware of the existing vessel mix deployed in handling iron ore on the corridors under reference. In view of the fact that in the existing vessel mix, vessels above 2000 DWT are highly affected by the low water tides, as a result, have to wait for adequate water levels for their loaded movement. In the current exercise following assumptions have been laid:

- On completion of the proposed development works, waterway under consideration will offer uninterrupted movement of vessel up to 3000 DWT.

- ❖ Keeping in view economies of scale, future additions of vessels will be only of higher capacity i.e. 3000 DWT.
- ❖ Additional vessel requirement created on account of scrap of old vessels (which have outlived their economic life of 30 years), will be replaced by the higher capacity vessels of 3000 DWT.
- ❖ No savings in vessel running expenditure has been envisaged.
- ❖ Improvement in throughput of the vessels barges (of above 2500 DWT) resulting in savings of overall unit transportation costs has been considered as the benefits of the proposed development expenditure.
- ❖ Vessel below 2000 DWT which are capable to operate in the current water levels, have been kept outside the purview of this study while estimating overall benefits of proposed development.
- ❖ To arrive at comparative benefits of introducing 3000 DWT vessels on the system, current operating costs of 2500 DWT vessels have been considered.

6.6.1 Barge Economics due to proposed waterway development

To arrive at net benefits to each type of vessels, comparative vessel operating norms have been worked out. Since all the costs and benefits are worked out on the base year structure, current capital costs (manufacturing cost) of vessels (2500 DWT and 3000 DWT) have been collected. The capital cost of 2500 DWT barge is Rs. 7.5 crores and the capital cost of 3000 DWT barge is Rs. 7.95 crores based on current prices. To estimate vessel running costs (fuel and lubricant consumption, periodic and running repairs & maintenance, crew costs, spending on Insurance, taxes and overheads etc.) and operating behavior (number of trips performed, load carried, operating difficulties etc.) requisite information from the existing barge operators have been collected. Net benefit has been worked out using 'with and without' proposed waterway development works. Under 'without' proposed waterway development, ongoing costs and throughputs of 2500 DWT vessels have been considered whereas under 'with' the project scenario revised costs and throughputs 2500 DWT vessels and 3000 DWT vessels have been estimated. Margin between the two cost structures is considered as the benefits of each category of vessel. The turnaround trips considered for 3000 DWT barges due to waterway development works are 187 per month. All the barges above 2000 DWT also need not wait till the high tide to sail due to the proposed deepening of waterway and hence will be beneficial. Hence, the barge turnaround trips for 2500 DWT would also be increased to 187 from the existing 150. The comparative benefits accrued to the existing 2500 DWT vessel worked out to Rs.8.62 per ton as against Rs. 15.41 per ton by the 3000 DWT vessels.

Table: 6.7 Barge Economics for Iron ore transportation – After waterway development

	2500 DWT barge without waterway development	2500 DWT barge after waterway development	3000 DWT barge after waterway development
Number of trips per year	150	187	187
Annualized capital cost per ton (Rs)	18.45	14.80	12.89
Annual operating cost per ton (Rs)	43.84	38.87	33.99
Total cost	62.29	53.67	46.87
Savings in transportation cost per ton due to proposed waterway development (Rs)		8.62	15.41

6.6.2 Financial Appraisal

To estimate overall impact of the proposed development, transport demand of iron ore for the following 17 years have been estimated using past trend and future international demand using actual iron ore movement recorded in the year 2010. As given under assumptions, year to year additional demand is considered for introduction on new vessel of 3000 DWT. Similarly, demand of new vessel capacity arising on account of scrap of old vessels have been estimated.

In the existing vessel mix broadly 40% of the transport demand is met by the vessel of 2000 DWT and above. To estimate benefits accruing to the existing vessel mix, 40% of base year iron movement is assumed constantly for the entire project period. Year wise beneficial traffic estimated for the project period is tabulated (Table 6.8).

Using forgoing analysis, costs and benefits series have been developed and year to year net benefit estimated. In the given scenario Financial Internal Rate of Return (FIRR) works out to 3.63% as indicated in the table 6.9.

Table 6.8: Beneficial Traffic Projection (tons)

S.No	Year	Traffic (Tons)	Base Year Traffic Distribution		Traffic Proposed for 3000 DWT			Capacity utilized by vessels above 2000 DWT	Total Benefitted Traffic
			Handled by Vessels Above 2000 DWT (40%)	**Handled by Vessels below 2000 DWT (60%)**	**Annual Traffic Growth (Estimated)**	**Capacity Released on Scrap of outlived vessels**	**Total Traffic Available for 3000 DWT Vessels**		
1	2010	53,132,002	21,252,801	31,879,201	0			26,566,001	
2	2011	55,257,282			2,125,280	1,771,067	3,896,347	26,566,001	30,462,348
3	2012	57,467,573			2,210,291	1,771,067	3,981,358	26,566,001	30,547,359
4	2013	59,766,276			2,298,703	1,771,067	4,069,770	26,566,001	30,635,771
5	2014	62,156,927			2,390,651	1,771,067	4,161,718	26,566,001	30,727,719
6	2015	64,643,204			2,486,277	1,771,067	4,257,344	26,566,001	30,823,345
7	2016	67,228,933			2,585,728	1,771,067	4,356,795	26,566,001	30,922,796
8	2017	69,918,090			2,689,157	1,771,067	4,460,224	26,566,001	31,026,225
9	2018	72,714,814			2,796,724	1,771,067	4,567,790	26,566,001	31,133,791
10	2019	75,623,406			2,908,593	1,771,067	4,679,659	26,566,001	31,245,660
11	2020	78,648,342			3,024,936	1,771,067	4,796,003	26,566,001	31,362,004
12	2021	81,794,276			3,145,934	1,771,067	4,917,000	26,566,001	31,483,001
13	2022	85,066,047			3,271,771	1,771,067	5,042,838	26,566,001	31,608,839
14	2023	88,468,689			3,402,642	1,771,067	5,173,709	26,566,001	31,739,710
15	2024	92,007,436			3,538,748	1,771,067	5,309,814	26,566,001	31,875,815
16	2025	95,687,734			3,680,297	1,771,067	5,451,364	26,566,001	32,017,365
17	2026	99,515,243			3,827,509	1,771,067	5,598,576	26,566,001	32,164,577
18	2027	103,495,853			3,980,610	1,771,067	5,751,676	26,566,001	32,317,677

Table 6.9: Financial Appraisal

Rs. In lacs

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	9,201.0			9,201.0				-	(9,201.0)
3	2012	21,469.0			21,469.0				-	(21,469.0)
4	2013		306.7		306.7	627.4	2,289.9		2,917.3	2,610.6
5	2014		306.7		306.7	641.5	2,289.9		2,931.4	2,624.7
6	2015		306.7		306.7	656.3	2,289.9		2,946.2	2,639.5
7	2016		306.7		306.7	671.6	2,289.9		2,961.5	2,654.8
8	2017		306.7		306.7	687.5	2,289.9		2,977.5	2,670.8
9	2018		306.7		306.7	704.1	2,289.9		2,994.0	2,687.3
10	2019		306.7		306.7	721.4	2,289.9		3,011.3	2,704.6
11	2020		306.7		306.7	739.3	2,289.9		3,029.2	2,722.5
12	2021		306.7		306.7	758.0	2,289.9		3,047.9	2,741.2
13	2022		306.7		306.7	777.4	2,289.9		3,067.3	2,760.6
14	2023		306.7		306.7	797.5	2,289.9		3,087.4	2,780.7
15	2024		306.7		306.7	818.5	2,289.9		3,108.4	2,801.7
16	2025		306.7		306.7	840.3	2,289.9		3,130.2	2,823.5
17	2026	-	306.7		306.7	863.0	2,289.9		3,152.9	2,846.2
18	2027	-	306.7		306.7	886.6	2,289.9		3,176.5	2,869.8

FIRR : 3.63%

6.6.3 Economic Appraisal

By adopting methodology discussed under Financial Appraisal, Economic Appraisal has been carried out. Since all the information collected on costs and benefits were in financial terms, the same were converted into economic terms by applying appropriate multiplying factors. Comparative benefits accrued in the economic terms to the existing 2500 DWT vessel worked out to Rs. 7.22 per ton as against 12.63 per ton by the 3000 DWT vessels.

Using forgoing analysis, costs and benefits series have been developed and year to year net benefit estimated. In the given scenario Economic Internal Rate of Return (EIRR) worked out to 5.2% as indicated in the table 6.10.

Table: 6.10 Economic Appraisals

Rs. In Lacs

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,901			6,901				0.0	(6,901)
3	2012	16,102			16,102				0.0	(16,102)
4	2013		230		230	513.9	1918.9		2432.8	2,203
5	2014		230.025		230	525.6	1918.9		2444.4	2,214
6	2015		230.025		230	537.6	1918.9		2456.5	2,226
7	2016		230.025		230	550.2	1918.9		2469.1	2,239
8	2017		230.025		230	563.3	1918.9		2482.1	2,252
9	2018		230.025		230	576.8	1918.9		2495.7	2,266
10	2019		230.025		230	591.0	1918.9		2509.8	2,280
11	2020		230.025		230	605.7	1918.9		2524.5	2,295
12	2021		230.025		230	620.9	1918.9		2539.8	2,310
13	2022		230.025		230	636.8	1918.9		2555.7	2,326
14	2023		230.025		230	653.4	1918.9		2572.2	2,342
15	2024		230.025		230	670.5	1918.9		2589.4	2,359
16	2025		230.025		230	688.4	1918.9		2607.3	2,377
17	2026	0	230.025		230	707.0	1918.9		2625.9	2,396
18	2027	0	230.025		230	726.3	1918.9		2645.2	2,415
									EIRR	**5.2%**

6.7 SENSITIVITY ANALYSIS

Sensitivity analysis is carried out to assess the impact of adverse conditions which negatively affect the project investment. In the current exercise sensitivity analysis has been carried out with proportionate decline in realization of estimated traffic and increase in estimated project cost. FIRR and EIRR estimated under different scenarios are tabulated in Table 6.11.

Table: 6.11 Sensitivity Analysis

S.No	Sensitivity Scenario	Capital Cost (Rs. In Lacs)	FIRR	EIRR
1	Base Case	30670.0	3.63%	5.23%
2	With 10% increase in Capital Expenditure	33737.0	2.24%	3.78%
3	With 20% increase in Capital Expenditure	36804.0	1.01%	2.51%
4	Annual Growth Registered 10% less than anticipated	30670.0	3.33%	4.93%
5	Annual Growth Registered 20% less than anticipated	30670.0	3.05%	4.64%
6	With 10% increase in Capital Exp. + 10% decline in anticipated AGCR	33737.0	1.95%	3.49%
7	With 20% increase in Capital Exp. + 10% decline in anticipated AGCR	36804.0	0.72%	2.22%
8	With 10% increase in Capital Exp. + 20% decline in anticipated AGCR	33737.0	1.67%	3.21%
9	With 20% increase in Capital Exp. + 20% decline in anticipated AGCR	36804.0	0.44%	1.94%

6.8 PUBLIC PRIVATE PARTERNERSHIP (PPP)

6.8.1 General:

The guide lines were notified by the ministry of finance, department of economic affairs for financial support to infrastructure project that are to be undertaken through Public Private Partnerships (PPP).

Proposal is to be made under this scheme shall be considered for providing Viability Gap Funding (GAF), one time or deferred with the objective of making a PPP project commercially viable.

The proposal shall relate to a public private partnership (PPP) project which is based on a contract or concession agreement between a Government or statutory entity(Inland Waterways Authority of India) on the one side and a private sector company on the other side, for delivering an infrastructure service on payment of user charges.

This scheme will apply only if the contract/concession is awarded in favour of a private company in which 51% or more of the subscribed and paid up equity is owned and controlled by a private entity.

A private sector company shall be eligible for VGF only if it is selected on the basis of open competitive bidding and is responsible for financing, construction, maintenance and operation of the project during concession period.

The project should provide a service against payment of a predetermined tariff or user charge.

The proposal for seeking clearance of the Empowered Institution shall be sent (in six copies, both in hard and soft form) to the PPP cell of the Department of Economic Affairs in the prescribed format. The proposal should include copies of all project agreements (such as concession agreement, state support agreement etc.) and the project report.

Once cleared by Empowered Institution, the project is elgible for financial support.

Financial bids shall be invited by the concerned ministry, state Government or statutory entity, as the case may be , for the award of the project within four months of the approval of the Empowered Institution. This period may be extended by the Department of Economic Affairs.

The private sector company shall be selected through a transparent and open competitive bidding process. The criterion for bidding shall be the amount of VGF required by a private sector company where all other parameters are comparable.

6.8.2 Development of Goa waterway through PPP:

The development of the Goa waterway can be taken up in PPP mode. With a view to providing an impetus to development of inland water transport mode, the Government of India had approved Inland Water Transport Policy in January 2001, which includes several fiscal concessions, and policy guidelines for development of this mode and to encourage private sector participation in development of infrastructure and ownership and operation of inland vessels. IWAI is also authorized for joint ventures and equity participation in BOT projects.

Such participation will be for areas like fairway development and maintenance, construction and operation of terminals, provision and operation of mechanized cargo handling systems, storage facilities, provision of navigational aids, pilotage projects and setting up and running of IWT training institutions.

The joint venture participation for development of waterways shall be with equity of 30% from IWAI and 70% from the private firm. The joint venture company can be incorporated through a Memorandum of Understanding (MOU) between the two parties.

Tax exemption: Grant of 100% tax exemption to investors in IWT sector for five years and further 30% tax exemption is permissible under the Income Tax Act to be availed of in the next five years within a period of 15 years as in the case of National Highways so as to enable this sector to develop

6.8.3 Public Private Partnership with various government support options

With view to attract private investment in the proposed development works, an attempt has been made to estimate Internal Rates of Return both in Financial and Economic terms under various Government support options. FIRR and EIRR under different Government Support options are tabulated in table 6.12.

Table: 6.12 PPP with Various Government Support Options

S.No	Sensitivity Scenario	Capital Cost (Rs. In Lacs)	FIRR	EIRR
1	Base Case	30670.0	3.63%	5.23%
2	With 10% Support from The IWAI	27603.0	5.23%	6.90%
3	With 20% Support from The IWAI	24536.0	7.09%	8.85%
4	With 30% Support from The IWAI	21469.0	9.33%	11.20%
5	With 40% Support from The IWAI	18402.0	12.10%	14.13%

6.9 Project Appraisal under cost recovery method

Internal Rate of Return under cost recovery method including full waterways development cost (option 1) for dumping muck outside prescribed distance (Project Cost about Rs. 310.0 Crores) has been worked with different Waterway User Charge rates levied on the barge operators ranging from Rs. 4.00 Per tonne to Rs 7.00 per tone per trip. The FIRR and EIRR under various options is summarized below:

Table 6.13: FIRR and EIRR Full Waterways Development Cost (Dumping Muck outside Prescribed Distance)

Waterway user charges (Rs / per ton)	FIRR (%)	EIRR (%)	Annex No.
4.00	3.83	8.00	Annex 1
4.50	5.48	9.80	Annex 2
5.00	7.02	11.60	Annex 3
5.50	8.46	13.60	Annex 4
6.00	9.83	14.80	Annex 5
6.50	11.13	16.30	Annex 6
7.00	12.39	17.70	Annex 7

From the above table it is clear that if Rs 7/- per ton is charged from the vessel operator as waterway user charges the FIRR will be 12.39 % and EIRR will be 17.70 %.

Under option 2, that involves muck dumping cost on the river banks or muck is used for refiling of land that can bear the additional cost of local cartage resulting the project cost at Rs. 160 crores. IRR with different Waterway Usage Charges is summarised in Table below:

Table 6.14: FIRR and EIRR Waterways Development Cost Dumping Muck on Banks of the Rivers

Waterway user charges Rs/per ton	FIRR (%)	EIRR (%)	Annex No.
2.00	3.63	7.80	Annex 8
2.50	6.79	11.30	Annex 9
3.00	9.68	14.50	Annex 10
3.50	12.12	17.40	Annex 11
4.00	14.48	20.20	Annex 12

The barge economics under cost recovery method is furnished below:

Table 6.15: Barge economics after levying user charges

	2500 DWT barge without waterway development	2500 DWT barge after waterway development	3000 DWT barge after waterway development	FIRR (%)	EIRR (%)
Cost incurred Rs / ton	62.29	53.67	46.87		
Saving Rs / ton		8.62	15.41		
Waterway user charges proposed to be levied after waterway development Rs / ton		7.00	7.00	12.39	17.70

If the investor / implementing agency charges additional Rs. 7 per ton per trip (present charges are Rs. 70 per ton per trip), the FIRR will be 12.39 % and EIRR will be around 17.70% during the project appraisal period of 15 years. After 15 years, once the waterway will be completely utilized by higher capacity barges of 3000 DWT, the savings on cost and the financial returns will be further enhanced.

Tariff

Tariff fixed for transportation of iron ore by barges during the study period (2011-12) was Rs. 70/- per ton per trip.

Barge Tax

Details of Barge tax levied on barge operators by State Government through Department of Inland Waterways, Office of the Captain of Ports, Government of Goa are as follows:

As per the Goa, Daman and Diu Barge Tax Act, 1973 (Act 10 of 1973) the Government of Goa fixes the rates of tax to be levied and collected on all barges used or kept for use in the State waterways are as stated below:

Table: Barge tax as per Barge tax act 1973

Capacity of barge	Annual rate per ton (Rs)
Less than 650 tons	35
650 tons and less than 1000 tons	40
1000 tons and less than 1600 tons	48
1600 tons and above	60

Current Barge Tax

In the recent budget of 2012, the barge tax has been hiked to Rs 100 per ton from existing Rs 90 per ton for a vessel less than 1000 DWT, while it will be Rs 200 per ton for vessels more than 1000 DWT from current Rs 145 per ton.

Annex 1/1.

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	4

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	2,390.7	2,390.7	2,079.9
5	2014		310.7		310.7	-	-	2,486.3	2,486.3	2,175.6
6	2015		310.7		310.7	-	-	2,585.7	2,585.7	2,275.0
7	2016		310.7		310.7	-	-	2,689.2	2,689.2	2,378.4
8	2017		310.7		310.7	-	-	2,796.7	2,796.7	2,486.0
9	2018		310.7		310.7	-	-	2,908.6	2,908.6	2,597.9
10	2019		310.7		310.7	-	-	3,024.9	3,024.9	2,714.2
11	2020		310.7		310.7	-	-	3,145.9	3,145.9	2,835.2
12	2021		310.7		310.7	-	-	3,271.8	3,271.8	2,961.1
13	2022		310.7		310.7	-	-	3,402.6	3,402.6	3,091.9
14	2023		310.7		310.7	-	-	3,538.7	3,538.7	3,228.0
15	2024		310.7		310.7	-	-	3,680.3	3,680.3	3,369.6
16	2025		310.7		310.7	-	-	3,827.5	3,827.5	3,516.8
17	2026	-	310.7		310.7	-	-	3,980.6	3,980.6	3,669.9
18	2027	-	310.7		310.7	-	-	4,139.8	4,139.8	3,829.1
									FIRR	**3.83%**

Annex 1/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 4

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233		233	0.0	0.0	2390.7	2390.7	2,158
5	2014		233.0325		233	0.0	0.0	2486.3	2486.3	2,253
6	2015		233.0325		233	0.0	0.0	2585.7	2585.7	2,353
7	2016		233.0325		233	0.0	0.0	2689.2	2689.2	2,456
8	2017		233.0325		233	0.0	0.0	2796.7	2796.7	2,564
9	2018		233.0325		233	0.0	0.0	2908.6	2908.6	2,676
10	2019		233.0325		233	0.0	0.0	3024.9	3024.9	2,792
11	2020		233.0325		233	0.0	0.0	3145.9	3145.9	2,913
12	2021		233.0325		233	0.0	0.0	3271.8	3271.8	3,039
13	2022		233.0325		233	0.0	0.0	3402.6	3402.6	3,170
14	2023		233.0325		233	0.0	0.0	3538.7	3538.7	3,306
15	2024		233.0325		233	0.0	0.0	3680.3	3680.3	3,447
16	2025		233.0325		233	0.0	0.0	3827.5	3827.5	3,594
17	2026	0	233.0325		233	0.0	0.0	3980.6	3980.6	3,748
18	2027	0	233.0325		233	0.0	0.0	4139.8	4139.8	3,907
									EIRR	**8.0%**

Annex 2/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	4.5

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	2,689.5	2,689.5	2,378.8
5	2014		310.7		310.7	-	-	2,797.1	2,797.1	2,486.4
6	2015		310.7		310.7	-	-	2,908.9	2,908.9	2,598.2
7	2016		310.7		310.7	-	-	3,025.3	3,025.3	2,714.6
8	2017		310.7		310.7	-	-	3,146.3	3,146.3	2,835.6
9	2018		310.7		310.7	-	-	3,272.2	3,272.2	2,961.5
10	2019		310.7		310.7	-	-	3,403.1	3,403.1	3,092.3
11	2020		310.7		310.7	-	-	3,539.2	3,539.2	3,228.5
12	2021		310.7		310.7	-	-	3,680.7	3,680.7	3,370.0
13	2022		310.7		310.7	-	-	3,828.0	3,828.0	3,517.3
14	2023		310.7		310.7	-	-	3,981.1	3,981.1	3,670.4
15	2024		310.7		310.7	-	-	4,140.3	4,140.3	3,829.6
16	2025		310.7		310.7	-	-	4,305.9	4,305.9	3,995.2
17	2026	-	310.7		310.7	-	-	4,478.2	4,478.2	4,167.5
18	2027	-	310.7		310.7	-	-	4,657.3	4,657.3	4,346.6
									FIRR	**5.48%**

Annex 2/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 4.5

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233		233	0.0	0.0	2689.5	2689.5	2,456
5	2014		233.0325		233	0.0	0.0	2797.1	2797.1	2,564
6	2015		233.0325		233	0.0	0.0	2908.9	2908.9	2,676
7	2016		233.0325		233	0.0	0.0	3025.3	3025.3	2,792
8	2017		233.0325		233	0.0	0.0	3146.3	3146.3	2,913
9	2018		233.0325		233	0.0	0.0	3272.2	3272.2	3,039
10	2019		233.0325		233	0.0	0.0	3403.1	3403.1	3,170
11	2020		233.0325		233	0.0	0.0	3539.2	3539.2	3,306
12	2021		233.0325		233	0.0	0.0	3680.7	3680.7	3,448
13	2022		233.0325		233	0.0	0.0	3828.0	3828.0	3,595
14	2023		233.0325		233	0.0	0.0	3981.1	3981.1	3,748
15	2024		233.0325		233	0.0	0.0	4140.3	4140.3	3,907
16	2025		233.0325		233	0.0	0.0	4305.9	4305.9	4,073
17	2026	0	233.0325		233	0.0	0.0	4478.2	4478.2	4,245
18	2027	0	233.0325		233	0.0	0.0	4657.3	4657.3	4,424
									EIRR	**9.8%**

Annex 3/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	5

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	2,988.3	2,988.3	2,677.6
5	2014		310.7		310.7	-	-	3,107.8	3,107.8	2,797.1
6	2015		310.7		310.7	-	-	3,232.2	3,232.2	2,921.5
7	2016		310.7		310.7	-	-	3,361.4	3,361.4	3,050.7
8	2017		310.7		310.7	-	-	3,495.9	3,495.9	3,185.2
9	2018		310.7		310.7	-	-	3,635.7	3,635.7	3,325.0
10	2019		310.7		310.7	-	-	3,781.2	3,781.2	3,470.5
11	2020		310.7		310.7	-	-	3,932.4	3,932.4	3,621.7
12	2021		310.7		310.7	-	-	4,089.7	4,089.7	3,779.0
13	2022		310.7		310.7	-	-	4,253.3	4,253.3	3,942.6
14	2023		310.7		310.7	-	-	4,423.4	4,423.4	4,112.7
15	2024		310.7		310.7	-	-	4,600.4	4,600.4	4,289.7
16	2025		310.7		310.7	-	-	4,784.4	4,784.4	4,473.7
17	2026	-	310.7		310.7	-	-	4,975.8	4,975.8	4,665.1
18	2027	-	310.7		310.7	-	-	5,174.8	5,174.8	4,864.1
									FIRR	**7.02%**

Annex 3/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 5

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233		233	0.0	0.0	2988.3	2988.3	2,755
5	2014		233.0325		233	0.0	0.0	3107.8	3107.8	2,875
6	2015		233.0325		233	0.0	0.0	3232.2	3232.2	2,999
7	2016		233.0325		233	0.0	0.0	3361.4	3361.4	3,128
8	2017		233.0325		233	0.0	0.0	3495.9	3495.9	3,263
9	2018		233.0325		233	0.0	0.0	3635.7	3635.7	3,403
10	2019		233.0325		233	0.0	0.0	3781.2	3781.2	3,548
11	2020		233.0325		233	0.0	0.0	3932.4	3932.4	3,699
12	2021		233.0325		233	0.0	0.0	4089.7	4089.7	3,857
13	2022		233.0325		233	0.0	0.0	4253.3	4253.3	4,020
14	2023		233.0325		233	0.0	0.0	4423.4	4423.4	4,190
15	2024		233.0325		233	0.0	0.0	4600.4	4600.4	4,367
16	2025		233.0325		233	0.0	0.0	4784.4	4784.4	4,551
17	2026	0	233.0325		233	0.0	0.0	4975.8	4975.8	4,743
18	2027	0	233.0325		233	0.0	0.0	5174.8	5174.8	4,942
									EIRR	**11.6%**

Annex 4/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	5.5

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	3,287.1	3,287.1	2,976.4
5	2014		310.7		310.7	-	-	3,418.6	3,418.6	3,107.9
6	2015		310.7		310.7	-	-	3,555.4	3,555.4	3,244.7
7	2016		310.7		310.7	-	-	3,697.6	3,697.6	3,386.9
8	2017		310.7		310.7	-	-	3,845.5	3,845.5	3,534.8
9	2018		310.7		310.7	-	-	3,999.3	3,999.3	3,688.6
10	2019		310.7		310.7	-	-	4,159.3	4,159.3	3,848.6
11	2020		310.7		310.7	-	-	4,325.7	4,325.7	4,014.9
12	2021		310.7		310.7	-	-	4,498.7	4,498.7	4,188.0
13	2022		310.7		310.7	-	-	4,678.6	4,678.6	4,367.9
14	2023		310.7		310.7	-	-	4,865.8	4,865.8	4,555.1
15	2024		310.7		310.7	-	-	5,060.4	5,060.4	4,749.7
16	2025		310.7		310.7	-	-	5,262.8	5,262.8	4,952.1
17	2026	-	310.7		310.7	-	-	5,473.3	5,473.3	5,162.6
18	2027	-	310.7		310.7	-	-	5,692.3	5,692.3	5,381.6
									FIRR	**8.46%**

Annex 4/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 5.5

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233		233	0.0	0.0	3287.1	3287.1	3,054
5	2014		233.0325		233	0.0	0.0	3418.6	3418.6	3,186
6	2015		233.0325		233	0.0	0.0	3555.4	3555.4	3,322
7	2016		233.0325		233	0.0	0.0	3697.6	3697.6	3,465
8	2017		233.0325		233	0.0	0.0	3845.5	3845.5	3,612
9	2018		233.0325		233	0.0	0.0	3999.3	3999.3	3,766
10	2019		233.0325		233	0.0	0.0	4159.3	4159.3	3,926
11	2020		233.0325		233	0.0	0.0	4325.7	4325.7	4,093
12	2021		233.0325		233	0.0	0.0	4498.7	4498.7	4,266
13	2022		233.0325		233	0.0	0.0	4678.6	4678.6	4,446
14	2023		233.0325		233	0.0	0.0	4865.8	4865.8	4,633
15	2024		233.0325		233	0.0	0.0	5060.4	5060.4	4,827
16	2025		233.0325		233	0.0	0.0	5262.8	5262.8	5,030
17	2026	0	233.0325		233	0.0	0.0	5473.3	5473.3	5,240
18	2027	0	233.0325		233	0.0	0.0	5692.3	5692.3	5,459
									EIRR	**13.2%**

Annex 5/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	6

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	3,586.0	3,586.0	3,275.3
5	2014		310.7		310.7	-	-	3,729.4	3,729.4	3,418.7
6	2015		310.7		310.7	-	-	3,878.6	3,878.6	3,567.9
7	2016		310.7		310.7	-	-	4,033.7	4,033.7	3,723.0
8	2017		310.7		310.7	-	-	4,195.1	4,195.1	3,884.4
9	2018		310.7		310.7	-	-	4,362.9	4,362.9	4,052.2
10	2019		310.7		310.7	-	-	4,537.4	4,537.4	4,226.7
11	2020		310.7		310.7	-	-	4,718.9	4,718.9	4,408.2
12	2021		310.7		310.7	-	-	4,907.7	4,907.7	4,596.9
13	2022		310.7		310.7	-	-	5,104.0	5,104.0	4,793.3
14	2023		310.7		310.7	-	-	5,308.1	5,308.1	4,997.4
15	2024		310.7		310.7	-	-	5,520.4	5,520.4	5,209.7
16	2025		310.7		310.7	-	-	5,741.3	5,741.3	5,430.6
17	2026	-	310.7		310.7	-	-	5,970.9	5,970.9	5,660.2
18	2027	-	310.7		310.7	-	-	6,209.8	6,209.8	5,899.0
									FIRR	**9.83%**

Annex 5/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 6

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233		233	0.0	0.0	3586.0	3586.0	3,353
5	2014		233.0325		233	0.0	0.0	3729.4	3729.4	3,496
6	2015		233.0325		233	0.0	0.0	3878.6	3878.6	3,646
7	2016		233.0325		233	0.0	0.0	4033.7	4033.7	3,801
8	2017		233.0325		233	0.0	0.0	4195.1	4195.1	3,962
9	2018		233.0325		233	0.0	0.0	4362.9	4362.9	4,130
10	2019		233.0325		233	0.0	0.0	4537.4	4537.4	4,304
11	2020		233.0325		233	0.0	0.0	4718.9	4718.9	4,486
12	2021		233.0325		233	0.0	0.0	4907.7	4907.7	4,675
13	2022		233.0325		233	0.0	0.0	5104.0	5104.0	4,871
14	2023		233.0325		233	0.0	0.0	5308.1	5308.1	5,075
15	2024		233.0325		233	0.0	0.0	5520.4	5520.4	5,287
16	2025		233.0325		233	0.0	0.0	5741.3	5741.3	5,508
17	2026	0	233.0325		233	0.0	0.0	5970.9	5970.9	5,738
18	2027	0	233.0325		233	0.0	0.0	6209.8	6209.8	5,977
									EIRR	**14.8%**

Annex 6/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	6.5

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	3,884.8	3,884.8	3,574.1
5	2014		310.7		310.7	-	-	4,040.2	4,040.2	3,729.5
6	2015		310.7		310.7	-	-	4,201.8	4,201.8	3,891.1
7	2016		310.7		310.7	-	-	4,369.9	4,369.9	4,059.2
8	2017		310.7		310.7	-	-	4,544.7	4,544.7	4,234.0
9	2018		310.7		310.7	-	-	4,726.5	4,726.5	4,415.8
10	2019		310.7		310.7	-	-	4,915.5	4,915.5	4,604.8
11	2020		310.7		310.7	-	-	5,112.1	5,112.1	4,801.4
12	2021		310.7		310.7	-	-	5,316.6	5,316.6	5,005.9
13	2022		310.7		310.7	-	-	5,529.3	5,529.3	5,218.6
14	2023		310.7		310.7	-	-	5,750.5	5,750.5	5,439.8
15	2024		310.7		310.7	-	-	5,980.5	5,980.5	5,669.8
16	2025		310.7		310.7	-	-	6,219.7	6,219.7	5,909.0
17	2026	-	310.7		310.7	-	-	6,468.5	6,468.5	6,157.8
18	2027	-	310.7		310.7	-	-	6,727.2	6,727.2	6,416.5
									FIRR	**11.13%**

Annex 6/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 6.5

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233		233	0.0	0.0	3884.8	3884.8	3,652
5	2014		233.0325		233	0.0	0.0	4040.2	4040.2	3,807
6	2015		233.0325		233	0.0	0.0	4201.8	4201.8	3,969
7	2016		233.0325		233	0.0	0.0	4369.9	4369.9	4,137
8	2017		233.0325		233	0.0	0.0	4544.7	4544.7	4,312
9	2018		233.0325		233	0.0	0.0	4726.5	4726.5	4,493
10	2019		233.0325		233	0.0	0.0	4915.5	4915.5	4,682
11	2020		233.0325		233	0.0	0.0	5112.1	5112.1	4,879
12	2021		233.0325		233	0.0	0.0	5316.6	5316.6	5,084
13	2022		233.0325		233	0.0	0.0	5529.3	5529.3	5,296
14	2023		233.0325		233	0.0	0.0	5750.5	5750.5	5,517
15	2024		233.0325		233	0.0	0.0	5980.5	5980.5	5,747
16	2025		233.0325		233	0.0	0.0	6219.7	6219.7	5,987
17	2026	0	233.0325		233	0.0	0.0	6468.5	6468.5	6,235
18	2027	0	233.0325		233	0.0	0.0	6727.2	6727.2	6,494
									EIRR	**16.3%**

Annex 7/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs)

WUC Rs/Ton	7

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Recoverable Water User Charges	Total	
1	2010									
2	2011	9,321.3			9,321.3				-	(9,321.3)
3	2012	21,749.7			21,749.7				-	(21,749.7)
4	2013		310.7		310.7	-	-	4,183.6	4,183.6	3,872.9
5	2014		310.7		310.7	-	-	4,351.0	4,351.0	4,040.3
6	2015		310.7		310.7	-	-	4,525.0	4,525.0	4,214.3
7	2016		310.7		310.7	-	-	4,706.0	4,706.0	4,395.3
8	2017		310.7		310.7	-	-	4,894.3	4,894.3	4,583.6
9	2018		310.7		310.7	-	-	5,090.0	5,090.0	4,779.3
10	2019		310.7		310.7	-	-	5,293.6	5,293.6	4,982.9
11	2020		310.7		310.7	-	-	5,505.4	5,505.4	5,194.7
12	2021		310.7		310.7	-	-	5,725.6	5,725.6	5,414.9
13	2022		310.7		310.7	-	-	5,954.6	5,954.6	5,643.9
14	2023		310.7		310.7	-	-	6,192.8	6,192.8	5,882.1
15	2024		310.7		310.7	-	-	6,440.5	6,440.5	6,129.8
16	2025		310.7		310.7	-	-	6,698.1	6,698.1	6,387.4
17	2026	-	310.7		310.7	-	-	6,966.1	6,966.1	6,655.4
18	2027	-	310.7		310.7	-	-	7,244.7	7,244.7	6,934.0
									FIRR	**12.39%**

Annex 7/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

(With Full Waterway Development Costs) WUC Rs/Ton 7

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	6,991			6,991				0.0	(6,991)
3	2012	16,312			16,312				0.0	(16,312)
4	2013		233.0325		233	0.0	0.0	4183.6	4183.6	3,951
5	2014		233.0325		233	0.0	0.0	4351.0	4351.0	4,118
6	2015		233.0325		233	0.0	0.0	4525.0	4525.0	4,292
7	2016		233.0325		233	0.0	0.0	4706.0	4706.0	4,473
8	2017		233.0325		233	0.0	0.0	4894.3	4894.3	4,661
9	2018		233.0325		233	0.0	0.0	5090.0	5090.0	4,857
10	2019		233.0325		233	0.0	0.0	5293.6	5293.6	5,061
11	2020		233.0325		233	0.0	0.0	5505.4	5505.4	5,272
12	2021		233.0325		233	0.0	0.0	5725.6	5725.6	5,493
13	2022		233.0325		233	0.0	0.0	5954.6	5954.6	5,722
14	2023		233.0325		233	0.0	0.0	6192.8	6192.8	5,960
15	2024		233.0325		233	0.0	0.0	6440.5	6440.5	6,207
16	2025		233.0325		233	0.0	0.0	6698.1	6698.1	6,465
17	2026	0	233.0325		233	0.0	0.0	6966.1	6966.1	6,733
18	2027	0	233.0325		233	0.0	0.0	7244.7	7244.7	7,012
									EIRR	**17.7%**

Annex 8/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

With Proposed Additional
Waterway User Charges Rs/Ton 2

Financial Appraisal Rs. In lacs

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	4,732.5			4,732.5				-	(4,732.5)
3	2012	11,042.5			11,042.5				-	(11,042.5)
4	2013		157.8		157.8	-	-	1,195.3	1,195.3	1,037.6
5	2014		157.8		157.8	-	-	1,243.1	1,243.1	1,085.4
6	2015		157.8		157.8	-	-	1,292.9	1,292.9	1,135.1
7	2016		157.8		157.8	-	-	1,344.6	1,344.6	1,186.8
8	2017		157.8		157.8	-	-	1,398.4	1,398.4	1,240.6
9	2018		157.8		157.8	-	-	1,454.3	1,454.3	1,296.5
10	2019		157.8		157.8	-	-	1,512.5	1,512.5	1,354.7
11	2020		157.8		157.8	-	-	1,573.0	1,573.0	1,415.2
12	2021		157.8		157.8	-	-	1,635.9	1,635.9	1,478.1
13	2022		157.8		157.8	-	-	1,701.3	1,701.3	1,543.6
14	2023		157.8		157.8	-	-	1,769.4	1,769.4	1,611.6
15	2024		157.8		157.8	-	-	1,840.1	1,840.1	1,682.4
16	2025		157.8		157.8	-	-	1,913.8	1,913.8	1,756.0
17	2026	-	157.8		157.8	-	-	1,990.3	1,990.3	1,832.6
18	2027	-	157.8		157.8	-	-	2,069.9	2,069.9	1,912.2

FIRR 3.63%

Annex 8/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	3,549			3,549				0.0	(3,549)
3	2012	8,282			8,282				0.0	(8,282)
4	2013		118		118	0.0	0.0	1195.3	1195.3	1,077
5	2014		118.313		118	0.0	0.0	1243.1	1243.1	1,125
6	2015		118.313		118	0.0	0.0	1292.9	1292.9	1,175
7	2016		118.313		118	0.0	0.0	1344.6	1344.6	1,226
8	2017		118.313		118	0.0	0.0	1398.4	1398.4	1,280
9	2018		118.313		118	0.0	0.0	1454.3	1454.3	1,336
10	2019		118.313		118	0.0	0.0	1512.5	1512.5	1,394
11	2020		118.313		118	0.0	0.0	1573.0	1573.0	1,455
12	2021		118.313		118	0.0	0.0	1635.9	1635.9	1,518
13	2022		118.313		118	0.0	0.0	1701.3	1701.3	1,583
14	2023		118.313		118	0.0	0.0	1769.4	1769.4	1,651
15	2024		118.313		118	0.0	0.0	1840.1	1840.1	1,722
16	2025		118.313		118	0.0	0.0	1913.8	1913.8	1,795
17	2026	0	118.313		118	0.0	0.0	1990.3	1990.3	1,872
18	2027	0	118.313		118	0.0	0.0	2069.9	2069.9	1,952
									EIRR	**7.8%**

Annex 9/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

With Proposed Additional

Waterway User Charges Rs/Ton *2.5*

Financial Appraisal

Rs. In lacs

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	4,732.5			4,732.5				-	(4,732.5)
3	2012	11,042.5			11,042.5				-	(11,042.5)
4	2013		157.8		157.8	-	-	1,494.2	1,494.2	1,336.4
5	2014		157.8		157.8	-	-	1,553.9	1,553.9	1,396.2
6	2015		157.8		157.8	-	-	1,616.1	1,616.1	1,458.3
7	2016		157.8		157.8	-	-	1,680.7	1,680.7	1,523.0
8	2017		157.8		157.8	-	-	1,748.0	1,748.0	1,590.2
9	2018		157.8		157.8	-	-	1,817.9	1,817.9	1,660.1
10	2019		157.8		157.8	-	-	1,890.6	1,890.6	1,732.8
11	2020		157.8		157.8	-	-	1,966.2	1,966.2	1,808.5
12	2021		157.8		157.8	-	-	2,044.9	2,044.9	1,887.1
13	2022		157.8		157.8	-	-	2,126.7	2,126.7	1,968.9
14	2023		157.8		157.8	-	-	2,211.7	2,211.7	2,054.0
15	2024		157.8		157.8	-	-	2,300.2	2,300.2	2,142.4
16	2025		157.8		157.8	-	-	2,392.2	2,392.2	2,234.4
17	2026	-	157.8		157.8	-	-	2,487.9	2,487.9	2,330.1
18	2027	-	157.8		157.8	-	-	2,587.4	2,587.4	2,429.6
									FIRR	**6.79%**

Annex 9/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	3,549			3,549				0.0	(3,549)
3	2012	8,282			8,282				0.0	(8,282)
4	2013		118		118	0.0	0.0	1494.2	1494.2	1,376
5	2014		118.313		118	0.0	0.0	1553.9	1553.9	1,436
6	2015		118.313		118	0.0	0.0	1616.1	1616.1	1,498
7	2016		118.313		118	0.0	0.0	1680.7	1680.7	1,562
8	2017		118.313		118	0.0	0.0	1748.0	1748.0	1,630
9	2018		118.313		118	0.0	0.0	1817.9	1817.9	1,700
10	2019		118.313		118	0.0	0.0	1890.6	1890.6	1,772
11	2020		118.313		118	0.0	0.0	1966.2	1966.2	1,848
12	2021		118.313		118	0.0	0.0	2044.9	2044.9	1,927
13	2022		118.313		118	0.0	0.0	2126.7	2126.7	2,008
14	2023		118.313		118	0.0	0.0	2211.7	2211.7	2,093
15	2024		118.313		118	0.0	0.0	2300.2	2300.2	2,182
16	2025		118.313		118	0.0	0.0	2392.2	2392.2	2,274
17	2026	0	118.313		118	0.0	0.0	2487.9	2487.9	2,370
18	2027	0	118.313		118	0.0	0.0	2587.4	2587.4	2,469
									EIRR	**11.3%**

Annex 10/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs
With Proposed Additional
Waterway User Charges Rs/Ton *3*

Financial Appraisal Rs. In lacs

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	4,732.5			4,732.5				-	(4,732.5)
3	2012	11,042.5			11,042.5				-	(11,042.5)
4	2013		157.8		157.8	-	-	1,793.0	1,793.0	1,635.2
5	2014		157.8		157.8	-	-	1,864.7	1,864.7	1,707.0
6	2015		157.8		157.8	-	-	1,939.3	1,939.3	1,781.5
7	2016		157.8		157.8	-	-	2,016.9	2,016.9	1,859.1
8	2017		157.8		157.8	-	-	2,097.5	2,097.5	1,939.8
9	2018		157.8		157.8	-	-	2,181.4	2,181.4	2,023.7
10	2019		157.8		157.8	-	-	2,268.7	2,268.7	2,111.0
11	2020		157.8		157.8	-	-	2,359.5	2,359.5	2,201.7
12	2021		157.8		157.8	-	-	2,453.8	2,453.8	2,296.1
13	2022		157.8		157.8	-	-	2,552.0	2,552.0	2,394.2
14	2023		157.8		157.8	-	-	2,654.1	2,654.1	2,496.3
15	2024		157.8		157.8	-	-	2,760.2	2,760.2	2,602.5
16	2025		157.8		157.8	-	-	2,870.6	2,870.6	2,712.9
17	2026	-	157.8		157.8	-	-	2,985.5	2,985.5	2,827.7
18	2027	-	157.8		157.8	-	-	3,104.9	3,104.9	2,947.1
									FIRR	**9.58%**

Annex 10/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	3,549			3,549				0.0	(3,549)
3	2012	8,282			8,282				0.0	(8,282)
4	2013		118		118	0.0	0.0	1793.0	1793.0	1,675
5	2014		118.313		118	0.0	0.0	1864.7	1864.7	1,746
6	2015		118.313		118	0.0	0.0	1939.3	1939.3	1,821
7	2016		118.313		118	0.0	0.0	2016.9	2016.9	1,899
8	2017		118.313		118	0.0	0.0	2097.5	2097.5	1,979
9	2018		118.313		118	0.0	0.0	2181.4	2181.4	2,063
10	2019		118.313		118	0.0	0.0	2268.7	2268.7	2,150
11	2020		118.313		118	0.0	0.0	2359.5	2359.5	2,241
12	2021		118.313		118	0.0	0.0	2453.8	2453.8	2,336
13	2022		118.313		118	0.0	0.0	2552.0	2552.0	2,434
14	2023		118.313		118	0.0	0.0	2654.1	2654.1	2,536
15	2024		118.313		118	0.0	0.0	2760.2	2760.2	2,642
16	2025		118.313		118	0.0	0.0	2870.6	2870.6	2,752
17	2026	0	118.313		118	0.0	0.0	2985.5	2985.5	2,867
18	2027	0	118.313		118	0.0	0.0	3104.9	3104.9	2,987
									EIRR	**14.5%**

Annex 11/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

With Proposed Additional

Waterway User Charges Rs/Ton *3.5*

Financial Appraisal Rs. In lacs

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	4,732.5			4,732.5				-	(4,732.5)
3	2012	11,042.5			11,042.5				-	(11,042.5)
4	2013		157.8		157.8	-	-	2,091.8	2,091.8	1,934.1
5	2014		157.8		157.8	-	-	2,175.5	2,175.5	2,017.7
6	2015		157.8		157.8	-	-	2,262.5	2,262.5	2,104.8
7	2016		157.8		157.8	-	-	2,353.0	2,353.0	2,195.3
8	2017		157.8		157.8	-	-	2,447.1	2,447.1	2,289.4
9	2018		157.8		157.8	-	-	2,545.0	2,545.0	2,387.3
10	2019		157.8		157.8	-	-	2,646.8	2,646.8	2,489.1
11	2020		157.8		157.8	-	-	2,752.7	2,752.7	2,594.9
12	2021		157.8		157.8	-	-	2,862.8	2,862.8	2,705.0
13	2022		157.8		157.8	-	-	2,977.3	2,977.3	2,819.6
14	2023		157.8		157.8	-	-	3,096.4	3,096.4	2,938.7
15	2024		157.8		157.8	-	-	3,220.3	3,220.3	3,062.5
16	2025		157.8		157.8	-	-	3,349.1	3,349.1	3,191.3
17	2026	-	157.8		157.8	-	-	3,483.0	3,483.0	3,325.3
18	2027	-	157.8		157.8	-	-	3,622.4	3,622.4	3,464.6
									FIRR	**12.12%**

Annex 11/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	3,549			3,549				0.0	(3,549)
3	2012	8,282			8,282				0.0	(8,282)
4	2013		118		118	0.0	0.0	2091.8	2091.8	1,974
5	2014		118.313		118	0.0	0.0	2175.5	2175.5	2,057
6	2015		118.313		118	0.0	0.0	2262.5	2262.5	2,144
7	2016		118.313		118	0.0	0.0	2353.0	2353.0	2,235
8	2017		118.313		118	0.0	0.0	2447.1	2447.1	2,329
9	2018		118.313		118	0.0	0.0	2545.0	2545.0	2,427
10	2019		118.313		118	0.0	0.0	2646.8	2646.8	2,529
11	2020		118.313		118	0.0	0.0	2752.7	2752.7	2,634
12	2021		118.313		118	0.0	0.0	2862.8	2862.8	2,744
13	2022		118.313		118	0.0	0.0	2977.3	2977.3	2,859
14	2023		118.313		118	0.0	0.0	3096.4	3096.4	2,978
15	2024		118.313		118	0.0	0.0	3220.3	3220.3	3,102
16	2025		118.313		118	0.0	0.0	3349.1	3349.1	3,231
17	2026	0	118.313		118	0.0	0.0	3483.0	3483.0	3,365
18	2027	0	118.313		118	0.0	0.0	3622.4	3622.4	3,504
									EIRR	**17.4%**

Annex 12/1

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

With Proposed Additional Waterway User Charges Rs/Ton *4*

Rs. In lacs

Financial Appraisal

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	4,732.5			4,732.5				-	(4,732.5)
3	2012	11,042.5			11,042.5				-	(11,042.5)
4	2013		157.8		157.8	-	-	2,390.7	2,390.7	2,232.9
5	2014		157.8		157.8	-	-	2,486.3	2,486.3	2,328.5
6	2015		157.8		157.8	-	-	2,585.7	2,585.7	2,428.0
7	2016		157.8		157.8	-	-	2,689.2	2,689.2	2,531.4
8	2017		157.8		157.8	-	-	2,796.7	2,796.7	2,639.0
9	2018		157.8		157.8	-	-	2,908.6	2,908.6	2,750.8
10	2019		157.8		157.8	-	-	3,024.9	3,024.9	2,867.2
11	2020		157.8		157.8	-	-	3,145.9	3,145.9	2,988.2
12	2021		157.8		157.8	-	-	3,271.8	3,271.8	3,114.0
13	2022		157.8		157.8	-	-	3,402.6	3,402.6	3,244.9
14	2023		157.8		157.8	-	-	3,538.7	3,538.7	3,381.0
15	2024		157.8		157.8	-	-	3,680.3	3,680.3	3,522.5
16	2025		157.8		157.8	-	-	3,827.5	3,827.5	3,669.8
17	2026	-	157.8		157.8	-	-	3,980.6	3,980.6	3,822.9
18	2027	-	157.8		157.8	-	-	4,139.8	4,139.8	3,982.1

FIRR 14.48%

Annex 12/2

Development of Mandovi River, Zuari River and Cumerjua Canal in Goa

Project Cost - Without Involving Additional Muck Transportation Costs

Economic Appraisal

(Rs. In Lacs)

S.No	Year	Total Expenditure				Savings in Costs (Revenue)				Net Savings
		Capital	R&M	Others	Total	From New Vessel of 3000T	From Existing Vessel of above 2000T	Others	Total	
1	2010									
2	2011	3,549			3,549				0.0	(3,549)
3	2012	8,282			8,282				0.0	(8,282)
4	2013		118		118	0.0	0.0	2390.7	2390.7	2,272
5	2014		118.313		118	0.0	0.0	2486.3	2486.3	2,368
6	2015		118.313		118	0.0	0.0	2585.7	2585.7	2,467
7	2016		118.313		118	0.0	0.0	2689.2	2689.2	2,571
8	2017		118.313		118	0.0	0.0	2796.7	2796.7	2,678
9	2018		118.313		118	0.0	0.0	2908.6	2908.6	2,790
10	2019		118.313		118	0.0	0.0	3024.9	3024.9	2,907
11	2020		118.313		118	0.0	0.0	3145.9	3145.9	3,028
12	2021		118.313		118	0.0	0.0	3271.8	3271.8	3,153
13	2022		118.313		118	0.0	0.0	3402.6	3402.6	3,284
14	2023		118.313		118	0.0	0.0	3538.7	3538.7	3,420
15	2024		118.313		118	0.0	0.0	3680.3	3680.3	3,562
16	2025		118.313		118	0.0	0.0	3827.5	3827.5	3,709
17	2026	0	118.313		118	0.0	0.0	3980.6	3980.6	3,862
18	2027	0	118.313		118	0.0	0.0	4139.8	4139.8	4,022
									EIRR	**20.2%**

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Goa Mineral Ore Exports, Selected Statistics, Goa Mineral Ore exporters' Association, Goa

Natural Resources of Goa: A Geological Perspective, Geological Society of India

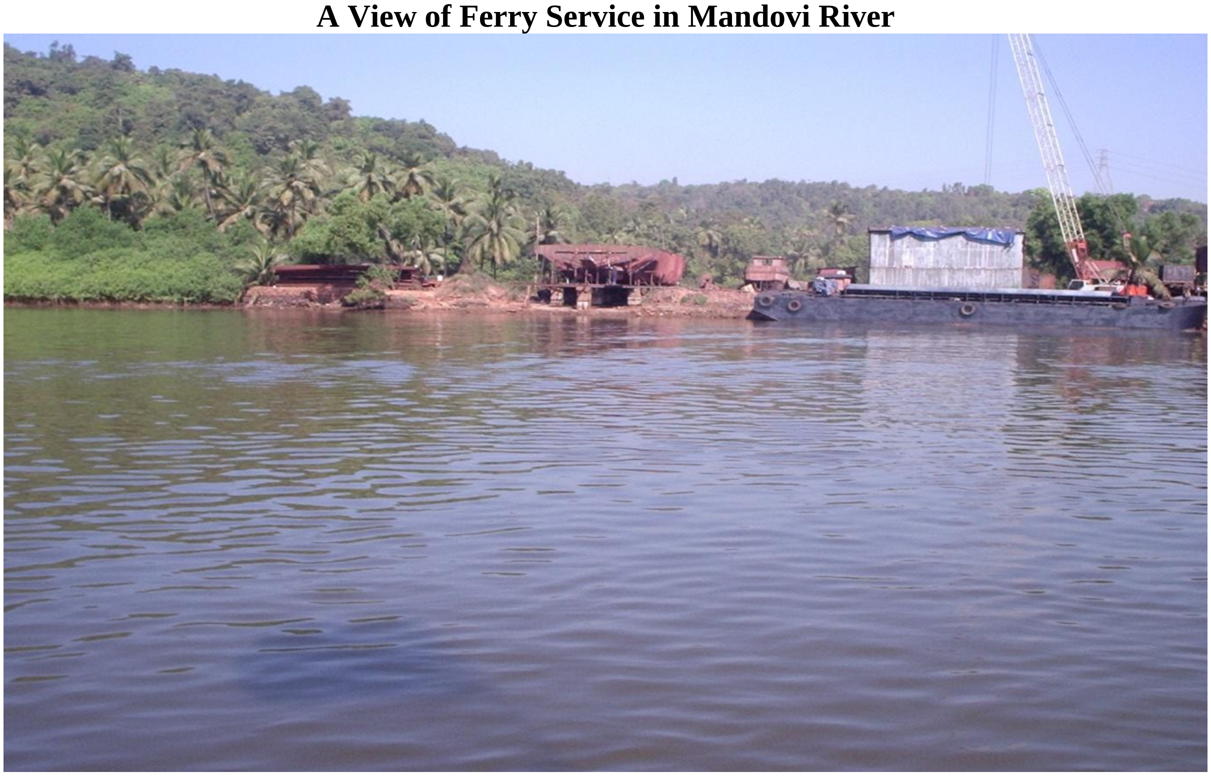
Traffic and Tidal data: Mormugao Port Trust (MPT)

Hydrgraphic Survey Chart (survey conducted by MPSO in 2002-2003), bed profile data and tidal records : Caption of Ports, Goa

Number and Details of barges: Goa Barge Owner Association (GBOA)

A View of Mandovi River near Old Goa

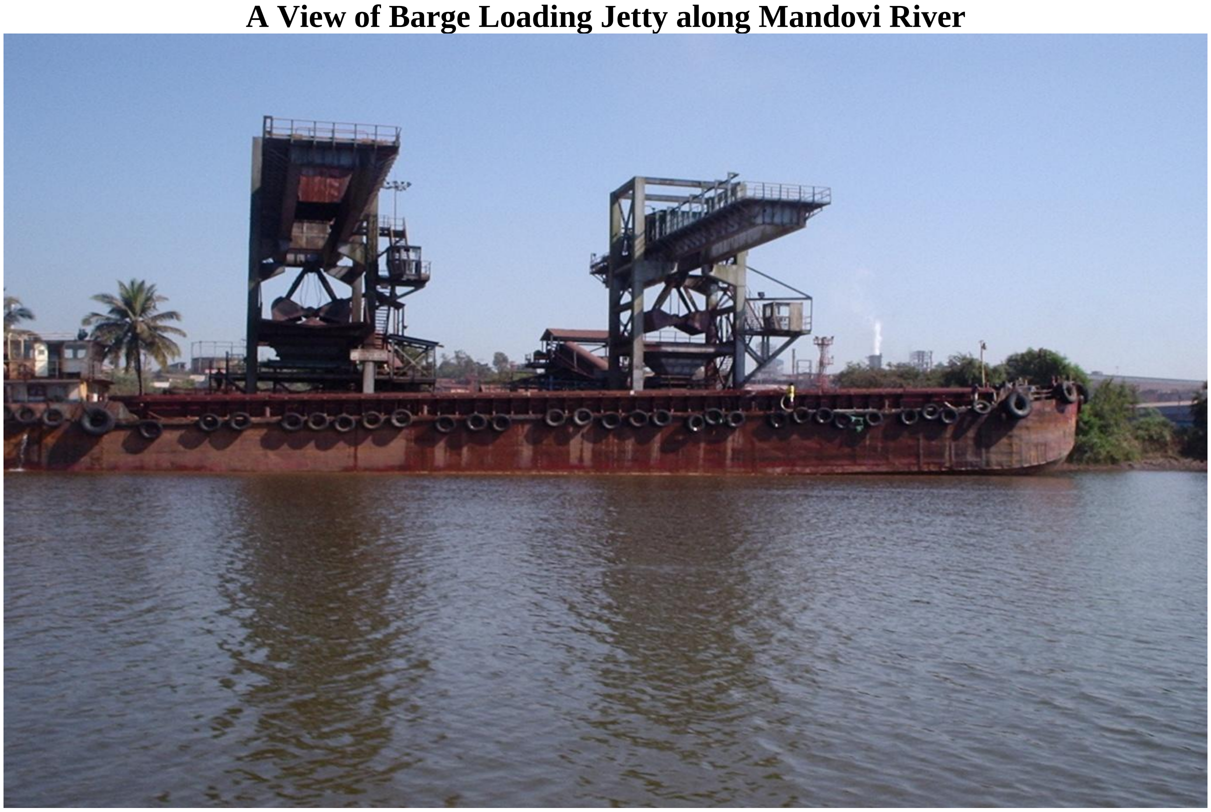
A View of Ferry Service in Mandovi River



A View of Barge Repair Facility in Zuari River

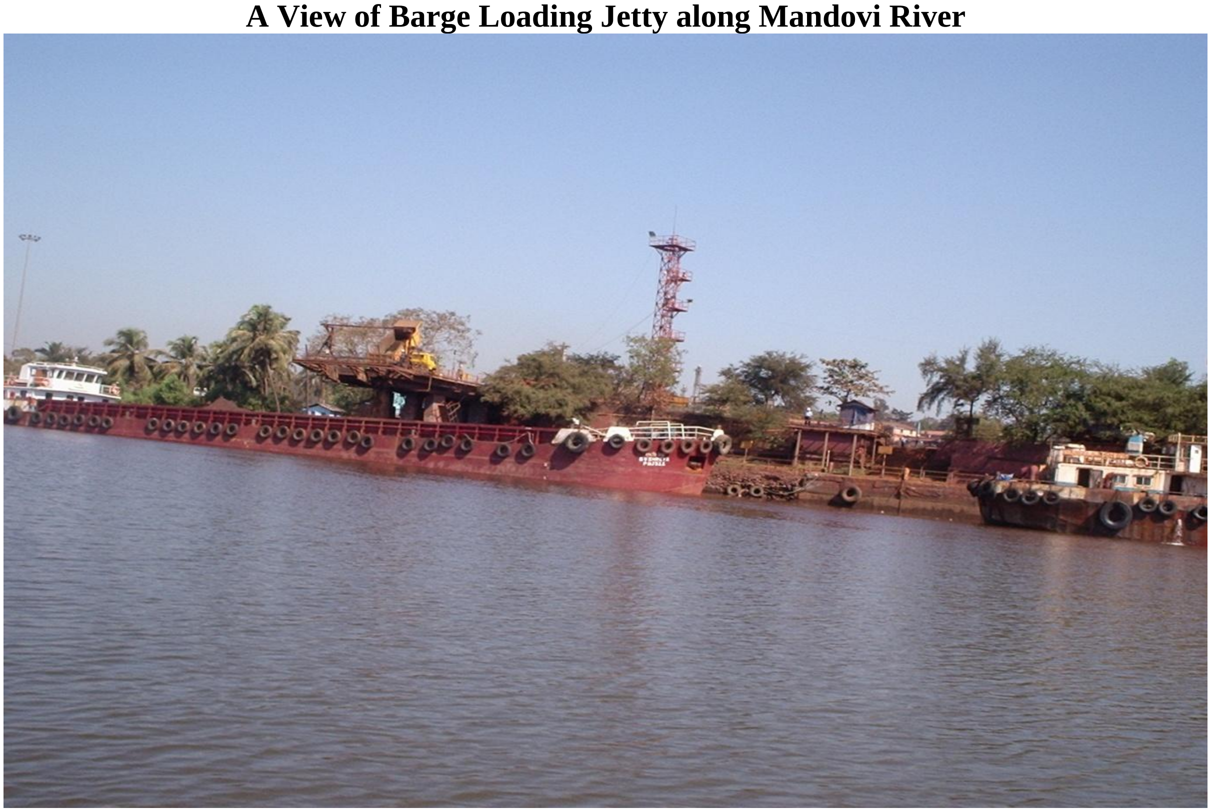
A View of Barge Construction Facility in Zuari River

A View of Barge Loading Jetty along Mandovi River



A View of Barge Loading Jetty along Zuari River

A View of Barge Loading Jetty along Mandovi River



A View of Barge Loading Jetty along Zuari River

MEETINGS INTERACTION WITH STAKE HOLDERS

The project waterways has the following major stake holders

Captain of Ports, Government of Goa – A Government Organisation
Mormugao Port Trust - A Government Organisation
Goa Barge Owners Association (GBOA) - A Private Organisation
Goa Minerals Ore Exporters Association (GMOEA) - A Private Organisation

The details of meetings convened with the above stakeholders and the outcome are furnished below:

S.No.	Stake Holders Name	Date	Matter of Discussion
1	Captain of Ports, Government of Goa (COP)	January,2011	Collected Navigational Survey charts (37 nos.), list of barges plying, Horizontal and vertical clearances of existing bridges, dredging details, tidal data, list of jetties and Bench Mark details of the project waterways
2.	Goa Barge Owners Association (GBOA)	January,2011	Meetings were convened with president and secretary of GBOA: List of barges, barge details (length, width, draft, DWT) were obtained
3	Goa Mineral Ore Exporters Association (GMOEA)	January,2011	List of major merchant mining companies, Iron ore and minerals exports from Goa were obtained. GMOEA suggestions were also obtained regarding development and infrastructural facilities required in the project waterways.
4	Mormugao Port Trust (MPT)	January,2011	Traffic and cargo details of exports and imports from the port, tidal data , cargo handling details etc were collected.
5	Captain of Ports, Government of Goa (COP)	November – December,2011	Contacted over email regarding disposal of dredged material, as per the Captain of Ports, Government of Goa (COP), dredged material can not be dumped in the vicinity of river banks due to CRZ environmental regulations. As per the recent regulations, the material has to be disposed off into the offshore dumping grounds identified and earmarked. Accordingly project cost modified.
6.	Captain of Ports, Government of Goa (COP)	January,2012	The details of soil investigation data on the project waterways had been obtained and incorporated in the report.
7	Goa Barge Owners	November,2011	Contacted over telephone and email

	Association (GBOA)		regularly with the secretary, GBOA regarding the number of barges, problems faced by barge owners, parking bay etc. The requirements of GBOA had been addressed in the report
8	Goa Barge Owners Association (GBOA)	December,2011	Contacted over telephone and email regularly to the secretary, GBOA regarding dry dock facilities , bends, dredging etc. The requirements of GBOA had been addressed in the report
9	Goa Barge Owners Association (GBOA)	January,2012	More details of barges provided by GBOA had been incorporated in the report. At this stage GBOA has informed that one barge of 3000 ton capacity has been introduced but carries less cargo due to operational restrictions. GBOA has also informed out of 72 workshops in Goa only 16 can only meeting the requirements of barge repairs. Proposed dredging activity and locations of dredging have also been discussed with GBOA. Discussions were also held on vertical & horizontal clearances for vessel movement with GBOA and obtained their views while preparation of report..