



SUSTAINABLE SAND MINING MANAGEMENT GUIDELINES 2016



पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय

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Acknowledgment

The Sustainable Sand Mining Management Guidelines 2016, has been prepared after extensive consultation with the States and stakeholders over a period of last one year. The Guideline assimilates the knowledge and experience of stakeholder. The main objective of the Guidelines is to ensure sustainable sand mining and environment friendly management practices in order to restore and maintain the ecology of river and other sand sources. The team of the officers of Ministry of Environment, Forest and Climate Change who have worked for preparing these Guidelines comprised of following:

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FOREWORD

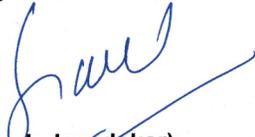
Environmental Protection and Sustainable Development have been the cornerstones of the policies and procedures governing the industrial and other developmental activities in India. The Ministry of Environment, Forest and Climate Change has taken several policy initiatives and enacted environmental and pollution control legislations to prevent indiscriminate exploitation of natural resources and to promote integration of environmental concerns in developmental projects. One such initiative is the Notification on Environmental Impact Assessment (EIA) of developmental projects issued on 14th September, 2006 under the provisions of Environment (Protection) Act, 1986, making EIA mandatory for certain categories of developmental projects.

Another land mark decision has been taken with the new notifications dated 15.01.2016 and 20.01.2016 on mining of minor minerals and constitution of District Level Environment Impact Assessment Authority and District Level Environment Appraisal Committee. This will ensure environmentally sustainable mining especially for sand and gravel under close supervision of district authorities. Use of information technology and information technology enabled services for scientific monitoring of mining and transportation of mined out material is another important feature of above notification.

Sand and gravel are one of the most important construction materials. Ensuring their availability is vital for the development of the infrastructure in the country. There are different sources of sand and gravel, the most important among them is the river. As the requirement of these construction materials is on rise, they also are very vital for the health, physical character of the river and the different important functions of the river. The extraction of sand and gravel from the river bodies has to be regulated and done with adoption of required environmental safeguards.

In view of evolving scenario in industry and development sector, My Ministry has prepared a "Sustainable Sand Mining Management Guidelines". The Guidelines *inter-alia* focus on preparation of District Survey Report; Management Plan; Marine Sand Mining and Impact on Marine Biodiversity; Issues and Management of Mining in Cluster; Management of Sand Deposited after Flood on Agricultural Field of Farmers; Mining of Sand from Agricultural Field; Monitoring System for Sustainable Sand Mining using Information Technology System; Creation of District Level Environment Impact Assessment Authority (DEIAA) and District Level Expert Appraisal Committee (DEAC) for granting Environment Clearance for Mining of Minor Minerals; Exemption of certain cases for requirement of Environment Clearance and Standard Environmental Conditions for Sustainable Sand Mining.

The Guidelines will help the Departments of Mines and Geology, State Pollution Control Boards/Committees, Industries, Regulators, Authorities and various Stakeholders to ensure environmentally sustainable mining in the Country.


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PREFACE

Sand is naturally occurring granular material composed of finely divided rock and mineral particles. Sand and gravel together known as aggregate, represent the highest volume of raw material used on earth. The mining of aggregate has been continuing for many years. Now the mining of aggregates has reached a level threatening the environment and ecosystem besides also reaching a level of scarcity that would threaten the economy. It is recommended that sand and aggregate mining, and quarrying should be done only after sound scientific assessment and adopting best practices to limit the impact on the environment.

The main objectives of the Guidelines, inter-alia, includes to ensure that sand and gravel mining is done in environmentally sustainable and socially responsible manner; availability of adequate quantity of aggregate in sustainable manner; improve the effectiveness of monitoring of mining and transportation of mined out material; conservation of the river equilibrium and its natural environment by protection and restoration of the ecological system; avoid aggradation at the downstream reach especially those with hydraulic structures such as jetties, water intakes etc.; to ensure the rivers are protected from bank and bed erosion beyond its stable profile; no obstruction to the river flow, water transport and restoring the riparian rights and in-stream habitats; to avoid pollution of river water leading to water quality deterioration; to prevent depletion of ground water reserves due to excessive draining out of ground water; and streamlining the process for grant of environmental clearance (EC) for sustainable mining.

The recommendations for management of sustainable sand extraction are the key objectives of the Guidelines. Emphasis is given to the setting up of monitoring plans that will provide data on profile changes and sediment transport capacity to enable the authorities to evaluate the long-term effect of the mining activities both upstream and downstream of sand extraction sites. Special emphasis is given on monitoring of the mined out material, which is key to the success of environment management plan. So use of IT and IT enabled services for effective monitoring of the quantity of mined out material and transportation along with process reengineering has been made a part of the Guideline. The Guidelines propose delegation of responsibility and authority to the cutting edge level i.e. the District Environment Impact Assessment Authority along with streamlining the process of impact assessment, environment management plan and environment clearance in cluster situation.



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EXECUTIVE SUMMARY

The sand and gravel are one of the most important construction materials. Ensuring their availability is vital for the development of the infrastructure in the country. There are different sources of sand and gravel, the most important among them is the river. As the requirement of these construction materials is on rise, they also are very vital for the health, physical character of the river and the different important functions of the river. The extraction of sand and gravel from the river bodies has to be regulated and done with adoption of required environmental safeguards.

For making available these resources, a mapping of these resources at the district level, identification of appropriate sites for extraction, appraisal of the extraction process, putting in place the required environmental safeguards, and rigorous monitoring of the volume of extracted material is required to ensure sustainability of the entire process.

The district is the unit of administration which is best placed to do the mapping of these resources, adopt the best environmental practices for extraction of these materials and monitor its extraction and movement. The large number of leases which are awarded, the scattered geographical location of the availability of these materials and decentralized requirement and usage of the sand and aggregates also places districts in a unique position to play a vital role in adoption of environmental safeguards needed for sustainable extraction of river sand and gravel.

Recommendations for management of sustainable sand extraction are the key objective of the Guidelines. Emphasis is given to the setting up of monitoring plans that will provide data on profile changes and sediment transport capacity to enable the authorities to evaluate the long-term effect of the mining activities both upstream and downstream of sand extraction sites.

Special emphasis is given on monitoring of the mined out material, which is key to the success of environment management plan. So use of IT and IT enabled services for effective monitoring of the quantity of mined out material and transportation along with process reengineering has been made a part of the Guidelines. The Guidelines proposes delegation of responsibility and authority to the cutting edge level i.e. the District Environment Impact Assessment Authority along with streamlining the process of impact assessment, environment management plan and environment clearance in cluster situation.

Promotion of manufactured sand, artificial sand and alternative technologies in construction materials and processes are also required for reducing the dependence and demand on naturally occurring sand and gravel. Development of slag sand, sand from stone chips and there certification under BIS is an important step in this direction.



INTRODUCTION

Sustainable Development is built on three pillars - environmental, social and economic. Sustainable development cannot be achieved if the environment is protected but poverty is prevalent in a significant part of the population. Similarly, sustainable development cannot be achieved through inappropriate economic growth, if it undermines the environment in which people and businesses exist. These Guidelines support that fundamental concept, promoting environmental protection, limiting negative physiological, hydrological and social impacts underpinning sustainable economic growth.

Sand and gravel have long been used as aggregate for construction of roads and buildings. Today, the demand for these materials continues to rise. In India, the main sources of sand are river flood plain, coastal sand, paleo channel sand, and sand from agricultural fields.

River sand mining is a common practice as habitation concentrates along the rivers and the mining locations are preferred near the markets or along the transportation route, for reducing the transportation cost. River sand mining can damage private and public properties as well as aquatic habitats. Excessive removal of sand may significantly distort the natural equilibrium of a stream channel.

Removing sediment from the active channel bed in a river interrupts the continuity of sediment transport through the river system, disrupting the sediment mass balance in the river downstream and induces channel adjustments (usually incision) extending considerable distances (commonly one kilometer or more) beyond the extraction site.

The magnitude of the impact basically depends on the magnitudes of the extraction relative to bed load sediment supply and transport through the reach. Implementation of the principles and processes outlined in these Guidelines will limit the negative externalities of sand and gravel mining.



NEED FOR POLICY GUIDELINES

Sand is naturally occurring granular material composed of finely divided rock and mineral particles between 150 micron to 4.75 mm in diameter (IS 383-1970). Sand is formed due to weathering of rocks due to mechanical forces. In the process the weathered rocks forms gravel and then sand.

Sand and gravel together known as aggregate, represent the highest volume of raw material used on earth after water. The mining of aggregate has been continuing for many years. Now the mining of aggregates has reached a level threatening the environment and ecosystem besides also reaching a level of scarcity that would threaten the economy. It is recommended that sand & aggregate mining, and quarrying should be done only after sound scientific assessment and adopting best practices to limit the impact on the environment.

It is also felt that the greater use of substitute material (Manufactured Sand, artificial sand etc.) & construction technology, and sustainable use of the resource could drastically reduce adverse impact of mining on the environment.

OBJECTIVE OF THE GUIDELINES

The Guidelines has been based on the following principles:

- Uncontrolled sand mining is not sustainable.
- Compliance with present and future legislation and regulations on the subject is mandatory and not voluntary.
- Each lease holder should be given the opportunity to self-regulate to the extent that it can demonstrate compliance with legislation and regulations.
- Where self-regulation fails to deliver compliance with legislation and regulations, increased formal enforcement and monitoring should be implemented with punitive measures applied in line with the legal framework.
- There is a need to protect the environment and the right of the population to live in clean and safe surroundings, with the need to use natural resources in a way that will make a positive and sustainable contribution to the economy.

The main objectives of the Guidelines

- To ensure that sand and gravel mining is done in environmentally sustainable and socially responsible manner.
- To ensure availability of adequate quantity of aggregate in sustainable manner.
- To improve the effectiveness of monitoring of mining and transportation of mined out material.



- Ensure conservation of the river equilibrium and its natural environment by protection and restoration of the ecological system.
- Avoid aggradation at the downstream reach especially those with hydraulic structures such as jetties, water intakes etc.
- Ensure that the rivers are protected from bank and bed erosion beyond its stable profile.
- No obstruction to the river flow, water transport and restoring the riparian rights and in-stream habitats.
- Avoid pollution of river water leading to water quality deterioration.
- To prevent depletion of ground water reserves due to excessive draining out of ground water.
- To prevent ground water pollution by prohibiting sand mining on fissures where it works as filter prior to ground water recharge.
- To maintain the river equilibrium with the application of sediment transport principles in determining the locations, period and quantity to be extracted.
- Streamlining and simplifying the process for grant of environmental clearance (EC) for sustainable mining.



THE EFFECT OF SAND AND GRAVEL MINING

Mining within or near riverbed has a direct impact on the stream's physical characteristics, such as channel geometry, bed elevation, substratum composition and stability, in-stream roughness of the bed, flow velocity, discharge capacity, sediment transport capacity, turbidity, temperature etc. Alteration or modification of the above attributes may cause hazardous impact on ecological equilibrium of riverine regime. This may also cause adverse impact on in-stream biota and riparian habitats. This disturbance may also cause changes in channel configuration and flow-paths.

The effects of sand and gravel mining are as follows:

- a) Extraction of bed material in excess of replenishment by transport from upstream causes the bed to lower (degrade) upstream and downstream of the site of removal.
- b) In-stream habitat is impacted by increase in river gradient, suspended load, sediment transport and sediment deposition. Excessive sediment deposition for replenishment increases turbidity which prevents penetration of light required for photosynthesis and reduces food availability of aquatic fauna.
- c) Riparian habitat including vegetative cover on and adjacent to the river banks it controls erosion, provide nutrient inputs into the stream and prevents intrusion of pollutants in the stream through runoff. Bank erosion and change of morphology of the river can destroy the riparian vegetative cover.
- d) Bed degradation are responsible for channel shifting, causing loss of properties and degradation of landscape, it can also undermine bridge supports, pipe lines or other structures.
- e) Degradation may change the morphology of the river bed, which constitutes one aspect of the aquatic habitat.
- f) Degradation can deplete the entire depth of gravelly bed material, exposing other substrates that may underlie the gravel, which could in turn affect the quality of aquatic habitat. Lowering of ground water table in the flood plain because of lowering of riverbed level as well as river water level takes place because of extraction and draining out of excessive ground water from the adjacent areas. So, if a floodplain aquifer drains to the stream, groundwater levels can be lowered as a result of bed degradation.
- g) Lowering of the water table can destroy riparian vegetation.
- h) Excessive pumping of ground water in the process of mining in abandoned channels depletes ground water causing scarcity of irrigation and drinking water. In extreme cases it may create ground fissures and subsidence in adjacent areas.
- i) Flooding is reduced as bed elevations and flood heights decrease, reducing hazard for human occupancy of floodplains and the possibility of damage to engineering works.
- j) The supply of overbank sediments to floodplains is reduced as flood heights decrease.
- k) An un-scientific and unregulated sand and gravel mining tends to increase channel bank



scouring and erosion. This causes a large degree of meandering of rivers and sometimes it could be in kms.

- l) Rapid bed degradation may induce bank collapse and erosion by increasing the heights of banks.
- m) Polluting ground water by reducing the thickness of the filter material especially if mining is taking place at top of recharge fissures.
- n) Choking of sand layer which acts as filter for ingress of ground water from river by dumping of finer material, compaction of filter zone due to movement of heavy vehicles. It also reduces the permeability and porosity of the filter material.
- o) Removal of gravel from bars may cause downstream bars to erode if they subsequently receive less bed material than is carried downstream from them by fluvial transport.
- p) Ecological effects on bird nesting, fish migration, angling, etc.
- q) Indiscrete mining activities lead to increased concentration of suspended sediment in the river which in turn causes siltation of water resources projects.
- r) Un-scientific and unregulated sand and gravel mining leads to the severe health hazards like air quality degradation and dust fog.
- s) Direct destruction from heavy equipment operation; discharges from equipment and refueling.
- t) Biosecurity and pest risks.
- u) Impacts on coastal processes.

The other deleterious impacts of indiscrete mining include

Loss of riparian habitat resulting from direct removal of vegetation along the stream bank to facilitate the use of a dragline or through the process of lowering the water table, bank undercutting, and channel incision. The physical composition and stability of substrates are altered as a result of in-stream mining and most of these physical effects may exacerbate sediment entrainment in the channel. Furthermore, the process of in-stream mining and gravel washing produces fine sediments under all flow conditions, resulting in a deposition of fine sediment in riffles as well as other habitats at low discharge. Excess sediment is considered the greatest pollutant in waters and constitutes one of the major environmental factors in the degradation of stream fisheries.

However, in-stream mining may contribute additional sediment to downstream reaches due to the disruption of substrate stability. Once sediment enters the stream, it is best to let natural geomorphological and hydrological processes reach a dynamic equilibrium, rather than further exacerbating the situation by additional disturbance.

**All other things being equal:**

- a) Extracting gravel from an excavation that does not penetrate the water table and is located away from an active stream channel should cause little or no change to the natural hydrological processes unless the stream captures the pit during periods of flooding.
- b) In-stream extraction of gravel from below the water level of a stream generally causes more changes to the natural hydrologic processes than limiting extraction to a reference point above the water level.
- c) In-stream extraction of gravel below the deepest part of the channel (the thalweg) generally causes more changes to the natural hydrological processes than limiting extraction to a reference point above the thalweg.
- d) Excavating sand and gravel from a small straight channel with a narrow floodplain generally will have a greater impact on the natural hydrological processes than excavations on a braided channel with a wide floodplain.
- e) Extracting sand and gravel from a large river or stream will generally create less impact than extracting the same amount of material from a smaller river or stream.
- f) Over-extraction of gravel can destabilise channels and banks, and/or affect the ecologic functioning of rivers particularly if undertaken at the wrong time, or in the wrong place, or in a way that damages the river bed or margins.



GENERAL APPROACH TO SUSTAINABLE SAND AND GRAVEL MINING

Following considerations should be kept in mind for sand / gravel mining:

- a) Parts of the river reach that experience deposition or aggradation shall be identified first. The Lease holder/ Environmental Clearance holder may be allowed to extract the sand and gravel deposit in these locations to manage aggradation problem.
- b) The distance between sites for sand and gravel mining shall depend on the replenishment rate of the river. Sediment rating curve for the potential sites shall be developed and checked against the extracted volumes of sand and gravel.
- c) Sand and gravel may be extracted across the entire active channel during the dry season.
- d) Abandoned stream channels on terrace and inactive floodplains be preferred rather than active channels and their deltas and flood plains. Stream should not be diverted to form inactive channel.
- e) Layers of sand and gravel which could be removed from the river bed shall depend on the width of the river and replenishment rate of the river.
- f) Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.
- g) Segments of braided river system should be used preferably falling within the lateral migration area of the river regime that enhances the feasibility of sediment replenishment.
- h) Sand and gravel shall not be extracted within 200 to 500 meter from any crucial hydraulic structure such as pumping station, water intakes, and bridges. The exact distance should be ascertained by the local authorities based on local situation. The cross-section survey should cover a minimum distance of 1.0 km upstream and 1.0 km downstream of the potential reach for extraction. The sediment sampling should include the bed material and bed material load before, during and after extraction period. Develop a sediment rating curve at the upstream end of the potential reach using the surveyed cross- section. Using the historical or gauged flow rating curve, determine the suitable period of high flow that can replenish the extracted volume. Calculate the extraction volume based on the sediment rating curve and high flow period after determining the allowable mining depth.
- i) Sand and gravel could be extracted from the downstream of the sand bar at river bends. Retaining the upstream one to two thirds of the bar and riparian vegetation is accepted as a method to promote channel stability.



- j) Flood discharge capacity of the river could be maintained in areas where there are significant flood hazard to existing structures or infrastructure. Sand and gravel mining may be allowed to maintain the natural flow capacity based on surveyed cross- section history.
- k) Alternatively, off-channel or floodplain extraction is recommended to allow rivers to replenish the quantity taken out during mining.
- l) The Piedmont Zone (Bhabhar area) particularly in the Himalayan foothills, where riverbed material is mined, this sandy-gravelly track constitutes excellent conduits and holds the greater potential for ground water recharge. Mining in such areas should be preferred in locations selected away from the channel bank stretches.
- m) Mining depth should be restricted to 3 meter and distance from the bank should be 3 meter or 10 percent of the river width whichever less.
- n) The borrow area should preferably be located on the river side of the proposed embankment, because they get silted up in course of time. For low embankment less than 6 m in height, borrow area should not be selected within 25 m from the toe/heel of the embankment. In case of higher embankment the distance should not be less than 50 m. In order to obviate development of flow parallel to embankment, cross bars of width eight times the depth of borrow pits spaced 50 to 60 meters centre-to-centre should be left in the borrow pits.
- o) Demarcation of mining area with pillars and geo-referencing should be done prior to start of mining.



THE WORLD SCENARIO

Sand and gravel are mined world-wide and account for the largest volume of solid material extracted globally. Formed by erosive processes over thousands of years, they are now being extracted at a rate far greater than their renewal. Furthermore, the volume being extracted is having a major impact on rivers, deltas and coastal and marine ecosystems, resulting in loss of land through river or coastal erosion, lowering of the water table and decrease in the amount of sediment supply. Despite the colossal quantities of sand and gravel being used, increasing dependence on them and the significant impact that their extraction has on the environment, this issue needs far better attention and awareness.

Globally, between 47 and 59 billion tonnes of material is mined every year of which sand and gravel, known as aggregates, account for both the largest share (from 68% to 85%) and the fastest growth in extraction increase. Although more sand and gravel are mined than any other material, reliable data on their extraction is not available. The absence of global data on aggregates mining makes environmental assessment very difficult and has contributed to the lack of awareness about this issue. One way to estimate the global use of aggregates indirectly is through the production of cement for concrete (concrete is made with cement, water, sand and gravel). The production of cement is reported by 150 countries and it reached 3.7 billion tonnes in 2012 (USGS, 2013a). For each tonne of cement, the building industry needs about six to seven times more tonnes of sand and gravel (USGS, 2013b). Thus, the world's use of aggregates for concrete can be estimated at 25.9 billion tonnes a year for 2012 alone.

Added to this are all the aggregates used in land reclamation, shoreline developments and road embankments (for which the global statistics are unavailable), added to this is the 180 million tonnes of sand used in industry (USGS, 2012). Aggregates also contribute to 90% of asphalt pavements and 80% of concrete roads (Robinson and Brown, 2002). Taking all these estimates into account, a conservative estimate for the world consumption of aggregates exceeds 40 billion tonnes a year.

This large quantity of material cannot be extracted and used without a significant impact on the environment. Extraction has an impact on biodiversity, water turbidity, water table levels and landscape and on climate through carbon dioxide emissions from transportation. There are also socio-economic, cultural and even political consequences. In some extreme cases, the mining of marine aggregates has changed international boundaries, such as through the disappearance of sand islands in Indonesia (New York Times, 2010; Guerin, 2003).

The impacts of sand mining can be mainly categorized as follows:



IMPACTS ON	DESCRIPTION
Biodiversity	Impacts on related ecosystems (for example; fisheries)
Land losses	Both inland and coastal through erosion
Hydrological functions	Change in water flows, flood regulation and marine currents
Water supply	Through lowering of the water table and pollution
Infrastructures	Damage to bridges, river embankments and coastal infrastructures
Climate	Directly through transport emissions
Landscape	Coastal erosion, changes in deltaic structures, quarries, pollution of rivers
Extreme events	Decline of protection against extreme events (flood, drought, storm surge)

World over sand was until recently extracted in land quarries and riverbeds; however, a shift to marine and coastal aggregates mining has occurred due to the decline of inland resources. River and marine aggregates remain the main sources for building and land reclamation. For concrete, in-stream gravel requires less processing and produces high-quality material while marine aggregate needs to be thoroughly washed to remove salt. If the chloride is not removed from marine aggregate, a structure built with it might collapse after few decades due to corrosion of steel reinforced structures. Most sand from deserts cannot be used for concrete and land reclaiming, as the wind erosion process forms round grains that do not bind well.



INDIAN SCENARIO

The data on consumption of sand and aggregate in country is not available with any source. It can be derived indirectly from the usage of cement, construction of roads and stowing of mines. The trend for aggregates extraction can be estimated using cement production as a proxy.

Cement production has multiplied three-fold in the last 20 years from 1.37 billion tonnes of cement in 1994 to 3.7 billion tonnes in 2012 (USGS, 2013a) mainly as a result of rapid economic growth in Asia (UNEP and CSIRO, 2011). Five countries: China (58%), India (6.75%), the United States (2%), Brazil and Turkey - produce 70% of the world's cement (USGS, 2013c). The consumption of cement is expected to reach 324 million tonnes, which equates to use of 2.2 billion tonnes of aggregates. This is in addition to sand and aggregates used in stowing of mines, industry and other allied usage.

In India the main sources of sand are:

- (a) River (riverbed and flood plain).
- (b) Lakes and reservoirs.
- (c) Agricultural fields (Haryana).
- (d) Coastal / marine sand.
- (e) Palaeo-channels (Bikaner in Rajasthan).



THE PRICE ELASTICITY FOR DEMAND OF SAND

As the price elasticity of demand for sand is inelastic (-0.88), any increase in price in absence of marketable alternative will not have any significant impact on demand. Use of crushed stones or other substitute material should be promoted. The regional context of aggregate resources, market demand, and the environmental impacts of various alternatives must be understood before any site-specific proposal for aggregate extraction can be reviewed.

Evaluation of aggregate supply and demand should be undertaken on the basis of production-consumption regions, encompassing the market for aggregate and all potential sources of aggregate within an economical transport distance. The finite nature of high-quality alluvial gravel resources must be recognized, and high-quality PCC-grade aggregates should be reserved only for the uses demanding this quality material (such as concrete). Alternative sources should be used in less demanding applications (such as road sub-base). Part replacement with fly ash in roads and embankments be promoted in place of sand and aggregates.

The environmental costs of sand mining should be incorporated into the price of the product so that alternative sources that require more processing but have less environmental impact become more attractive.

PROCESS OF SEDIMENT TRANSPORT

The loose boundary (consisting of movable material) of an alluvial channel deforms under the action of flowing water and the deformed bed with its changing roughness (bed forms) interacts with the flow. The resulting movement of the bed material (sediment) in the direction of flow is called sediment transport and a critical bed shear stress must be exceeded to start the particle movement.

Such a critical shear stress is referred as incipient (threshold) motion condition, below which the particles will be at rest and the flow is similar to that on a rigid boundary. Some sediment particles roll or slide along the bed intermittently and some others saltate (hopping or bouncing along the bed). The material transported in one or both of these modes is called 'bed load'.

Finer particles (with low fall velocities) are entrained in suspension by the fluid turbulence and transported along the channel in suspension. This mode of transport is called 'suspended load'. Sometimes finer particles from upland catchment (sizes which are not present in the bed material), called 'wash load', are also transported in suspension. The combined bed material and wash load is called 'total load'.



Bed load ranges from a few percent of total load in lowland rivers to perhaps 15% in Mountain Rivers to over 60% in some arid catchments. Although a relatively small part of the total sediment load, the arrangement of bed load sediment constitutes the architecture of sand, and gravel-bed channels.

The rate of sediment transport typically increases as a power function of flow; that is, a doubling of flow typically produces more than a doubling in sediment transport and most sediment transport occurs during floods. The environmental impacts from in-stream mining can be avoided, if the annual bed load is calculated and aggregate extraction is restricted to that value or some portion of it. To accurately limit extraction to some portion of bed load, the amount of sediment that passes the in-stream mining site during a given period of time must be calculated.

There is a large amount of uncertainty in the process of calculating annual rates of bed load transport. How much coarse material is moved, how long it remains in motion as also how far it moves depends on the size, shape & packing of the material and the characteristics of the river flow.

Downstream movement commonly occurs as irregular bursts of short-distance movement separated by longer periods, when the particles remain at rest. Because bed load changes from hour-to-hour, day-to-day, and year-to-year, estimating annual bed load rates is a dynamic process involving careful examination.

Constant variations in the flow of the river make the channel floor and riverbanks a dynamic interface, where some materials are being eroded while others are being deposited. The net balance of this activity, on a short- term basis, is referred to as scour or fill.

On a long-term basis, continued scour results in erosion (degradation), while continued fill results in deposition (aggradation).

A general indicator of the stability of a stream relates to the amount of vegetation present. Gravel bars that are vegetated or where the gravel is tightly packed, generally indicate streams, where the gravel supply is in balance. Streams with excessive gravel generally have gravel bars with little or no vegetation, and are surfaced with loosely packed gravel.



SUSTAINABLE SAND AND GRAVEL MINING GUIDELINES

The broad principle on which any sustainable sand mining Guidelines / policy can be based is that river/ natural resources must be utilized for the benefit of the present and future generation, so river resources should be prudently managed and developed. The preparation of District Survey Report is an important initial step.

The Processes under the Guidelines:

- (a) Identification of areas of aggradation / deposition where mining can be allowed; and identification of areas of erosion and proximity to infrastructural structures and installations where mining should be prohibited. Use of satellite imagery for identifying areas of sand deposit and quantity be done.
- (b) Calculation of annual rate of replenishment and allowing time for replenishment after mining in area.
- (c) Identifying ways of scientific and systematic mining.
- (d) Identifying measures for protection of environment and ecology.
- (e) Determining measures for protection of bank erosion.
- (f) A bench mark (BM) with respect to mean sea level (MSL) should be made essential to in-mining channel reaches (MCR). Below which no mining shall be allowed.
- (g) Identifying steps for conservation of mineral.
- (h) Permanent gauging facilities (for discharge and sediment both) should be made compulsory for the sites having excessive mining in consultation with Central Water Commission or any competent State Agency.
- (i) Implementing safeguards for checking illegal and indiscrete mining.

Following the above processes, to begin with it is important to prepare a survey document mapping the status of sand sources in a district. This survey should be conducted and report be prepared for each district. Though it is an acceptable fact that rivers cut across districts and States and every river is an ecosystem in itself. But, keeping in view the fact that the district is the most established unit of administration at which this kind of survey, planning and monitoring can be ensured effectively, it is proposed that every district will prepare this document taking the river stretch in that district as an ecological unit and inventorising other sources of sand in the district.

Besides, the production of aggregate in a particular area is a function of availability of natural resources, the size of the population, the economy of the area and various developmental and infrastructural works being undertaken in the area.



The natural resources must be utilized in environment friendly manner in scientific and systematic way and with the objective of sustainable development the policy on the subject should have provisions for protection of environment & ecology. These factors can be accounted for in a most efficient manner at district level.

The sustainable mining plan needs to be dynamic. A survey should be carried out by the District Environment Impact Assessment Authority (DEIAA) with the assistance of Geology Department, Irrigation Department, Forest Department, Public Works Department, Ground Water Boards, Remote Sensing Department and Mining Department etc. in the district at regular intervals.

The survey shall contain:

1. District wise detail of river or stream and other sand source.
2. District wise availability of sand or gravel or aggregate resources.
3. District wise detail of existing mining leases of sand and aggregates.

Based on this survey document, the action plan shall divide the river/ stream/ other sources of the District into the following categories:

1. River / Stream beds sections / other sources suitable for extraction of sand and aggregates.
2. River / Stream beds sections / other sources prohibited for extraction of sand and aggregates.

The river/ streams/ other sources of sand and aggregate are studied on following parameters:

a) Geomorphological studies

- i) Place of origin
- ii) Catchment area.
- iii) General profile of river stream.
- iv) Annual deposition factor.
- v) Replenishment.
- vi) Total potential of minor mineral in the river bed.

b) Geological studies

- i) Lithology of catchment area.
- ii) Tectonics and structural behavior of rocks.

c) Climatic Factors

- i) Intensity of rainfall.
- ii) Climate Zone.
- iii) Temperature variation



The following points to be considered while selecting the river / stream for mining besides the above parameters:

- i) A stable river is able to constantly transport the flow of sediments produced by watershed such that its dimensions (width and depth) pattern and vertical profile are maintained without aggrading (building up) or degrading (scouring down).
- ii) The amount of boulders, cobbles, pebbles, and sand deposited in river bed equals to the amount delivered to the river from catchment area and from bank erosion minus amount transported downstream each year.
- iii) It is compulsive nature of river to meander in their beds and therefore they will have to be provided with adequate corridor for meandering without hindrance. Any attempt to diminish the width of the corridor (floodway) and curb the freedom to meander would prove counterproductive.
- iv) Erosion and deposition is law of nature. The river stream has to complete its geomorphological cycles from youth, mature to old age.
- v) River capturing is unavoidable.
- vi) Fundamentally the lowest point of any stream is fixed by sea level.

This survey document should be prepared in the district based on direct and indirect benefits of mining and identification of the potential threats to the river / stream beds in the district.

Besides, calculating the carrying capacity of the river / stream beds / other sources to find out maximum quantity available to be allowed for removal each year from the sources, it should also provide various measures to regulate sand and aggregate mining in a systemic way.

It has to provide for environmentally safe depth of mining and safeguards of banks by prescribing safe distance from banks. It is required that there should be a Sub-Divisional Committee which should visit each site and make recommendation. The Committee should comprise of Sub-Divisional Magistrate, Officers from Irrigation department, State Pollution Control Board or Committee, Forest department, Geology or mining officer shall visit each site for which environmental clearance has been applied for and make recommendation on suitability of site for mining or prohibition thereof.



THE STRUCTURE OF DISTRICT SURVEY REPORT

The report can have following structure:

1. Introduction
2. Overview of Mining Activity in the District
3. The List of Mining Leases in the District with location, area and period of validity
4. Details of Royalty or Revenue received in last three years
5. Detail of Production of Sand or Bajari or minor mineral in last three years
6. Process of Deposition of Sediments in the rivers of the District
7. General Profile of the District
8. Land Utilization Pattern in the district: Forest, Agriculture, Horticulture, Mining etc.
9. Physiography of the District
10. Rainfall: month-wise
11. Geology and Mineral Wealth

12. Drainage System with description of main rivers.

Sl.No.	NAME OF RIVER	AREA DRAINED (Sq. Km)	% AREA DRAINED

13. Salient Features of Important Rivers and Streams:

Sl.No.	Name of the River / Stream	Total Length in the District (in Km)	Place of origin	Altitude at Origin

14. Methodology Adopted for Calculating of Mineral Potential

The mineral potential is calculated based on field investigation and geology of the catchment area of the river/ streams. As per the policy of the State and location, depth of minable mineral is defined. The area for removal of mineral in a river or stream can be decided depending on geo-morphology



and other factors, it can be 50% to 60% of the area of a particular river/stream, e.g. in Himachal Pradesh mineral constituents like boulders, river born bajari, sand up to a depth of one meter are considered as resource mineral. Other constituents like clay and silt are excluded as waste while calculating the mineral potential of particular river/ stream.

The specific gravity of each mineral constituent is different. While calculating the mineral potential, the average specific gravity is taken as 2.25. The percent of mineral constituent like boulder, river bajari, sand also varies for different river and streams. While calculating the mineral potential the percentage of each mineral constituent is taken as, Boulders 35-40%, Bajari - 30-35%, Sand 25-30% and 5-10% for silt and clay.

The quantum of deposition varies from stream to stream depending upon factors like catchment lithology, discharge, river profile and geomorphology of the river course. There are certain geomorphological features developed in the river beds such as channel bar, point bar etc. where annual deposition is more even two to three meters.

For illustration one example of Yamuna River in Sirmaour district of Himachal Pradesh is given below:

Portion of the River / Stream Recommended for Mineral Concession	Length of area recommended for mineral concession (in kilometer)	Average width of area recommended for mineral concession (in meters)	Area recommended for mineral concession (in square meter)	Mineable mineral potential (in metric tonne) (60% of total mineral potential)
From Downstream of confluence with Tons River to Behral near Haryana and Uttar Pradesh border	31	478	14818000	16803612

Note: Considering the density of river bed material to be **1.89 g/cm³**

Present Status of Mining

This gives the detail of mining leases already in operation in this stretch, area and production in last three years from these leases is calculated.



zone of deposition. These zones of deposition and erosion are extended in different patches in the river.

Any mining lease granted in larger tract can cover both the zones, and mining activity in zone of erosion can further aggravate the problem of erosion and as such the mining activity can be allowed only in the zone of the deposition. The mining leases of larger areas in rivers are neither in interest of environment nor in the interest of mineral conservation.

In Himalayan states the rivers and wasteland has been mostly classed as forest land and mining on that requires diversion of forest land and payment of compensatory afforestation and NPV etc. The land in river beds in hilly tracts and many small rivers at any one site seldom exceed 5 hectare, so not allowing sand mining leases less than 5 hectare on river beds further aggravates the situation. So the size of mining lease for river sand mining should be determined by the State as per the local situation.



MANAGEMENT PLAN

1. River Bed Mining Recommendations:

a) Permit Mining Volume Based on Measured Annual Replenishment

In the first year following adoption of the management plan, a volume equal to the estimated annual replenishment could be extracted from the reach of channel. Replenishment (up to the elevation of the selected channel configuration) would need to occur before subsequent extraction could take place. The concept of annual replenishment accounts for the episodic nature of sediment transport. For example, during wet periods with high stream flows, and a high contribution of sediment from hill slopes and tributaries, monitoring data would show that sand and gravel bars are replenished quickly. During drought periods with low stream flow, and little sediment supply or transport, monitoring data would likely show that bars were replenished at a slower rate.

The use of monitoring data is essential in measuring when actual replenishment occurs. The use of the concept of annual replenishment protects long-term channel stability as well as aquatic and riparian habitat by extracting a volume sustainable by watershed processes.

b) Establish an Absolute Elevation below Which No Extraction May Occur (Minimum Enveloped Level or Redline).

The absolute elevation below which no mining could occur or "redline" would be surveyed on a site-specific basis in order to avoid impacts to structures such as bridges and to avoid vegetation impacts associated with down-cutting due to excessive removal of sediment. An extraction site can be determined after setting the deposition level at 1 m above natural channel thalweg elevation, as determined by the survey approved by mine plan approving authority.

c) Limit River Bed Extraction Methods to Bar Skimming

If mining is limited to the downstream end of the bar with a riparian buffer on both the channel and hill slope (or floodplain) side, bar skimming would minimise impacts. Other methods such as excavation of trenches or pools in the low flow channel lower the local base level, and maximise upstream (head cutting and incision) and downstream (widening and braiding) impacts. In addition, direct disturbance of the substrate in the low flow channel should be avoided. Trenching on bars may be beneficial in the future if the river becomes severely aggraded, flat, shallow and braided. Trenching of bars may initially impact a smaller area of riparian habitat than skimming - as a result of excavating deeper rather than shallow skimming of a large area. However, over the



long-term, the upstream and downstream effects of a trench on the bar or in the channel may offset any short-term benefit derived from this method.

d) Extract Sand and Gravel from the Downstream Portion of the Bar:

Retaining the upstream one to two thirds of the bar and riparian vegetation while excavating from the downstream one to two third of the bar is accepted as a method to promote channel stability and protect the narrow width of the low flow channel necessary for aquatic life. Sand and gravel would be re-deposited in the excavated downstream one to two thirds of the bar (or downstream of the widest point of the bar) where an eddy would form during sediment transporting flows. In contrast, if excavation occurs on the entire bar after removing existing riparian vegetation, there is a greater potential for widening and braiding of the low flow channel.

e) Concentrate Activities to Minimise Disturbance:

River bed extraction activities should be concentrated or localised to a few bars rather than spread out over many bars. This localisation of extraction will minimise the area of disturbance of upstream and downstream effects. Skimming decreases habitat and species diversity - these effects should not be expanded over a large portion of the area.

f) Review Cumulative Effects of Sand and Gravel Extraction:

The cumulative impact of all mining proposals should be reviewed on an annual basis to determine if cumulative riverine effects or effects to the estuary are likely.

g) Maintain Flood Capacity:

Flood capacity in the river should be maintained in areas where there are significant flood hazards to existing structures or infrastructure.

h) Establish a Long-term Monitoring Program:

Monitoring of changes in bed elevation and channel morphology, and aquatic and riparian habitat upstream and downstream of the extraction would identify any impacts of sand and gravel extraction to biologic resources. Long-term data collected over a period of decades as sand and gravel extraction occurs will provide data to use in determining trends.

i) Minimise Activities That Release Fine Sediment to the River:

No washing, crushing, screening, stockpiling, or plant operations should occur at or below the streams "average high water elevation," or the dominant discharge. These and similar activities have the potential to release fine sediments into the stream, providing habitat conditions harmful to local fish.



j) Retain Vegetation Buffer at Edge of Water and Against River Bank:

Riparian vegetation performs several functions essential to the proper maintenance of geomorphic and biological processes in rivers. It shields river banks and bars from erosion. Additionally, riparian vegetation, including roots and downed trees, serves as cover for fish, provides food source, works as a filter against sediment inputs, and aids in nutrient cycling. More broadly, the riparian zone is necessary to the integrity of the ecosystem providing habitat for invertebrates, birds and other wildlife.

k) The River Bed mining should only be allowed during the dry season.

No River bed mining should be permitted during rainy season (see Appendix 9).

l) An Annual Status and Trends Report:

This report should review permitted extraction quantities in light of results of the monitoring program, or as improved estimates of replenishment become available. The report should document changes in bed elevation, channel morphology, and aquatic and riparian habitat. The report should also include a record of extraction volumes permitted, and excavation location. Finally, recommendations for reclamation, if needed should be documented.

2. Off-Channel or Floodplain Extraction Recommendations

a) Floodplain Extraction should be set back from the Main Channel

In a dynamic alluvial system, it is not uncommon for meanders to migrate across a floodplain. In areas where sand and gravel occurs on floodplains or terraces, there is a potential for the river channel to migrate toward the pit. If the river erodes through the area left between the excavated pit and the river, there is a potential for "river capture," a situation where the low flow channel is diverted through the pit. In order to avoid river capture, excavation pits should set back from the river to provide a buffer, and should be designed to withstand the 100-year flood (100-year ARI). Adequate buffer widths and reduced pit slope gradients are preferred over engineered structures which require maintenance in perpetuity. Hydraulic, geomorphic, and geotechnical studies should be conducted prior to design and construction of the pit and bund. In addition to river capture, extraction pits create the possibility of stranding fish.

b) The maximum depth of Floodplain Extraction should remain above the Channel Thalweg

Floodplain pits should not be excavated below the elevation of the thalweg in the adjacent channel. This will minimise the impacts of potential river capture by limiting the potential for head cutting and the potential of the pit to trap sediment. A shallow excavation (above the water table) would provide a depression that would fill with



water part of the year, and develop seasonal wetland habitat. An excavation below the water table would provide deep water habitat.

c) Side Slopes of Floodplain Excavation Should Range from 3:1 to 10:1

Side slopes of a floodplain pit should be graded to a slope that ranges from 3:1 to 10:1. This will allow for a range of vegetation from wetland to upland. Steep side slopes excavated in floodplain pits on other systems have not been successfully reclaimed, since it is difficult for vegetation to become stabilised. Terrace pits should be designed with a large percentage of edge habitat with a low gradient which will naturally sustain vegetation at a variety of water levels.

d) Place Stockpiled Topsoil above the 25-year Return Period or ARI Level

Stockpiled topsoil can introduce a large supply of fines to the river during a flood event and degrade fish habitat. Storage above the 25-year flood (25-year ARI) inundation level is sufficient to minimise this risk.

e) Floodplain Pits Should Be Restored to Wetland Habitat or Reclaimed for Agriculture

The key to successful restoration or reclamation is to conserve or import adequate material to re-fill the pit, while ensuring that pit margins are graded to allow for development of significant wetland and emergent vegetation.

f) Establish a Long-term Monitoring Program

A long-term monitoring program should provide data illustrating any impacts to river stability, groundwater, fisheries, and riparian vegetation. The monitoring program should assess the success of any reclamation or restoration attempted.

g) An Annual Status and Trends Report

The status and trends report described previously should include a section on the hydrologic and biologic components of floodplain pit reclamation.

3. Extraction Methods

The important methods of sand and gravel mining operations are as below:

- a) Bar scalping or skimming** is extraction of sand and gravel from the surface of bars. This method generally requires that surface irregularities be smoothed out and that the extracted material be limited to what could be taken above an imaginary line sloping upwards and away from the water from a specified level above the river's water surface at the time of extraction (typically 0.3 - 0.6 m (1-2 ft)). Bar scalping is commonly repeated year after year. To maintain the hydraulic control provided to upstream by the Riffle head, the preferred method of bar scalping is now generally to leave the top one-third (approximately) of the bar undisturbed, mining only from the downstream two-



thirds.

b) Dry-Pit Channel Mining

Dry-pit channel mines are pits excavated within the active channel on dry intermittent or ephemeral stream beds. Dry pits are often left with abrupt upstream margins, from which head cuts are likely to propagate upstream.

c) Wet-Pit Channel Mining

Wet-pit mining involves excavation of a pit in the active channel below the surface water in a perennial stream or below the alluvial groundwater table.

d) Bar Excavation

A pit is excavated at the downstream end of the bar as a source of aggregate and as a site to trap sand and gravel. Upon completion, the pit may be connected to the channel at its downstream end to provide side channel habitat.

e) Channel-wide River bed Mining

In rivers with a highly variable flow regime, sand and gravel are commonly extracted across the entire active channel during the dry season. The bed is evened out and uniformly (or nearly so) lowered.

4. Reclamation Plans

Reclamation plans should include:

- a) A baseline survey consisting of existing condition cross-section data: Cross-sections must be surveyed between two documented endpoints set back from the top of bank, and elevations should be referenced to bench mark;
- b) The proposed mining cross-section data should be plotted over the baseline data to illustrate the vertical extent of the proposed excavation;
- c) The cross-section of the replenished bar should be the same as the baseline data. This illustrates that the bar elevation after the bar is replenished will be the same as the bar before extraction;
- d) A planimetric map showing the aerial extent of the excavation and extent of the riparian buffers;
- e) A planting plan developed by a plant ecologist familiar with the flora of the river for any areas such as roads that need to be restored;
- f) A monitoring plan: The appropriate reclamation plans can turn river-bed and floodplain sand and gravel mining operations into something perceived by the public as desirable.



MARINE SAND MINING AND IMPACT ON MARINE BIODIVERSITY

The mining of marine aggregates is increasing significantly. Marine sand mining has had an impact on seabed flora and fauna. Dredging and extraction of aggregates from the benthic (sea bottom) zone destroys organisms, habitats and ecosystems and deeply affects the composition of biodiversity, usually leading to a net decline in faunal biomass and abundance or a shift in species composition. Aggregate particles that are too fine to be used are rejected by dredging boats, releasing vast dust plumes and changing water turbidity, resulting in major changes to aquatic and riparian habitats over large areas.

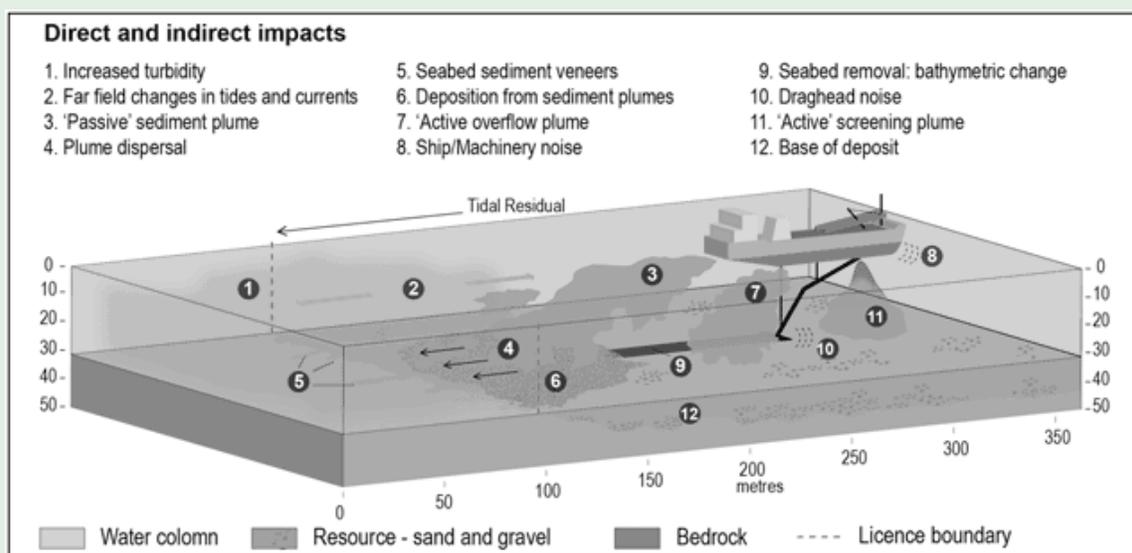


Figure: Direct and indirect consequences of aggregates dredging on the marine environment.

Source: Tillin, H.M., Houghton, A.J., Saunders, J.E., Drabble, R. and Hull, S.C., 2011. Direct and Indirect Impacts of Aggregate Dredging, Marine Aggregate Levy Sustainability Fund (MALSF). Science Monograph Series 1, 1-46.



REDUCING CONSUMPTION OF SAND

Because sand is still very cheap - sand itself is freely accessible; only extraction and transportation costs need to be covered - there is little or no incentive to induce a change in our consumption. Despite the very high value of minerals found in the sand, it is mostly used for concrete or is buried under highways. Recycled building and quarry dust material can be a substitute for sand. Concrete rubble should be recycled to avoid using aggregates, at least for low-quality uses.

Substitutes for sand are available. Quarry dust could be used to replace sand in general concrete structures. The replacement of sand by up to 40% of incinerator ash exhibits higher compressive strength than regular cement mortars. Some desert sand can be used if mixed with other material. There are alternatives for building houses, including wood, straw and recycled material. However, the current building industry is geared toward concrete know-how and equipment.

Training of architects and engineers, new laws and regulations, and positive incentives are needed to initiate a shift for lowering our dependency on sand. Renewable and recycled materials need to be targeted for building houses and roads. Use of Manufactured Sand (M-Sand) also needs to be promoted.

Alternative sources of sand and gravel, which accumulate at the bottom of dams, can also be targeted. Their use would address the problem of these aggregates accumulating which leads to a reduced capacity of dams to store water and could result in the dams' water intakes being blocked. Dams regularly release large amounts of water to flush out aggregates.

The important standard setting bodies in India are taking steps to promote the usage of alternatives to sand and gravel. Bureau of Indian Standards, the National Standards Body of the country, considering the scarcity of sand and coarse aggregates from natural sources, has evolved number of alternatives which are ultimately aimed at conservation of natural resources apart from promoting use of various waste materials without compromising in quality.

These measures include permitting in the Concrete Code (IS 456) as also in the National Building Code of India, the use of slag - a waste from steel industry, fly ash - a waste from thermal power plants, crushed over-burnt bricks and tiles - waste from clay brick and tile industry, in plain cement concrete as an alternative to sand/natural aggregate, subject to fulfilling the requirements of the Code. This Code, further, encourages use of fly ash and ground granulated blast furnace slag as part replacement of ordinary Portland cement in plain as well as reinforced cement concrete.

The Indian Standard on concrete mix design (IS 10262) has been upgraded to include guidance and examples of designing concrete mixes using fly ash and slag. Provisions for compliance for requisite quality of concrete made using fly ash and slag have been duly covered for the manufacturers of ready-mixed concrete in the Indian Standard Code of practice for RMC (IS 4926).

BIS has also formulated an Indian Standard Specification for artificial lightweight aggregates covering manufactured aggregates, such as foamed blast furnace slag, bloated clay aggregate, sintered fly ash aggregate and cinder aggregate (IS 9142).

A series of Indian Standards has also been formulated on various precast concrete products such as solid and hollow concrete blocks, light weight concrete blocks, autoclaved aerated concrete blocks, preformed foam concrete blocks, partial prefabricated concrete flooring and roofing units, concrete pipes, etc, all permitting use of fly ash and slag.



THE REPORT OF THE COMMITTEE HEADED BY SECRETARY, MoEF - 2010

A Committee headed by Secretary, Ministry of Environment and Forest was set up on the subject in 2010. The Committee considered this subject in detail and prepared a report. The important parts of the report are as follows:

Definition of Minor Mineral:

The term 'minor mineral' is defined in clause (e) of Section 3 of MMDR Act, 1957: '3 (e) "minor minerals" means building stones, gravel, ordinary clay, ordinary sand other than sand used for prescribed purposes and any other material which the Central Government may, by Notification in the Gazette of India declare to be a minor mineral;'

The term 'ordinary sand' used in clause (e) of Section 3 of the MMDR Act, 1957 has been further clarified in rule 70 of the MCR, 1960 as:

- (iv) Purposes of stowing in coal mines,
- (v) For manufacture of silvicate cement,
- (vi) Manufacture of sodium silicate and for
- (vii) Manufacture of pottery and glass.

Additionally, the Central Government has declared the following minerals as minor minerals:

Sl.No.	Minor Minerals	Sl.No.	Minor Minerals	Sl.No.	Minor Minerals
i)	Boulder	vi)	Brick-earth	xi)	Slate and shale when used for building material
ii)	Shingle	vii)	Fuller's earth	xii)	Marble
iii)	Chalcedony pebbles used for ball mill purposes only	viii)	Bentonite	xiii)	Stone used for making household utensils
iv)	Lime shell, kankar and limestone used in kilns for manufacture of lime used as building material	ix)	Road metal	xiv)	Quartzite and sandstone when used for purposes of building or for making road metal and household utensils
v)	Murram	x)	Reh-matti	xv)	Saltpetre, and
xvi)	Ordinary earth (Used for filling or leveling purposes in construction or embankments, roads, railways building).				



It may thus be observed that minerals have been classified into major and minor minerals based on their end use rather than level of production, level of mechanization, export and import etc. There do exist some minor mineral mines of silica sand and limestone where the scale of mechanization and level of production is much higher than those of industrial mineral mines. Further, in terms of the economic cost and revenue, it has been estimated that the total value of minor minerals constitutes about 10% of the total value of mineral production whereas the value of non-metallic minerals comprises only 3%. It is, therefore, evident that the operations of mines of minor minerals need to be subject to some regulatory parameters as that of mines of major minerals. Further, unlike India there does not exist such system in any other country where minerals are classified as major and minor based on end usage. Thus, there is a need to re-look at the definition of 'minor minerals' per se. It is, therefore, recommended that Ministry of Mines along with Indian Bureau of Mines, in consultation with the State Governments may re-examine the classification of minerals into major and minor categories so that the regulatory aspects and environment mitigation measures are appropriately integrated for ensuring sustainable and scientific mining with least impacts on environment.

Size of the Mine Lease:

Area for grant of mine lease varies from State to State. Maximum area which can be held under one or more mine lease is 2590 ha or 25.90 sq. miles in Jammu and Kashmir. Rajasthan prescribed a minimum limit of 1 ha for a lease. Maximum area prescribed for permit is 50x50 m. In most of the States area of permit is not specified in the rules.

It has recently been observed by Punjab and Haryana High Court in its order dated 15.05.2009 that State Government are apparently granting short term permits by dividing the mining area into small zones in effect to avoid environmental norms. There is, thus a need to bring uniformity in the extent of area to be granted for mine lease so as to ensure that eco-friendly scientific mining practices can be adopted. It is recommended that the minimum size of mine lease should be 5 ha. Further, preparation of comprehensive mine plan for contiguous stretches of mineral deposits by the respective State Governments may also be encouraged. This may suitably be incorporated in the Mineral Concession Rules, 1960 by Ministry of Mines.

Period of Mine Lease:

The period of lease varies from State to State depending on type of concessions, minerals and its end use. The minimum lease period is one year and maximum 30 years. Minerals like granite where huge investments are required, a period of 20 years is generally given with the provisions of renewal. Permits are generally granted for short periods which vary from one month to a maximum one year. In States like Haryana, minor mineral leases are auctioned for a particular time period. Mining is considered to be capital intensive industry and considerable time is lost for developing the mine before it attains the status of fully developed mine. If the tenure of the mine lease is short, it would encourage the lessee to concentrate more on rapid exploitation of mineral without really undertaking adequate measures for reclamation and rehabilitation of mined out area, posing thereby a serious threat to the environment and health of the workers and public at large.



There is thus, a need to bring uniformity in the period of lease. It is recommended that a minimum period of mine lease should be 5 years, so that eco- friendly scientific and sustainable mining practices are adopted. However, under exceptional circumstances arising due to judicial interventions, short term mining leases / contracts could be granted to the State Agencies to meet the situation arising there from.

Cluster of Mine Approach for Small Sized Mines:

Considering the nature of occurrence of minor mineral, economic condition of the lessee and the likely difficulties to be faced by Regulatory Authorities in monitoring the environmental impacts and implementation of necessary mitigation measures, it may be desirable to adopt cluster approach in case of smaller mine leases being operated presently. Further, these clusters need be provided with processing/crusher zones for forward integration and minimizing excessive pressure on road infrastructure. The respective State Governments / Mine Owners Associations may facilitate implementation of Environment Management Plans in such cluster of mines.

Requirement of Mine Plan for Minor Minerals:

At present, most of the State Governments have not made it mandatory for preparation of mining plan in respect of minor minerals. In some States like Rajasthan, eco- friendly mining plans are prepared, which are approved by the State Mining Department. The eco- friendly mining plans so prepared, though conceptually welcome, are observed to be deficient and need to be made comprehensive in a manner as is being done for major minerals. Besides, the aspects of reclamation and rehabilitation of mined out areas, progressive mine closure plan, as in vogue for major minerals could be introduced for minor minerals as well.

It is recommended that provision for preparation and approval of mine plan, as in the case of major minerals may appropriately be provided in the Rules governing the mining of minor minerals by the respective State Governments. These should specifically include the provision for reclamation and rehabilitation of mined out area, progressive mine closure plan and post mine land use.

Creation of Separate Corpus for Reclamation / Rehabilitation of Mines of Minor Minerals:

Mining of minor minerals, in our country, is by and large unorganized sector and is practiced in haphazard and unscientific manner. At times, the size of the leasehold is also too small to address the issue of reclamation and rehabilitation of mined outs areas. It may, therefore, be desirable that before the concept of mine closure plan for minor minerals is adopted, the existing abandoned mines may be reclaimed and rehabilitated with the involvement of the State Government. There is thus, a need to create a separate corpus, which may be utilized for reclamation and rehabilitation of mined out areas. The respective State Governments may work out a suitable mechanism for creation of such corpus on the 'polluter pays' principle. An organizational structure may also need to be created for undertaking and monitoring these activities.

Depth of Mining:

Mining of minerals, whether major or minor have a direct bearing on the hydrological regime of the



area. Besides, affecting the availability of water as a resource, it also affects the quality of water through direct run of going into the surface water bodies and infiltration / leaching into groundwater. Further, groundwater withdrawal, dewatering of water from mine pit and diversion of surface water may cause surface and sub- surface hydrologic systems to dry up. An ideal situation would require that quarrying should be restricted to unsaturated zone only above the phreatic water table and should not intersect the groundwater table at any point of time. However, from the point of view of mineral conservation, it may not be desirable to impose blanket ban on mining operation below groundwater table. It is, therefore, recommended that detailed hydro-geological report should be prepared in respect of any mining operation for minor minerals to be undertaken below groundwater table. Based on the findings of the study so undertaken and the comments/ recommendations of Central Ground Water Authority/ State Ground Water Board, a decision regarding restriction on depth of mining for any area should be taken on case to case basis.

Uniform Minor Mineral Concession Rules:

The economic value of the minor minerals excavated in the country is estimated to contribute to about 9% of the total value of the minerals whereas the non- metallic minerals contribute to about 2.8%. Keeping in view the large extent of mining of minor minerals and its significant potential to adversely affect the environment, it is recommended that Model Mineral Concession rules may be framed for minor minerals as well and the minor minerals may be subjected to a simpler regulatory regime, which is, however, similar to major minerals regime.

River Bed Mining:

1. Environment damage being caused by unregulated river bed mining of sand, bajri and boulders is attracting considerable attention including in the courts. The following recommendations are therefore made for the river bed mining.
 - (a) In the case of mining leases for riverbed sand mining, specific river stretches should be identified and mining permits/lease should be granted stretch wise, so that the requisite safeguard measures are duly implemented and are effectively monitored by the respective Regulatory Authorities.
 - (b) The depth of mining may be restricted to 3m / water level, whichever is less.
 - (c) For carrying out mining in proximity to any bridge and / or embankment, appropriate safety zone should be worked out on case to case basis, taking into account the structural parameters, locational aspects, flow rate etc. and no mining should be carried out in the safety zone so worked out.

Conclusion:

Mining of minor minerals, though individually, because of smaller size of mine leases is perceived to have lesser impact as compared to mining of major minerals. However, the activity as a whole is seen to have significant adverse impacts on environment. It is, therefore, necessary that the mining of minor minerals is subjected to simpler but strict regulatory regime and carried out only under an



approved framework of mining plan, which should provide for reclamation and rehabilitation of the mined out areas. Further, while granting mining leases by the respective State Governments "location of any eco-fragile zone (s) within the impact zone of the proposed mining area, the linked Rules/ Notifications governing such zones and the judicial pronouncements, if any, need be duly noted.

The Union Ministry of Mines along with Indian Bureau of Mines and respective State Governments should therefore make necessary provisions in this regard under the Mines and Minerals (Development and Regulation) Act, 1957, Mineral Concession Rules, 1960 and adopt model Guidelines to be followed by all States (emphasis supplied)".



REGIME OF LAW AND ADMINISTRATIVE ORDERS RELATING TO MINING OF MINOR MINERALS

The Entry 54 of List 1 in Schedule VII to the Constitution of India is the entry which empowers the Parliament in respect of 'Regulation of Mines and Minerals Development. Entry 23 of List 2 of the same Schedule, read with Article 246 (3) of the Constitution confers legislative powers on the State Legislature in respect of Regulation of Mines and Mineral Development, but, this power is subject to the provisions of List 1 with respect to the regulation and development under the control of the Union. The Parliament, with the object to amend and consolidate the law relating to the regulation of labour and safety in mines enacted the Mines Act, 1952. Section 2 (JJ) of the Mines Act, 1952 defines "minerals" to mean, all substances which can be obtained from the earth by mining, digging, drilling, dredging, hydraulic, quarrying or by any other operation and includes mineral oils (which, in turn, include natural gas and petroleum). On 1st June, 1958, the Mines and Minerals (Development and Regulation) Act, 1957 was promulgated. This Act provides, inter alia, for general restrictions on undertaking prospecting and mining operations, the procedure for obtaining prospecting licenses or mining leases in respect of the land in which the minerals vests in the Government, the rule making power for regulating the grant of prospecting licenses and mining leases, special powers of Central Government to undertake prospecting or mining operations in certain cases, and for development of minerals.

The protection of natural environment is one of the fundamental duties of every citizen under Article 51-A of the Constitution of India. Article 48-A of the Constitution, obliged the State to endeavor to protect and improve the environment and to safeguard the forests and wild life of the country. The Environment (Protection) Act and Rules, 1986 were enacted and came into force on 19th November, 1986. The object of this Act is to provide for the protection and improvement of environment and for matters connected therewith. Under provisions of the Act and Rules of 1986, MoEFCC has issued various Notifications regulating the mining of minor minerals, specifically stating the procedures that were required to be complied by persons intending to carry on such mining activity and for the authorities to regulate the same.

Prior to 1994, there was no specific regime in place in relation to mining activity being carried out. The Notification issued by MoEF on 27th January, 1994, in exercise of the powers vested in it under Sub-Rule 3 of Rule 5 of the Rules of 1986 and Sub Section (1) and Clause (v) of Sub-Section (2) of Section 3 of the Act of 1986, prescribed the requirement and procedure for seeking Environmental Clearance for the projects listed in Schedule I. Schedule I of this Notification did not list mining projects of minor minerals. On the contrary, the projects covered under S. No. 20 of Schedule I of this Notification were only "mining projects (major mineral) with leases more than 5 hectares".

It provided for the constitution of Expert Committees and preparation of Environmental Impact Assessment Report which was to be evaluated and assessed by the Impact Assessment Agency. In exercise of its statutory powers afore-indicated, the Central Government on 14th September, 2006,



issued a Notification, i.e., 'Environment Impact Assessment Notification, 2006'. In terms of this Notification, the projects as stated in the Schedule to this Notification required prior Environmental Clearance as per the procedure. The projects have been categorised into two kinds, i.e., Category 'A' and Category 'B' under Clause 2 of the Notification. Projects under Category 'A' were required to take prior Environmental Clearance by MoEFCC. For Category 'B' projects, Environmental Clearance was to be given by State Environment Impact Assessment Authority (SEIAA).

The mining of minerals (both major and minor) were brought under the ambit of the EIA Notification, 2006. The mine lease area of more than equal to 50 ha was Category 'A' and mine lease area less than 50 ha and more than equal to 5 ha was category 'B' project. Mine lease area of less than 5 ha (both major and minor) was kept out of EIA Notification purview.

The Notification of 2006 came to be amended by Notification dated 1st December, 2009. It included the category of non-coal mine and coal mine lease and provided that non-coal mine lease of area more than equal to 5 ha and less than 50 ha will be category 'B' and mine lease area more than equal to 50 ha will be category 'A'. Similarly, mine lease area of more than equal to 5 ha and less than 150 ha for coal mine lease will be category 'B' and mine lease area of coal mine more than 150 ha will be category 'A'. Here again mining lease area of less than 5 ha (both coal and non-coal mine) was kept out of EIA Notification purview.

The Hon'ble Supreme Court, vide its order dated 27.2.2012 in I.A. No.12-13 of 2011 in SLP (C) No.19628-19629 of 2009 titled Deepak Kumar etc. v/s State of Haryana & Ors. has inter alia ordered *"We, in the meanwhile, order that leases of minor mineral including their renewal for an area of less than five hectares be granted by the States/Union Territories only after getting environmental clearance from the MoEF."*

Hon'ble Apex Court in Deepak Kumar's case (supra) extensively examined the environmental concerns, in the context of mining of minor minerals, considering its impact on the environment. The Apex Court observed that Extraction of alluvial material from within or near a streambed has a direct impact on the stream's physical habitat characteristics. These characteristics include bed elevation, substrate composition and stability, in-stream roughness elements, depth, velocity, turbidity, sediment transport, stream discharge and temperature. Altering these habitat characteristics can have deleterious impacts on both in-stream biota and the associated riparian habitat. The demand for sand continues to increase day by day as building and construction of new infrastructures and expansion of existing ones is continuous thereby placing immense pressure on the supply of the sand resource and hence mining activities are going on legally and illegally without any restrictions. Lack of proper planning and sand management cause disturbance of marine ecosystem and also upset the ability of natural marine processes to replenish the sand. Quarrying, mining and removal of sand from in-stream and upstream of several rivers, which may have serious environmental impact on ephemeral, seasonal and perennial rivers and river beds and sand extraction may have an adverse effect on bio-diversity as well. Further it may also lead to bed degradation and sedimentation having a negative effect on the aquatic life.

Apex Court observed that without conducting any study on the possible environmental impact on/



in the river beds and else- where the auction notices have been issued. Hon'ble Apex Court observed that "We are of the considered view that when we are faced with a situation where extraction of alluvial material within or near a river bed has an impact on the rivers physical habitat characteristics, like river stability, flood risk, environmental degradation, loss of habitat, decline in biodiversity, it is not an answer to say that the extraction is in blocks of less than 5 hectares, separated by 1 kilo meter, because their collective impact may be significant, hence the necessity of a proper environmental assessment plan".

In order to ensure compliance of the aforesaid order of the Hon'ble Supreme Court, MoEF issued an OM No.L-11011/47/2011-IA.II(M) dated 18.05.2012 stating inter alia that all mining projects of minor minerals including their renewal, irrespective of the size of the lease would henceforth require prior EC and that the projects of minor minerals with lease area less than 5 ha would be treated as Category "B" as defined in EIA Notification, 2006 and will be considered by the respective State Environment Impact Assessment Authorities (SEIAAs) notified by MoEF and following the procedure prescribed under the EIA Notification, 2006.

On 24th June, 2013, MoEF issued another Office Memorandum stating Guideliness for consideration of proposals for grant of Environmental Clearance under the Notification of 2006 for mining of 'brick earth' and 'ordinary earth' having lease area of less than 5 hectares. Referring to the judgment of the Hon'ble Supreme Court in the case of Deepak Kumar (supra) and its Office Memorandum dated 18th May, 2012, it further considered that the 'brick kiln' manufactures had stated that it was a small scale activity requiring that certain depth should be kept outside the purview of Environmental Clearance. Having considered various aspects, examining the recommendations of the Expert Committee, constituted by MoEF, finally it was directed as follows:

"(a) The activities of borrowing / excavation of 'brick earth' and ordinary earth', upto an area of less than 5 ha, may be categorized under 'B2' Category subject to the following Guideliness in terms of the provisions under '7.I Stage(1)-Screening' of EIA Notification, 2006:

- (i) The activity associated with borrowing/excavation of 'brick earth' and 'ordinary earth' for purpose of brick manufacturing, construction of roads, embankments etc. shall not involve blasting.
- (ii) The borrowing/excavation activity shall be restricted to a maximum depth of 2 m below general ground level at the site.
- (iii) The borrowing/excavation activity shall be restricted to 2 m above the ground water table at the site.
- (iv) The borrowing/excavation activity shall not alter the natural drainage pattern of the area.
- (v) The borrowed/excavated pit shall be restored by the project proponent for useful purpose(s).
- (vi) Appropriate fencing all around the borrowed/excavated pit shall be made to prevent any mishap.



- (vii) Measures shall be taken to prevent dust emission by covering of borrowed/excavated earth during transportation.
 - (viii) Safeguards shall be adopted against health risks on account of breeding of vectors in the water bodies created due to borrowing/excavation of earth.
 - (ix) Workers / labourers shall be provided with facilities for drinking water and sanitation.
 - (x) A berm shall be left from the boundary of adjoining field having a width equal to at least half the depth of proposed excavation.
 - (xi) A minimum distance of 15 m from any civil structure shall be kept from the periphery of any excavation area.
2. (a) The concerned SEIAA while considering granting environmental clearance for such activity for brick earth / ordinary earth will prescribe the Guideliness as stated at (i) to (xi) above and specify that the clearance so granted shall be liable to be cancelled in case of any violation of above Guideliness.
- (b) Notwithstanding what has been stated at (a) above, the following will apply:
- (i) No borrowing of earth / excavation of 'brick earth' or 'ordinary earth' shall be permitted in case the area of borrowing/ excavation is within 1 km of boundary of national parks and wild life sanctuaries.
 - (ii) In case the area of borrowing / excavation is likely to result into a cluster situation i.e. if the periphery of one borrow area is less than 500 m from the periphery of another borrow area and the total borrow area equals or exceeds 5 ha, the activity shall become Category 'B 1' Project under the EIA Notification, 2006. In such a case, mining operations in any of the borrow areas in the cluster will be allowed only if the environmental clearance has been obtained in respect of the cluster. This issues with the approval of the Competent Authority."

These directions which were specific only to 'brick earth' and 'ordinary earth' activities for areas less than 5 hectares, as decided to be categorised as 'B 2' Category projects, subject to the restrictions stated in the memorandum, provided that if the cluster area exceeded 5 hectares, then it would become Category 'B 1' and would not be treated as Category 'B 2' projects. The above Office Memorandum was not dealing with the issues of sand mining or any other minor mineral activity except 'brick earth' and 'ordinary earth'. Further, MoEF has issued an amendment to EIA Notification vide Notification S.O. 2731 (E) dated 9th September 2013 and amended the EIA Notification, 2006 for item 1 (a) as follows:



(1)	(2)	(3)	(4)	(5)
"1(a)	(i) Mining of minerals.	≥ 50 ha of mining lease area in respect of non-coal mine lease	<50 ha of mining lease area in respect of minor minerals mine lease ; and < 50 ha ≥5 ha of mining lease area in respect of other non-coal mine lease.	General Conditions shall apply except for project or activity of less than 5 ha of mining lease area for minor minerals: Provided that the above exception shall not apply for project or activity if the sum total of the mining lease area of the said project or activity and that of existing operating mines and mining projects which were accorded environment clearance and are located within 500 metres from the periphery of such project or activity equals or exceeds 5 ha.
		>150 ha of mining lease area in respect of coal mine lease.	≤ 150 ha ≥ 5 ha of mining lease area in respect of coal mine lease.	(i) Prior environmental clearance is required at the stage of renewal of mine lease for which an application shall be made up to two years prior to the date due for renewal. Further, a period of two years with effect from the 4th April, 2011 is provided for obtaining environmental clearance for all those mine leases, which were operating as



(1)	(2)	(3)	(4)	(5)
	(ii) Slurry pipelines (coal lignite and other ores) passing through national parks or sanctuaries or coral reefs, ecologically sensitive areas.	All projects.		<p>on the 4th April, 2011 with requisite valid environmental clearance and which have fallen due for renewal on or after the 4th November, 2011:</p> <p>Provided that no fresh environmental clearance shall be required for a mining project or activity at the time of renewal of mining lease, which has already obtained environmental clearance under this notification.</p> <p>(ii) Mineral prospecting is exempted.</p>



In this Notification a new category of minor mineral was introduced and it was provided that mining lease area of minor mineral less than 50 ha will be category 'B' and will require EC. Accordingly the minor mineral mining projects having less than 5 hectare of lease area are required to be appraised by the SEIAA/SEAC of respective State for granting environment clearance. It was provided that the project or activity of less than 5 ha of mining lease area for minor minerals will be exempt from the General Conditions. Simultaneously the concept of cluster was introduced and it was provided that the exemption of applicability of General Conditions shall not apply for project or activity if the sum total of the mining lease area of the said project or activity and that of existing operating mines and mining projects which were accorded EC and are located within 500 m from the periphery of such project or activity equal or exceeds 5 ha.

The Ministry, on 24th December, 2013, issued another Office Memorandum for consideration of proposals for grant of Environmental Clearance regarding categorisation of Category 'B' projects into Category 'B (1)' and 'B (2)'. Mining of minor minerals had been separately dealt with in this Office Memorandum. This Office Memorandum stated that no river sand mining project with mining lease area of less than 5 hectares may be considered for grant of Environmental Clearance. Such area up to 25 hectares would be categorised as 'B (2)' and such projects were to be considered, subject to the stipulations stated therein. This Office Memorandum stated that no Environmental Clearance would be granted for extraction of minor minerals from any riverbed where the area is less than 5 hectares. Sand mining, in area other than riverbeds, would be permitted, only if the Project Proponent takes Environmental Clearance.

The Ministry vide Notification No. S.O. 1599 (E) dated 25.06.2014 reduced the area of 10 kilo meter to 5 kilo meters for applicability of General Conditions increasing the delegation to States by taking out projects located in 5 to 10 kilo meter of interstate boundary, CEPI, and, PAs from category 'A'.

The anomaly created by the Notification dated 09.09.2013 was corrected vide Notification No. S.O. 2601 (E) dated 7th October 2014, and category of minor mineral was deleted and mining leases were again classed as non-coal mine and coal mine and mining lease area of less than 50 ha was made category 'B' for non-coal mine and mine lease area of less than equal to 150 ha for coal mine was made category 'B'. The mine lease area of less than 5 ha was exempt from the applicability of General Conditions and cluster concept of Notification dated 09.09.2013 was retained.



Notification S.O. 2601 (E) dated 7th October 2014 provides as follows:

(1)	(2)	(3)	(4)	(5)
"1(a)	<p>(i) Mining of minerals.</p> <p>(ii) Slurry pipelines (coal lignite and other ores) passing through national parks or sanctuaries or coral reefs, ecologically sensitive areas</p>	<p>≥ 50 ha of mining lease area in respect of non-coal mine lease.</p> <p>>150 ha of mining lease area in respect of coal mine lease.</p> <p>Asbestos mining irrespective of mining area.</p> <p>All projects.</p>	<p><50 ha of mining lease area in respect of non-coal mine lease.</p> <p>≤ 150 ha of mining lease area in respect of coal mine lease.</p>	<p>General Conditions shall apply except for project or activity of less than 5 ha of mining lease area:</p> <p>Provided that the above exception shall not apply for project or activity if the sum total of the mining lease area of the said project or activity and that of existing operating mines and mining projects which were accorded environment clearance and are located within 500 metres from the periphery of such project or activity equals or exceeds 5 ha.</p> <p>Note:</p> <p>(i) Prior environmental clearance is required at the stage of renewal of mine lease for which an application shall be made up to two years prior to the date due for renewal.</p> <p>Provided that no fresh environmental clearance shall be required for a mining project or activity at the time of renewal of mining lease, which has already obtained environmental clearance under this notification.</p> <p>(ii) Mineral prospecting is exempted. "</p>



The NGT vide order dated 13.01.2015 (O.A. No. 123 of 2014 and M.A. No. 419 of 2014) has declared the Notification dated 09.09.2013 as invalid, inoperative and quashed it. The above order has also quashed the paragraph 4 (b) (i) of O.M. dated 24th June 2013 which provided that "No borrowing of earth / excavation of 'brick earth' or 'ordinary earth' shall be permitted in case the area of borrowing / excavation is within 1 km of boundary of national parks and wild life sanctuary." Though this provision was taken from the observation of Hon'ble Supreme Court in W.P. No. 435 of 2012 (Goa Foundation Vs. Union of India) and order dated 04.08.2006 of Supreme Court in *T.N. Godavarman Thirumulpad v. Union of India & Ors.* Supreme Court has taken a view that 1 km. from the boundaries of National Parks and Sanctuaries would be a safety zone, subject to the orders that may be made in IA No.1000 regarding Jamua Ramgarh Sanctuary and the State will not grant any Temporary Working Permit (TWP) in these safety zones comprising 1 km. from the boundaries of National Parks and Sanctuaries.

Similarly the proviso at paragraph 2 (iii) of O.M. dated 24.12.2013 which says that "No river sand mining project, with mine lease area less than 5 ha, may be considered for granting EC" has been quashed. This condition was taken from the recommendations of the Committee headed by the Secretary, MoEF constituted in 2010. The above proviso were quashed on the ground that as EIA Notification places no such restriction, so same cannot be imposed by an executive order and many hill States find it very difficult to get an area equal to or more than 5 ha. in riverbed. The information made available by the States also makes it clear that majority of the mining leases of sand are of area less than 5 hectares.



THE ISSUES AND MANAGEMENT OF MINING IN CLUSTER

In I.A. No. 12-13 of 2011 in SLP Nos. 729-731 / 2011, 21833 / 2009, 12498-499 / 2010, SLP (C) CC ... 16157 / 2011 & CC 18235 / 2011 (Deepak Kumar and Ors. Vs. State of Haryana and Ors. etc.) Hon'ble Supreme Court in its order dated 27.02.2012 on the subject of cluster has quoted the submission of affidavit dated 23.11.2011 of MOEFCC. It says that "The Ministry is of the opinion that where the mining area is homogeneous, physically proximate and on identifiable piece of land of 5 ha. or more, it should not be broken into smaller sizes to circumvent the EIA Notification, 2006 as the EIA Notification, 2006 is not applicable to the mining projects having lease area of less than 5 ha. The Report of Committee on Minor Minerals, under the Chairmanship of Secretary (E&F) with representatives of various state governments as members including the State of Haryana and Rajasthan recommended a minimum lease size of 5 ha for minor minerals for undertaking scientific mining for the purpose of integrating and addressing environmental concerns. Only in cases of isolated discontinued mineral deposits in less than 5 ha, such mining leases may be considered keeping in view the mineral conservation".

The order further quotes that "Cluster of Mine Approach for Small Sized Mines: Considering the nature of occurrence of minor mineral, economic condition of the lessee and the likely difficulties to be faced by Regulatory Authorities in monitoring the environmental impacts and implementation of necessary mitigation measures, it may be desirable to adopt cluster approach in case of smaller mine leases being operated presently. Further these clusters need be provided with processing / crusher zones for forward integration and minimizing excessive pressure on road infrastructure. The respective State Governments / Mine Owners Association may facilitate implementation of Environment Management Plans in such cluster of mines." The order has further quoted the letter dated 1.06.2010 written by the then Minister of Environment, Forest and Climate Change which says on the subject that "A cluster approach to mines should be taken in case of smaller mines leases operating currently". The Hon'ble Court has ordered that "The State of Haryana and various other States have not so far implemented the above recommendations of the MoEF or the Guideliness issued by the Ministry of Mines before issuing auction notices granting short term permits by way of auction of minor mineral boulders gravel, sand etc., in the river beds and elsewhere of less than 5 hectares. We therefore, direct to all the States, Union Territories, MoEF and the Ministry of Mines to give effect to the recommendations made by MoEF in its report of March 2010 and the model Guideliness framed by the Ministry of Mines, within a period of six months from today and submit their compliance reports."

"We in the meanwhile, order that leases of minor mineral including their renewal for an area of less than five hectares be granted by the States/ Union Territories only after getting environmental clearance from the MoEF."



The Ministry vide O.M. No. L-11011/47/2011-IA.II (M) dated 18th May 2012 said that "In order to ensure compliance of the above referred order of the Hon'ble Supreme Court dated 27.02.2012, it has now been decided that all mining projects of minor minerals including their renewal, irrespective of the size of the lease would henceforth require prior environment clearance. Mining projects with lease area up to less than 50 ha including projects of minor mineral with lease area less than 5 ha would be treated as Category 'B' as defined in EIA Notification, 2006 and will be considered by the respective SEIAAs notified by MoEF and following the procedure prescribed under EIA Notification, 2006."

On the issue of cluster, the Notifications No. S.O. 2731 (E) dated 09.09.2013 and Notification No. S.O. No. 2601 (E) of 07.10.2014 were issued.

The above Notifications in Schedule at Item No. 1 (a) in Conditions mentions that "General Conditions shall apply except for projects or activity of less than 5 ha of mining lease area:

Provided that the above exception shall not apply for project or activity if the sum total of the mining lease area of the said project or activity and that of existing operating mines and mining projects which were accorded environment clearance and are located within 500 meters from the periphery of such projects or activity equals or exceeds 5 ha. The Office Memorandum No. J-13012/12/2013-IA-II (1) dated 24.12.2013 is about Guideliness for consideration of proposals for grant of environment clearance under Environment Impact Assessment Notification 2006 and its amendments - regarding categorization of Category 'B' projects/ activities into Category 'B1' & 'B2'.

The above O.M. besides categorizing the Category B into Category B1 & B2 also has directions on mining of brick earth / ordinary earth and river sand mining. These provisions are as follows:

"Mining of minor minerals:

As of now, mining projects of minor minerals with less than 50 hectare of mining lease areas are categorized as Category 'B' as per Notification S.O. 2731 (E) dated 9th September 2013. Also vide O.M. No. L-11011/47/2011-IA-II (M) dated 24.06.2013, Guideliness has been issued regarding categorization of mining projects of brick earth and ordinary earth having lease areas less than 5 hectare as Category 'B2' subject to stipulations stated therein.

In the above backdrop, the projects of mining of minor minerals, categorized as Category 'B' are hereby categorized as 'B2' as per the following:

- (i) 'Brick Earth' / 'Ordinary Earth' mining projects having lease area less than 5 ha will be considered for granting EC as per the aforesaid Guideliness issued by MOEF on 24.06.2013.
- (ii) 'Brick Earth' / 'Ordinary Earth' mining projects with mining lease area more than equal to 5 ha but less than equal to 25 ha and all other minor , mineral mining projects with mining lease area < 25 ha, except for river sand mining projects will be appraised as Category 'B2' projects.



These projects will be appraised based on the following documents:

- (a) Form-1 as per the Appendix-I under the EIA Notification 2006
- (b) Pre-feasibility report of the project
- (c) Mining plan approved by the authorized agency of the concerned State Government.

Provided in case the mining lease area is likely to result into a cluster situation, i.e. if the periphery of one lease area is less than 500 meter from the periphery of another lease area and the total lease area equals or exceeds 25 ha, the activity shall become Category 'B1' Project under the EIA

Notification, 2006. In such a case, mining operations in any of the mine lease areas in the cluster will be allowed only if the environmental clearance has been obtained in respect of the cluster.

About river sand mining it says that:

(iii) No river sand mining project, with mine lease area less than 5 ha, may be considered for granting EC. The river sand mining projects with lease area more than equal to 5 ha but less than 25 ha will be categorized as 'B2'. In addition to the requirement of documents, as brought out above under sub-para (ii) above for appraisal, such projects will be considered subject to the following stipulations:

- (a) The mining activity shall be done manually. The depth of mining shall be restricted to 3 m / water level, whichever is less.
- (b) For carrying out mining in proximity to any bridge and / or embankment, appropriate safety zone shall be worked out on case to case basis to the satisfaction of SEAC / SEIAA, taking into account the structural parameters, locational aspects, flow rate etc., and no mining shall be carried out in the safety zone so worked out. No in-stream mining shall be allowed.
- (c) The mining plan approved by the authorized agency of the State Government shall inter-alia include study to show that the annual replenishment of sand in the mining lease area is sufficient to sustain mining operations at levels prescribed in the mining plan and that the transport infrastructure is adequate to transport the mines material. In case of transportation by road the transport vehicles will be covered with the tarpaulin to minimize dust/ sand particle emissions.
- (d) EC will be valid for mine lease period subject to a ceiling of 5 years.

Provided, in case the mining lease area is likely to result into a cluster situation i.e. if the periphery of one lease area is less than 1 km from the periphery of another lease area and total lease area equals to or exceeds 25 ha., the activity shall become Category 'B1' Projects under EIA Notification, 2006. In such a case, mining operation in any of the mine lease area in the cluster will be allowed only if the environment clearance has been obtained in respect of the cluster.



The NGT order dated 13.01.2015 in O.A. No. 123 of 2014 and M.A. No. 419 of 2014 has following directions on the issue of cluster: "In light of the judgment of the Supreme Court and what has emerged from the various cases that are subject matter of this Judgment, we direct the Ministry of Environment and Forest to formulate a uniform cluster policy in consultation with the States for permitting minor mineral mining activity including its regulatory regime, in accordance with law.

Notification S.O. 1559 (E) dated 25th June 2014 provides that "Any project or activity specified in Category 'B' will be appraised at the Central Level as Category 'A', if located in whole or in part within 5 km. from the boundary of: (i) Protected Areas; (ii) CEPI; (iii) ESA; (iv) I n t e r - s t a t e boundaries or international boundaries".

The NGT vide its order dated 13.01.2015 has quashed the Notification dated 9th September 2013, but similar provision on clusters exists in Notification dated 7th October 2014.

The EIA Notification 2006, as amended makes it clear that projects in respect of non-coal mine leases, where the area is more than equal to 50 hectares would require prior Environmental Clearance from MoEFCC, while the projects of area less than 50 hectares would be appraised for prior Environmental Clearance at the level of SEIAA.

The EIA Notification of 2006 in Clause 7 specifies the stages through which projects for grant of Environmental Clearance are required to be passed and processed. The stages include Screening, Scoping, Public Consultation and Appraisal, upon which, the Expert Appraisal Committee makes recommendation to the MoEF/SEIAA. Under 'Screening', this Clause 7 also provides for a further bifurcation of projects falling under category 'B' into 'B 1' and 'B 2'. The relevant part of Clause 7, dealing with this aspect, reads as under: "Stage (1) - Screening (Only for Category 'B' projects and activities): In case of Category 'B' projects or activities, this stage will entail the scrutiny of an application seeking prior environmental clearance made in Form 1 by the concerned State level Expert Appraisal Committee (SEAC) for determining whether or not the project or activity requires further environmental studies for preparation of an Environmental Impact Assessment (EIA) for its appraisal prior to the grant of environmental clearance depending up on the nature and location specificity of the project . The projects requiring an Environmental Impact Assessment report shall be termed Category 'B1' and remaining projects shall be termed Category 'B2' and will not require an Environment Impact Assessment report. For categorization of projects into B1 or B2 except item 8 (b), the Ministry of Environment and Forests shall issue appropriate Guideliness from time to time."

The Ministry on 24th December, 2013, issued Office Memorandum for consideration of proposals for grant of Environmental Clearance regarding categorisation of Category 'B' projects into Category 'B1' and 'B2'. Mining of minor minerals had been separately dealt with in this Office Memorandum. Such area up to 25 hectares would be categorised as 'B 2' and such projects were to be considered, subject to the stipulations stated therein.



The EIA Notification, 2006 does not provide for issuance of Environment Clearance to Cluster of mines. It provides for EC to individual lease holders / project proponents. This position has also been upheld by the Hon'ble Supreme Court in its judgment of Vivek Bansal Vs. State of Haryana that EC should be applied for and granted to the individual lease holder.

There has been rising concerns about adverse impact of mining on small leases (less than 5 hectare) in case the numbers of such leases are large and they are located in close proximity to each other. This leads to the definition of Cluster. To avoid the rigors of environment impact assessment studies, environment management plan and the environment clearance there has been a tendency to break the leases into size which does not attract the provisions of environment impact assessment studies, environment management plan, public consultation and the environment clearance. In Deepak Kumar's case Hon'ble Supreme Court also encountered this situation and in its order dated 27.02.2012 mandated that no mining lease or renewal be done without environment clearance irrespective of size.

It is seen that the categorization of mines into 'B1' and 'B2' category in which Category 'B2' leases are being exempted from the requirement of Environment Impact Assessment, Environment Management Plan, and Public Consultation for grant of EC, in many cases now the mining leases are being given for 25 hectares or less. This defeats the purpose and intent of Hon'ble Supreme Court Judgment which orders environment clearance for all mining leases irrespective of size. The environment clearance without Environment Impact Assessment, Environment Management Plan, and Public Consultation does not serve the purpose of environment clearance which is to ensure environmentally sustainable and socially responsible mining. So if a cluster or individual lease size exceeds 5 hectare, the EIA/ EMP should be completed in the process of grant of prior environment clearance.

The EIA Notification, 2006 and subsequent amendments to that or any O.M. issued by the Ministry do not provide for procedures and Competent Authority for environment clearance for cluster. In a cluster there will mostly be situation where there are a number of different lease holders and as per the settled law the lease holder has to do the working of mine and the lease holder is the one who can apply for and get the environment clearance. The conditions stipulated in the environment clearance have to be complied by the EC holder and any violation of that empowers the authority to cancel the environment clearance or prosecute the EC holder if necessitated by the circumstances.

For cluster there is no mechanism about who will apply for EC, EC will be issued in whose name, and who will be responsible for compliance of EC conditions.

The intent of cluster assessment is to have a holistic knowledge of the impact on environment by different mines operating in close proximity of each other. There are also requirement of mitigative measures which need implementation in concerted manner by different EC holders of that cluster. To ensure that it is important that there should be an integrated Environment Impact Assessment /



Environment Management Plan for the cluster to be presented before the authority appraising the projects and considering the proposals for grant of EC. This integrated EIA/ EMP can be prepared by either the lease holder, group of lease holders, State or the State Agencies. This EIA/ EMP need to be prepared by the accredited consultants / Registered Qualified Persons of the State Governments. The application for EC and grant of EC should be done in the name of individual lease holders in the background of the integrated EIA/EMP report. The Competent Authority (SEIAA/ SEAC / EAC) will entertain individual lease holder's application for grant of EC to individual mining lease projects in that cluster in the name of lease holders. The conditions related to mitigative measures necessitated by the integrated EIA/EMP may run across more than one lease holder or EC holders, that should figure in each EC accordingly and its compliance be ensured by the individual EC holders.

The Hon'ble Supreme Court, NGT, SEAC/EAC and the Project Proponents have raised issue of cluster in mine lease allotment and environment clearance for the same, so following conditions need to be ensured for cluster of mines:

1. To address the concern of adverse impact of minor mineral mining on environment it is proposed that all mining activity including river sand mining (above 5 hectare individual or cluster) will need to prepare Environment Impact Assessment Report - and Environment Management Plan before grant of environment clearance. These reports (EIA /EMP) can be prepared by the State or State nominated Agency / the Project Proponent (s).
2. As can be seen from the data provided by the States most of the mining leases for minor minerals are of lease area less than 5 hectare. It is also reported that in hill states getting a stretch in river with area more than 5 hectare is very uncommon. So the size of lease for minor minerals including river sand mining will be determined by the States as per their circumstances.
3. The EIA Notification, 2006 does not provide for cluster EC, it provides for issuance of EC to individual project proponents and the same has also been upheld in the judgment of Hon'ble Supreme Court in Vijay Bansal vs. State of Haryana case. So EC will have to be applied for and issued to the individual project proponent.
4. A cluster shall be formed when the distance between the peripheries of one lease is less than 500 meters from the periphery of other lease in a homogeneous mineral area.
5. The mining of minor minerals is mostly in clusters. The Environment Impact Assessment or Environment Management Plan are required to be prepared for the entire cluster in order to capture all the possible externalities. These reports shall capture carrying capacity of the cluster, transportation and related issues, replenishment and recharge issues, geo-hydrological study of the cluster area. The Environment Impact Assessment or Environment Management Plan shall be prepared by the State or State nominated Agency or group of project proponents



in the Cluster or the project proponent in the cluster.

6. The individual lease holders in cluster can use the same Environment Impact Assessment or Environment Management Plan for application for environmental clearance. The cluster Environment Impact Assessment or Environment Management Plan shall be updated as per need keeping in view any significant change.
7. There shall be one public consultation for entire cluster after which the final Environment Impact Assessment or Environment Management Plan report for the cluster shall be prepared.
8. The details of cluster Environment Impact Assessment or Environment Management Plan shall be reflected in each environmental clearance in that cluster and District Expert Appraisal Committee (DEAC), SEAC, and EAC shall ensure that the mitigative measures emanating from the Environment Impact Assessment or Environment Management Plan study are fully reflected as environmental clearance conditions in the environmental clearance's of individual project proponents in that cluster.
9. As the sand is mostly mined from rivers and majority of the rivers which are important source of sand also form boundary between States, so because of General Conditions most of the sand mining projects become Category 'A' project. So the General Conditions will not apply in case of river sand and gravel mining projects on account of being in 5 kilometer of inter-state boundary.
10. The Committee headed by the District Magistrate or District Collector will be empowered to appraise and grant EC for mining leases up to 5 ha in case of individual lease and up to 25ha in case of cluster for sand mining.
11. In case the mining leases are in cluster (if periphery of one lease is within 500 meters), following are the categorization of projects:-
 - Category 'B2'Project: Cluster area of mine leases up to 5 ha and to be dealt at DEIAA/ DEAC level
 - Category 'B2'Project: Cluster area of Mine leases > 5 ha and < 25 ha with no individual lease > 5 ha and to be dealt at DEIAA/DEAC level
 - Category 'B1'Project: Cluster of mine leases of area > 25 hectares with individual lease size < 50ha and to be dealt at SEIAA/SEAC level
 - Category 'A' Project: Cluster of any size with any of the individual lease >50ha and to be dealt at MoEFCC/EAC level



The schematic presentation of requirements on Environmental Clearance of Sand Mining including cluster situation is detailed as below:-

Area of Lease (Hectare)	Category of Project	Requirement of EIA / EMP	Requirement of Public Hearing	Requirement of EC	Who can prepare EIA/ EMP	Who will apply for EC	Authority to appraise/ grant EC	Authority to monitor EC compliance
EC Proposal of Sand Mining in cluster situation								
Cluster area of mine leases up to 5 ha	'B2'	Form-1M, PFR and Approved Mine Plan	No	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	DEAC/ DEIAA/	DEIAA SEIAA SPCB CPCB MoEFCC Agency nominated by MoEFCC
Cluster area of Mine leases > 5 ha and < 25 ha with no individual lease > 5 ha	'B2'	Form-I, PFR and Approved Mine Plan and one EMP for all leases in the Cluster	No	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	DEAC/ DEIAA/	
Cluster of mine leases of area > 25 hectares with individual lease size < 50ha	'B1'	Yes	Yes	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	SEAC/ SEIAA	



Cluster of any size with any of the individual lease > 50ha	'A'	Yes	Yes	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	EAC/ MoEFCC	
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MANAGEMENT OF SAND DEPOSITED AFTER FLOOD ON AGRICULTURAL FIELD OF FARMERS

The Standing Committee on Water Resources on issues, concerning flood management, compensation, and status of ownership of submerged and eroded land in the country including compensation to farmers for loss of their crops destroyed by floods and right to disposal of the sand left in the fields of farmers in its meeting held on 29.04.2015 made observations on this subject.

The Committee observed that pursuant to Hon'ble Supreme Court of India decision in "Deepak Kumar Case" in 2012, regulations were framed by the Ministry of Mines to guide environmental clearance of minor minerals. ... The Committee, therefore, desires the Ministry of Water Resources, River Development and Ganga Rejuvenation to work in close coordination with the Ministry of Mines and Environment, Forest and Climate Change to frame regulations / Guidelines in this regard expeditiously.

Mining of Sand

The Committee further observed that due to the floods, the agricultural land of farmer is destroyed and rendered infertile. Further the farmer loses his livelihood as the produce of his land is destroyed by flood and become unsalable. The farmer is also deprived of the right of lifting sand from his land. He is therefore, left helpless and destitute and leave their land in search of job.

The Committee observes that "mining operation" means any operation undertaken for the purpose of winning any mineral. Accordingly, if desilting is undertaken perse with the objective of winning a mineral then only it will be construed as a mining operation. Apparently, if the desilting is undertaken not for winning any mineral, it will not be construed as mining operation and therefore, the farmer can remove the sand from the land without requiring the requisite permits. However, the Committee strongly feels that the farmer be given the right to use and dispose-off the sand accumulated over their land post flood, by incorporating the necessary provisions in the Mines and Mineral (Development and Regulation) Act, 1957".

Removal of sand from the agricultural field by the owner farmer of the land from environment point of view will not be considered as mining operation and its removal and disposal can be allowed without the requirement of environment clearance till it is done only to the extent of reclaiming the agricultural land. The sand deposited after flood only be removed, so no mining / digging below the ground level is allowed. For removing sand in case where private land has gone into the river due to erosion, the requirement of mining lease and environment clearance will continue. This operation



of removal of sand deposited on agricultural field should be done after a mapping of deposition is done by the Land Management Committee of the Gram Panchayat. The sand so deposited post flood can be removed by the farmer owning the land / group of farmers affected by this post flood sand deposition or the Gram Panchayat. Customary rights to remove and dispose off the sand should be given to the farmer affected by deposition of sand on account of sudden flood in his agricultural land.



MINING OF SAND FROM AGRICULTURAL FIELD

This practice is prevalent in Haryana, where the top layer of soil varying between 1 and 2 meters is removed and stacked separately and thereafter the sand deposit which may be 10-15 meter deep is mined. After removing the sand layer up to a maximum depth of 09 meters, the top soil stacked is spread out on the field and the same is brought under the cultivation. Though the level of this land (mined out area) is lowered to the depth of the excavation and in initial years of cultivation the productivity is low, but the productivity of the fields improves with continued cultivation and addition of organic manure in the field. In Haryana some leases are of large area (ranging from 1000 hectare to 2000 hectare) the agricultural fields and river bed both are included in the same lease for mining.

The following recommendations should be kept in mind for mining in such leases:

1. Mining of sand in such mine leases will require environment clearance.
2. The lease should be of sand mining either from the agricultural field or river. In same lease both type of area should not be included.
3. The sand mining from agricultural field is being done in Haryana for a long time and it can be done in a more sustainable manner without adverse impact on agricultural productivity, if proper environmental safeguards are taken.
4. The slope of mining area adjacent to agricultural fields should be proper (preferably 45-60 degree) and adequate gap (minimum 10 feet) be left from adjacent agricultural field to avoid erosion and scouring.

CUSTOMARY RIGHT ON SAND MINING

The native people have their long held customary rights to take silt, sand & soil from their tanks and nearby rivers for their use or community works in the village in almost all the States in some form or the other.

Next to the reserved forests, tanks and rivers are the biggest common properties in India. Most of the village tanks are 'government properties' with some exceptions of privately held tanks. Land revenue department, irrigation department and forest department is given powers to deal with property right' and hence protecting all tanks and rivers preventing damages including encroachments is their responsibility. The local villagers were given 'customary rights' under the Revenue Department Orders, and other laws related to Panchayats and Easements to take sand, soil and earth for agricultural and domestic purposes without seeking any permission from anyone. The States strive to keep these customary rights to use such resources like soil and sand for individuals work and community work in the village intact without requirement of any permit and clearance. These customary rights need to be protected and respected.



DESILTING OF RESERVOIRS / BARRAGES / ANNECUTS / LAKES / CANALS

These structures are generally in possession and maintenance of Irrigation Department / Minor Irrigation Department / PHED of State Governments. The dams and reservoirs can be a significant source of sand. Many such structures are silted and their water holding capacity has gone down considerably. In some instances to compensate for silted capacity raising of height of dam or construction of new structures is proposed which further leads to submergence of new areas of agricultural field and forests. Taking up desilting of such projects can serve dual purpose of increasing the water holding capacity and making available the sand for other usage. In some States the Irrigation Department is permitted to use it for the departmental works free of charge and balance can be disposed of in market after paying the due royalty. A detailed study is required to be carried out to verify economic viability and environmental sustainability before contemplating dredging of storage reservoirs for sand / gravel mining.

The de-silting of reservoir, dredging for upkeep and maintenance of structures, channels and averting natural disasters will not be treated as mining for the purpose of environmental clearance.

The Ministry of Water Resources (MoWR) view on desiltation from flood control point of view is as follows:

A multidisciplinary Committee (Mittal Committee) under the chairmanship of Dr. B.K. Mittal, former Chairman, Central Water Commission was constituted by MoWR, vide letter dated 08.10.2001 to identify cause and extent of siltations in rivers, suggest measures to minimize siltation, examine as to whether desilting is a technically feasible means to minimize magnitude of flood in rivers, suggest appropriate technology/ methods of desilting of rivers, propose a realistic operational programme in a time bound manner and other related aspects. The committee studied in respect of few sites on Ganga, Brahmaputra, Godavari, Krishna etc., and inter-alia concluded that:

- i) Siltation in river is not pronounced and alarming;
- ii) Desilting of rivers for flood control is not an economically viable solution;
- iii) Dredging in general has been found to be inadequate and should not be resorted to, particularly in major rivers;
- iv) There are, of course, some locations such as tidal rivers, confluence points with narrow constrictions and the like which can be tackled by desilting after thorough examination and techno-economic justification;
- v) Selective dredging is suggested depending upon local conditions; and
- vi) Desilting of rivers can marginally minimize the magnitude of floods and be effective only for a short period.

Thus, desilting in general is not feasible technically, due to several reasons like non-sustainability, non-availability of vast land required for disposal of dredged material etc. This cannot be viewed in isolation of other approaches to manage floods. Desilting of rivers in vulnerable reaches may be suggested based on model study, if it is found techno-economically viable. For navigation purposes, the river reaches in the water ways path may be dredged to have minimum depth of water.



MINING PLAN

The Environment Clearance shall be given to only those mining leases which have mine plan approved by the Competent Authority designated by the States. Modification of the mining plan during operation will also need approval of the Competent Authority. The Mining Plan shall be prepared by the Recognised Qualified Persons (RQP). The person to be recognized for preparing the mining plan should be a holding a degree of Mining Engineering, Environmental Engineering or a post graduate degree in Geology granted by a University established or incorporated by or under a Central Act or a State Act including any institutions recognized by the UGC or any equivalent qualification granted by any University or institution outside India and have a professional experience of three years of working in a supervisory capacity in the field of mining after obtaining a degree. The States will devise their own mechanism of selection and empanelment of RQPs. A mining plan should be valid for a period of 5 years, which can be renewed further.

EVALUATING THE IMPACT OF SAND MINING

To assess the impact of mining and effect of remedial measures can be assessed through monitoring. This is also required for mid-course corrections. Monitoring will provide data to evaluate the upstream and downstream effects of sand and gravel extraction activities, and long-term changes. A brief report summarizing the annual results of the physical and biological monitoring should document the evolution of the sites over time, and the cumulative effects of sand and gravel extraction. The summary should also recommend any modification of extraction rates needed to minimize impacts of extraction.

Sand Replenishment, Geomorphology and Hydrology:

Physical monitoring requirements of sand and gravel extraction activities should include surveyed channel cross-sections, longitudinal profiles, bed material measurements, geomorphic maps, and discharge and sediment transport measurements. The physical data will illustrate bar replenishment and any changes in channel morphology, bank erosion, or particle size.

In addition to local monitoring for replenishment at specific mining sites, monitoring of the entire reach through the estuary will provide information on the cumulative response of the system to sand and gravel extraction. For example, it is important for downstream bars and the estuary to receive sufficient sand and gravel to maintain estuarine structure and function. Because the elevation of the bed of the channel is variable from year to year, a reach-based approach to monitoring will provide a larger context for site-specific changes. If long-term monitoring data show that there is a reach-scale trend of bed lowering (on bars or in the thalweg), the extraction could be limited.

Cross-sections:

Surveyed channel cross-sections should be located at permanently documented sites upstream, downstream and within the extraction area. Cross-sections intended to show reach- scale changes



should be consistently located over geomorphic features such as at the head of riffles, across the deepest part of pools, or across particular types of channel bars.

Cross-section spacing should be close enough to define the morphology of the river channel. Cross-section data should be surveyed in March or April to evaluate changes that may occur during the flooding season.

Cross-section data should be collected over the reach to the estuary, and locally upstream, downstream, and within each mining site. This long-term monitoring data should be collected and analyzed even if no mining occurs in order to understand and estimate the sand budget of the river reach.

Photo-documentation:

Photographs of the project sites should be taken prior to excavation to document the baseline conditions, and again during each monitoring session. Photos should be taken twice a year. Photos of structures nearby like outfalls / off-takes, intakes, bridges and other structures may also be regularly taken.

Groundwater Level:

Monitoring wells should be established adjacent to each off-channel floodplain excavation to record changes in ground water levels. Measurements should be taken monthly. This should help analyse surface water and ground water interaction along the reach.

Extent and Quality of Riparian Vegetation:

Document the extent and quality of riparian vegetation, including successional status, and any increase in disturbance indicators (non-native plants). The extent of riparian habitat can be determined utilising aerial photos. Habitat quality data, i.e., successional status and species composition, must be determined through field reconnaissance.

Riparian Vegetation Maps:

Develop yearly maps of the sensitive habitat areas and document their aerial extent over time. These maps may be combined with the geomorphic maps. Monitor sites identified as sensitive for disturbance in excess of expected geomorphic trends - i.e., massive bank wasting up or downstream from an active mine site. Monitor sand and gravel mining impacts which may translate up and downstream, causing accelerated erosion of sensitive zones and impacting the ability of new habitat to form due to excessive scour or sedimentation.

This monitoring / documentation should be done by the EC holders and will be regularly checked and assessed by the DEIAA for corrective steps in time. The DEIAA should review the status of monitoring and documentation data of each mining site especially for sand mining once in a year.



MONITORING SYSTEM FOR SUSTAINABLE SAND MINING

The implementation of these Guidelines on Sustainable Sand Mining is not possible till States create a robust mechanism to monitor the mining operation and measure the mined out mineral. The entire exercise of Environment Impact Assessment and Environment Management Plan aims towards making the mining process environmentally sustainable. The Environment Clearance letter indicates the EC capacity that is the quantity of material which can be mined in a year. If this quantity is not measured, and much more mineral than envisaged in the EC is mined out then the entire process of EC is rendered futile. Keeping above objective in mind it is required of the State / State Agencies to create and establish a robust system to monitor and measure the mined out mineral at each lease location and its transportation in State.

The State Governments have tried various methods for monitoring the sand mining in their areas, the main feature of which generally has been through Transport Permits (T.P.). The printing of Transport Permits on security paper, invisible ink mark, fugitive ink background, VOID pantograph and Unique Barcode are some of the tools used by the States. These tools need to be backed by suitable software and dedicated websites with security certifications at different levels.

The system proposed is that States should issue Transport Permit. Bar code on the T.P. when scanned using the system, will generate a unique invoice number. The bidder has to enter destination, distance between plot and destination, vehicle number etc in the system. After scanning, unique bar code number; invoice date & time and validity date & time is sent to the bidder, which need to be written on T.P. Validity of T.P. is calculated based on distance between plot and destination. After validity time is over the T.P. stands invalid. The officers involved in monitoring should be provided with the android application using which the T.P. can be checked anywhere on road. As soon as the bar code on T.P. gets scanned through using android application, all details of T.P. such as plot details, vehicle details, validity time etc. should get fetched from server. This means, if anything is re-written on T.P. and attempt is made to reuse the same, it can be traced immediately. Registering of T.P. on server can be done using website, using android application (smartphone with internet) or even through SMS (smartphone without internet). This implies that TP can be registered on server even if only mobile phone range is available on plot. Various reports can be generated using the system showing daily lifting reports and user performance report. This way the vehicles carrying sand can be tracked from source to destination.



MONITORING SYSTEM FOR SUSTAINABLE SAND MINING

PROCEDURE FOR MONITORING OF SAND MINING OR RIVER BED MINING

1. **The security feature of Transport Permit shall be as under:**
 - (a) Printed on Indian Banks' Association (IBA) approved Magnetic Ink Character Recognition (MICR) Code paper.
 - (b) Unique Barcode.
 - (c) Unique Quick Response (QR) code.
 - (d) Fugitive Ink Background.
 - (e) Invisible Ink Mark.
 - (f) Void Pantograph.
 - (g) Watermark.

2. **Requirement at Mine Lease Site:**
 - (a) Small Size Plot (Up to 5 hectare): Android Based Smart Phone.
 - (b) Large Size Plots (More than 5 hectare): CCTV camera, Personal Computer (PC), Internet Connection, Power Back up.
 - (c) Access control of mine lease site.
 - (d) Arrangement for weight or approximation of weight of mined out mineral on basis of volume of the trailer of vehicle used.

3. **Scanning of Transport Permit or Receipt and Uploading on Server:**
 - (a) Website: Scanning of receipt on mining site can be done through barcode scanner and computer using the software;
 - (b) Android Application: Scanning on mining site can be done using Android Application using smart phone. It will require internet availability on SIM card;
 - (c) SMS: Transport Permit or Receipt shall be uploaded on server even by sending SMS through mobile. Once Transport Permit or Receipt get uploaded, an unique invoice code gets generated with its validity period.



4. **Proposed working of the system:**

The State Mining Department should print the Transport Permit or Receipt with security features enumerated at Paragraph 1 above and issue them to the mine lease holder through the District Collector. Once these Transport Permits or Receipts are issued, they would be uploaded on the server against that mine lease area. Each receipt should be preferably with pre-fixed quantity, so the total quantity gets determined for the receipts issued.

When the Transport Permit or Receipt barcode gets scanned and invoice is generated, that particular barcode gets used and its validity time is recorded on the server. So all the details of transporting of mined out material can be captured on the server and the Transport Permit or Receipt cannot be reused.

5. **Checking On Route:**

The staff deployed for the purpose of checking of vehicles carrying mined mineral should be in a position to check the validity of Transport Permit or Receipt by scanning them using website, Android Application and SMS.

6. **Breakdown of Vehicle:**

In case the Vehicle breakdown, the validity of Transport Permit or Receipt shall be extended by sending SMS by driver in specific format to report breakdown of vehicle. The server will register this information and register the breakdown. The State can also establish a call centre, which can register breakdowns of such vehicles and extend the validity period. The subsequent restart of the vehicle also should be similarly reported to the server or call centre.

7. **Tracking of Vehicles:**

The route of vehicle from source to destination can be tracked through the system using check points, RFID Tags, and GPS tracking.

8. **Alerts or Report Generation and Action Review:**

The system will enable the authorities to develop periodic report on different parameters like daily lifting report, vehicle log or history, lifting against allocation, and total lifting. The system can be used to generate auto mails or SMS. This will enable the District Collector or District Magistrate to get all the relevant details and shall enable the authority to block the scanning facility of any site found to be indulged in irregularity. Whenever any authority intercepts any vehicle transporting illegal sand, it shall get registered on the server and shall be mandatory for the officer to fill in the report on action taken. Every intercepted vehicle shall be tracked.

The monitoring of mined out mineral, environmental clearance conditions and enforcement of Environment Management Plan will be ensured by the DEIAA, SEIAA and the State Pollution Control Board or Committee. The monitoring arrangements envisaged above shall be put in place. The monitoring of enforcement of environmental clearance conditions shall be done by the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change and the agency nominated by the Ministry for the purpose.



ADMINISTRATIVE STRUCTURE FOR ENVIRONMENT CLEARANCE AND ENSURING COMPLIANCE OF EC CONDITIONS

An no mining in allowed without Envirnomental Clearance. The process of EC involves preparation of EIA/EMP, PER and mine plan.

The EIA/EMP can be prepared by the State Government or any agency of the State, group of project proponents in the cluster or the individual project proponent. The EIA / EMP can be prepared by the accredited consultants or the Registered Qualified Person(s) / agencies selected by the States.

DISTRICT ENVIRONMENT IMPACT ASSESSMENT AUTHORITY

The Central Government has constituted the District Level Environment Impact Assessment Authority (DEIAA), for grant of environmental clearance for Category 'B2' Projects for mining of minor minerals, for all the districts in the country.

For, minor minerals including sand and gravel mining lease of area up to 5 hectare in case of individual lease and up to 25 ha in case of cluster for sand mining, the grant of EC will be done by the District Environment Impact Assessment Authority (DEIAA) headed by the District Magistrate or District Collector. This Authority will be responsible for proper and sustainable management of sand mining in the district. The Authority will be responsible for designating the area / stretch in river suitable for mining in the district and also identifying the area / stretch in river prohibited for sand mining. The Authority will ensure clear demarcation of mining site, its documentation, and ensuring that no mining takes place without EIA / EMP and EC of the mining site.

The Chairperson and official members of the Authority for the districts should hold office during their tenure in the district on said posts and the expert member shall hold office for a period of three years from the date of nomination by the Competent Authority. The Committee shall meet at least once in a month.

The District Environment Impact Assessment Authority (DEIAA) :

The DEIAA will have following composition :

- | | | |
|----|--|------------------|
| 1. | District Magistrate or District Collector of the district | Chairperson |
| 2. | Senior most Divisional Forest Officer in the district | Member |
| 3. | An expert member to be nominated by the Divisional Commissioner or Chief Conservator of the Forest | Member |
| 4. | Sub-Divisional Magistrate or Sub-Divisional Officer of the district head quarter | Member-Secretary |



DISTRICT LEVEL EXPERT APPRAISAL COMMITTEE:

The District Level Expert Appraisal Committee (DEAC) will appraise the cases and make recommendations to the District Environment Impact Assessment Authority for environmental clearance. This Committee will also make recommendations / suggestions on the District Survey Report to the DEIAA. The DEAC will have following composition:

- | | |
|--|-------------------|
| 1. Senior most Executive Engineer, Irrigation Department | Chairperson |
| 2. Senior most Sub-Divisional Officer (Forest) | Member |
| 3. A representative of Remote Sensing Department or Geology Department or State Ground Water Department to be nominated by the District Magistrate or District Collector | Member |
| 4. Occupational health expert or Medical Officer to be nominated by the District Magistrate or District Collector | Member |
| 5. Engineer from Zila Parishad | Member |
| 6. A representative of State Pollution Control Board or Committee | Member |
| 7. An expert to be nominated by the Divisional Commissioner or Chief Conservator of Forest | Member |
| 8. An expert to be nominated by the Divisional Commissioner or Chief Conservator of Forest | Member |
| 9. An expert to be nominated by the Divisional Commissioner or Chief Conservator of Forest | Member |
| 10. Senior most Assistant Engineer, Public Works Department | Member |
| 11. Assistant Director or Deputy Director or District Mines Officer or Geologist in the district in that order | Member- Secretary |

The DEAC will meet at least once a month, depending on the work load the frequency of meetings can be decided by the Chairperson of DEAC and Chairperson, DEIAA.

Each proposal for the mining lease under consideration for environmental clearance in the district will be inspected on-site by the Sub-Divisional Level Committee headed by the SDM.



The Sub-Divisional Committee should comprise of following officers:

Sub-Divisional Magistrate	Chairperson
Sub-Divisional Officer, Forest/ Assistant Conservator of Forest/ Forest Range Officer	Member
Representative of State Pollution Control Board	Member
SDO, Irrigation Department	Member
Geologist or Assistant Geologist or Mining Officer / Mining Inspector	Member

The presence of at least three members will be needed for inspection. This Committee shall submit its report within 15 days from the receipt of the proposal.

The monitoring of EC conditions and enforcement of EMP will be ensured by the District Collector and the, State Pollution Control Board. The monitoring of enforcement of EC conditions can also be done by the Central Pollution Control Board, Ministry of Environment, Forest & Climate Change and the agency nominated by the Ministry for the purpose.

Schematic Presentation of Requirements on Environmental Clearance of Sand Mining including cluster situation

Area of Lease (Hectare)	Category of Project	Requirement of EIA / EMP	Requirement of Public Hearing	Requirement of EC	Who can prepare EIA/ EMP	Who will apply for EC	Authority to appraise/ grant EC	Authority to monitor EC compliance
EC Proposal of Sand Mining on the basis of individual mine lease								
0 - 5ha	'B2'	Form - 1M, PFR and Approved Mine Plan	No	Yes	Project Proponent	Project Proponent	DEAC/ DEIAA	DEIAA SEIAA SPCB CPCB MoEFCC Agency nominated by MoEFCC



> 5 ha and < 25 ha	'B2'	Form-I, PFR and Approved Mine Plan and EMP	No	Yes	Project Proponent	Project Proponent	SEAC / SEIAA	DEIAA SEIAA SPCB CPCB MoEFCC Agency nominated by MoEFCC
≥ 25ha and < 50ha	'B1'	Yes	Yes	Yes	Project Proponent	Project Proponent	SEAC / SEIAA	
≥ 50 ha	'A'	Yes	Yes	Yes	Project Proponent	Project Proponent	SEAC / SEIAA	
EC Proposal of Sand Mining in cluster situation								
Cluster area of mine leases up to 5 ha	'B2'	Form - 1M, PFR and Approved Mine Plan	No	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	DEAC/ DEIAA/	DEIAA SEIAA SPCB CPCB MoEFCC Agency nominated by MoEFCC
Cluster area of Mine leases > 5 ha and < 25 ha with no individual lease > 5 ha	'B2'	Form -I, PFR and Approved Mine Plan and one EMP for all leases in the Cluster	No	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	DEAC/ DEIAA/	



Cluster of mine leases of area \geq 25 hectares with individual lease size $<$ 50ha	'B1'	Yes	Yes	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	SEAC/ SEIAA	
Cluster of any size with any of the individual lease \geq 50ha	'A'	Yes	Yes	Yes	State, State Agency, Group of Project Proponents, Project Proponent	Project Proponent	EAC/ MoEFCC	

General Conditions will not apply on account of inter- state boundaries for river sand mining leases.



EXEMPTION OF CERTAIN CASES FROM BEING CONSIDERED AS MINING FOR THE PURPOSE OF REQUIREMENT OF ENVIRONMENTAL CLEARANCE

Keeping in view the purpose, maintenance of infrastructure, abatement of disasters, customary easement and property rights, it is felt that following cases may not be treated as mining for the purpose of requirement of environmental clearance. The following cases shall not require prior environmental clearance, namely:-

1. Extraction of ordinary clay or sand, manually, by the Kumhars (Potter) to prepare earthen pots, lamp, toys, etc. as per their customs.
2. Extraction of ordinary clay or sand, manually, by earthen tile makers who prepare earthen tiles.
3. Removal of sand deposits on agricultural field after flood by farmers.
4. Customary extraction of sand and ordinary earth from sources situated in Gram Panchayat for personal use or community work in village.
5. Community works like de-silting of village ponds or tanks, construction of village roads, ponds, bunds undertaken in Mahatama Gandhi National Rural Employment and Guarantee Schemes, other Government sponsored schemes, and community efforts.
6. Dredging and de-silting of dams, reservoirs, weirs, barrages, river, and canals for the purpose of their maintenance, upkeep and disaster management.
7. Traditional occupational work of sand by Vanjara and Oads in Gujarat vide notification number GU/90(16)/MCR-2189(68)/5-CHH, dated the 14th February, 1990 of the Government of Gujarat.
8. Digging of well for irrigation or drinking water.
9. Digging of foundation for buildings not requiring prior environmental clearance.
10. Excavation of ordinary earth or clay for plugging of any breach caused in canal, nala, drain, water body, etc., to deal with any disaster or flood like situation upon orders of District Collector or District Magistrate.
11. Activities declared by State Government under legislations or rules as non- mining activity with concurrence of the Ministry of Environment, Forest and Climate Change, Government of India.



STANDARD ENVIRONMENTAL CONDITIONS FOR SAND MINING

Impact Category	S.No.	Environmental Conditions
Stakeholder Engagement	1	In the case of private land not owned by the lease holder an affidavit should be obtained regarding consent of the concerned land owner (s) for carrying out the mining operation.
	2	Stakeholder awareness and ability to raise concerns and getting it to be addressed.
	3	Implementation of Action Plan on the issues raised during the Public Hearing. The Proponent shall complete all the tasks as per the Action Plan submitted with the budgetary provisions during the Public Hearing.
	4	Having valid lease and all the permits is very much needed.
	5	To establish a Monitoring Committee including Local Panchayat, to check on traffic due to transportation and submit an annual report on the same.
	6	The directions given by the Hon'ble Supreme Court of India vide order dated 27.02.2012 in Deepak Kumar case [SLP(C) Nos. 19628-19629 of 2009] and order dated 05.08.2013 of the Hon'ble National Green Tribunal in application No. 171/2013 may be strictly followed.
	7	All the provisions made and restrictions imposed as covered in the Minor Mineral Rule, shall be complied with, particularly regarding Environment Management Practices and its fund management and Payment of compensation to the land owners.
Sustainable Mining Practices	8	District level Survey Report should be prepared and area suitable for mining and area prohibited for mining be identified.
	9	The depth of mining in Riverbed shall not exceed one meter or water level whichever is less, provided that where the Joint Inspection Committee certifies about excessive deposit or over accumulation of mineral in certain reaches requiring channelization, it can go up to 3 meters on defined reaches of the River.
	10	No River sand mining be allowed in rainy season.
	11	To submit annual replenishment report certified by an authorized agency. In case the replenishment is lower than the approved rate of production,



		then the mining activity / production levels shall be decreased / stopped accordingly till the replenishment is completed.
	12	Ultimate working depth shall be up to 3.0 m from Riverbed level and not less than one meter from the water level of the River channel whichever is reached earlier. In hilly terrain this depth be preferably restricted to one meter.
	13	In River flood plain mining a buffer of 3 meter to be left from the River bank for mining.
	14	In mining from agricultural field a buffer of 3 meter to be left from the adjacent field.
	15	Mining shall be done in layers of 1 meter depth to avoid ponding effect and after first layer is excavated, the process will be repeated for the next layers.
	16	To maintain safety and stability of Riverbanks i.e. 3 meter or 10% of the width of the River whichever is more will be left intact as no mining zone.
	17	No stream should be diverted for the purpose of sand mining. No natural water course and/ or water resources are obstructed due to mining operations.
	18	No blasting shall be resorted to in River mining and without permission at any other place.
	19	Depending upon the location, thickness of sand, deposition, agricultural land/Riverbed, the method of mining may be manual, semi-mechanized or mechanized; however, manual method of mining shall be preferred over any other method.
Identification and Preparation of Mining Site	20	Mining should be done only in area / stretch identified in the District Level Survey Report suitable for mining and so certified by the Sub-Divisional Level Committee after site visit.
	21	Mining should begin only after pucca pillar marking the boundary of lease area is erected at the cost of the lease holder after certification by the mining official and its geo coordinates are made available to the District Level Committee.
	22	The top soil in case of surface land mining shall be stored temporarily in an earmarked site and concurrently used for land reclamation.



Monitoring the Mining of Mineral and its Transportation	23	The EC holder shall keep a correct account of quantity of mineral mined out, dispatched from the mine, mode of transport, registration number of vehicle, person in-charge of vehicle and mine plan. This should be produced before officers of Central Government and State for inspection.
	24	For each mining lease site the access should be controlled in a way that vehicles carrying mineral from that area are tracked and accounted for.
	25	The State / District Level Environment Committee should use technology like Bar Coding, Information and Communications Technology (ICT), Web based and ICT enabled services, mobile SMS App etc. to account for weight of mineral being taken out of the lease area and the number of trucks moving out with the mineral.
	26	There should be regular monitoring of the mining activities in the State to ensure effective compliance of stipulated EC conditions and of the provisions under the Minor Mineral Concessions Rules framed by the State Government.
Noise Management	27	Noise arising out of mining and processing shall be abated and controlled at source to keep within permissible limit.
	28	Restricted working hours. Sand mining operation has to be carried out between 6 am to 7 pm.
Air Pollution and Dust Management	29	The pollution due to transportation load on the environment will be effectively controlled and water sprinkling will also be done regularly.
	30	Air Pollution due to dust, exhaust emission or fumes during mining and processing phase should be controlled and kept in permissible limits specified under environmental laws.
	31	The mineral transportation shall be carried out through covered trucks only and the vehicles carrying the mineral shall not be overloaded. Wheel washing facility should be installed and used.
Management of Visual Impact	32	The mining operations are to be done in a systematic manner so that the operations shall create a major visual impact on the site.
Bio-Diversity Protection	33	Restoration of flora affected by mining should be done immediately. Twice the number of trees destroyed by mining to be planted preferably of indigenous species. Each EC holder should plant and maintain for lease period at least 5 trees per hectare in area near lease.
	34	No mining lease shall be granted in the forest area without forest clearance in accordance with the provisions of the Forest Conservation Act, 1980 and the rules made thereunder.



	35	Protection of turtle and bird habitats shall be ensured.
	36	No felling of tree near quarry is allowed. For mining lease within 10km of the National Park / Sanctuary or in Eco-Sensitive Zone of the Protected Area, recommendation of Standing Committee of National Board of Wild Life (NBWL) have to be obtained as per the Hon'ble Supreme Court order in I.A. No. 460 of 2004.
	37	Spring sources should not be affected due to mining activities. Necessary Protection measures are to be incorporated.
Management of Instability and Erosion	38	Removal, stacking and utilization of top soil in mining are should be ensured. Where top soil cannot be used concurrently, it shall be stored separately for future use keeping in view that the bacterial organism should not die and should be spread nearby area.
	39	The EC should stipulate conditions for adequate steps to check soil erosion and control debris flow etc. by constructing engineering structures
	40	Use of oversize material to control erosion and movement of sediments
	41	No overhangs shall be allowed to be formed due to mining and mining shall not be allowed in area where subsidence of rocks is likely to occur due to steep angle of slope.
	42	No extraction of stone / boulder / sand in landslide prone areas.
	43	Controlled clearance of riparian vegetation to be undertaken
Waste Management	44	Site clearance and tidiness is very much needed to have less visual impact of mining.
	45	Dumping of waste shall be done in earmarked places as approved in Mining Plan.
	46	Rubbish burial shall not be done in the Rivers.
Pollution Prevention	47	The EC holder shall take all possible precautions for the protection of environment and control of pollution.
	48	Effluent discharge should be kept to the minimum and it should meet the standards prescribed.
Protection of Infrastructure	49	Mining shall not be undertaken in a mining lease located in 200-500 meter of bridge, 200 meter upstream and downstream of water supply / irrigation scheme, 100 meters from the edge of National Highway and railway line, 50 meters from a reservoir, canal or building, 25 meter from the edge of State Highway and 10 meters from the edge of other



		roads except on special exemption by the Sub-Divisional level Joint Inspection Committee.
	50	For carrying out mining in proximity to any bridge or embankment, appropriate safety zone (not less than 200 meters) should be worked out on case to case basis, taking into account the structural parameters, location aspects and flow rate, and no mining should be carried out in the safety zone so worked out.
	51	Mining activities shall not be done for mine lease where mining can cause danger to site of flood protection works, places of cultural, religious, historical, and archeological importance.
Enhancement Road Safety	52	Vehicles used for transportation of sand are to be permitted only with of fitness and PUC Certificates.
	53	Junction at takeoff point of approach road with main road be properly developed with proper width and geometry required for safe movement of traffic by concession holder at his own cost.
	54	Project Proponent shall ensure that the road may not be damaged due to transportation of the mineral; and transport of minerals will be as per IRC Guideliness with respect to complying with traffic congestion and density.
	55	No stacking allowed on road side along National Highways.
Closure and Reclamation of Mined Out Area	56	The Project Proponent shall undertake phased restoration, reclamation and rehabilitation of land affected by mining and completes this work before abandonment of mine.
	57	Restoration, reclamation and rehabilitation in cluster should be done systematically and jointly by each EC holder in that cluster. This should be appropriately reflected as EC condition in each EC in cluster.
	58	Site specific plan with eco-restoration should be in place and implemented.
Health and Safety	59	Health and safety of workers should be taken care of.
	60	Transport of mineral will not be done through villages / habitations.
	61	The Project Proponent shall make arrangement for drinking water, first aid facility (along with species specific anti-venom provisioning) in case of emergency for the workers.



	62	Project Proponent shall implement the Disaster Management Plan if the mine lease area is located in Seismic Zone-IV. Project Proponent shall appoint a Committee to have a check over any disaster to warn workers well before for the safety of the workers. Emergency helpline number will be displayed at all levels.
	63	Project Proponent shall appoint an Occupational Health Specialist for Regular and Periodical medical examination of the workers engaged in the Project and records maintained; also, Occupational health check-ups for workers having some ailments like BP, diabetes, habitual smokers, etc. shall be undertaken once in six months and necessary remedial/preventive measures taken accordingly. Recommendations of National Institute for Labour for ensuring good occupational environment for mine workers would also be adopted.
Monitoring the Impact of Mining	64	The Project Proponent shall report monitoring data on replenishment, traffic management, levels of production, River Bank erosion and maintenance of Road etc.
Mineral Conservation	65	Use of alternate material such as M-sand in place of natural River sand shall be encouraged in order to reduce stress on natural eco-system.



APPENDIX: TABLE - 1

REVENUE FROM SAND MINING IN STATES / UTs

(Rs. in crores)

Sl.No.	STATE / U.T	2012 - 2013	2013 - 2014	2014 - 2015
01	Andaman & Nicobar	0.073	0	0
02	Arunachal Pradesh	7	8	5
03	National Capital Territory of Delhi	0	0	
04	Himachal Pradesh	0.70	0.35	0.07
05	Jharkhand	4.25	3.04	0.07
06	Karnataka	23.74	15.33	25.99
07	Madhya Pradesh	184.93	179.41	172.53
08	Meghalaya	14.50	15.88	15.50 (as forest royalty from govt. contractors)
09	Mizoram	0.018	0.0475	0.0861
10	Puducherry	0.80	0.20	0.03
11	Rajasthan	173.36	252.06	134
12	Tamil Nadu	188.50	117.73	109.10
13	Uttar Pradesh	97.27	166.45	168.38

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE - 2

NUMBER OF MINING LEASES IN STATE

Sl.No.	STATE / U.T	In stream	Flood Plain	Sea Shore	Agricultural field	River	Total
01	Andaman & Nicobar						Nil
02	Andhra Pradesh						Nil
03	Haryana	5	12		7		31
04	Jammu & Kashmir					650	650
05	Jharkhand	10				387	397
06	Lakshadweep					1090	1090
07	Manipur						NIL
08	Meghalaya						NIL
09	Odisha						NIL
10	Punjab	2 + 80 Temporary Working Permit				73	155
11	Sikkim		85				85
12	Tripura	21	244		5		270

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE - 3

**AVERAGE SIZE OF SAND MINING LEASES IN
STATE / UT: 2014-15**

(In Hectare)

Sl.No.	STATE / U.T	AVERAGE SIZE	SMALLEST MINING LEASE AREA	LARGEST MINING LEASE AREA
01	Andaman & Nicobar	NOT APPLICABLE		
02	Arunachal Pradesh	ONLY MINING PERMITS		
03	Himachal Pradesh	1.20	0.25	4.09
04	Jharkhand	0.25	0.13	87.38
05	Karnataka	5	5	19.42
06	Madhya Pradesh	8.52	0.30	306.98
07	Meghalaya	Mostly < 1.5 ha.		
08	Mizoram	NA		
09	Puducherry	NA		
10	Rajasthan	2 5 in Bikaner	24.82 2 in Bikaner	1901.89 5 in Bikaner
11	Tamil Nadu	29 leases < 10 ha.	14 leases of 10 - 15 ha.	42 leases > 15 ha.
12	Uttar Pradesh	25	5	200

* States/UTs not mentioned have not provided the data.

**APPENDIX: TABLE - 4**
**AVERAGE PERIOD OF SAND MINING
LEASES IN STATE / UT**

(In Hectare)

Sl.No.	STATE / U.T	AVERAGE MINING LEASE PERIOD (YEARS)
01	Andaman & Nicobar	Not Applicable
02	Arunachal Pradesh	Only mining permit is given
03	Himachal Pradesh	5
04	Jharkhand	3
05	Karnataka	2
06	Madhya Pradesh	5 to 10
07	Meghalaya	No lease in operation currently
08	Mizoram	No mining lease in operation currently
09	Puducherry	One year permit
10	Rajasthan	5 20-30 years in Bikaner
11	Tamil Nadu	3
12	Uttar Pradesh	3

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE - 5

COMMON METHOD AND PRACTICE OF SAND MINING IN STATE / UT

Sl.No.	STATE / U.T	COMMON METHOD AND PRACTICE OF SAND MINING
01	Andaman & Nicobar	<ol style="list-style-type: none"> 1. The Apex Court in its order dated 7.5.2002 in I.A. No. 502 in WP (C) No. 202 of 1995, had directed that extraction of sand be phased out @ minimum 20% per year on reducing balance basis to bring the sand mining to a level of 33% of the present level of mining within a maximum period of five years. 2. Since the level of extraction of sand in the territory in the year 2001-02 i.e. the base year, was 68909 cubic meter, the quantity of extractable sand is fixed at 22581 cubic meter. 3. The quantity of sea sand so allowed by MoEF is extracted from the identified and approved sites having such deposits on the sea beaches (identified accreting area) with adequate environmental safeguards so as to prevent any damage to the sensitive coastal eco-system including corals, turtle/ bird nesting sites and the protected areas. 4. The allotment of sea sand is made to the individuals by the Sand Allotment Committee constituted by the Lieutenant Governor under the Chairmanship of Chief Secretary who also heads the A&N CZMA. The quantum of sea sand allotted is fixed by the Committee on the basis of availability of sea sand and the number of applicants (local) applied for their bonafide use.
02	Arunachal Pradesh	<ol style="list-style-type: none"> 1. Mining of sand restricted to foothills only that too for a very short period. Grant of mining lease is kept in abeyance, short term mining permits are issued to various Central and State agencies for carrying out developmental works under the strict supervision of the departmental officers.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	COMMON METHOD AND PRACTICE OF SAND MINING
03	Himachal Pradesh	Manual. The mining lease areas are sanctioned on the river bed if the area is approved in survey document. The mining activities are allowed strictly in accordance with the approved working cum Environment Management Plan and after the environment clearance.
04	Jharkhand	Manual
05	Karnataka	Manual
06	Madhya Pradesh	Manual
07	Meghalaya	Hill quarrying in private areas
08	Mizoram	Extraction of sand limited mainly for domestic purpose in the state. The produce extracted illegally is seized as per the Mizoram Forest Act, 1955. Mining is only limited to river banks and riverbeds with improvised equipments like spade, shovel, small canoes, etc.
09	Puducherry	Manual
10	Rajasthan	In Rajasthan sand is available in seasonal streams and rivers except Chambal which is perennial but mining is banned because of Chambal Crocodile Sanctuary. Mining is done up to 3 meters and is open cast. It is filled in trucks either manually or semi mechanized method. In Bikaner no river exists and mining for sand is being done from palaeo-channel. In this palaeo-channel the sand deposit occurs at the depth of 5 meter to 20 meter below ground level with an over burden of 5 to 20 meters. The mining here is done open cast benching method, where overlying blown sand, gravel, pebble etc. is removed, the sand is further sieved, graded and washed upto 12 to 18 mesh size.
11	Tamil Nadu	Manual mining is carried out in certain quarries. In most of the sand quarries two poclains are used by the PWD.
12	Uttar Pradesh	Manual and Semi-mechanised

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE - 6

**SUGGESTIONS / RECOMMENDATIONS FROM STATES / UTs
FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING**

Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
01	Andaman & Nicobar	The quantum of extractable sand fixed at 22581 cubic meter should be enhanced. This limit has been fixed by the orders of Hon'ble Supreme Court subject to study by National Institute of Oceanography.
02	Arunachal Pradesh	<ol style="list-style-type: none"> 1. For environmentally sustainable sand mining a strict and comprehensive sand mining policy need to be framed. 2. River sand is becoming a scarce commodity and hence exploring alternative to it has become imminent. Manufactured sand is a good alternative both for fine as well as coarse sand used in concrete. 3. Sand mining should be restricted to surface collection only without the use of heavy machinery. 4. Due to turbulent and inaccessible nature of rivers flowing in the hilly terrains of the state, deposition of the sand in the river bed is very negligible and except for few quarries in the foothills and plains, most of the notified quarries are boulders and mining of sand is very negligible. 5. In view of environment related issues the grant of mining lease for river bed minor mineral viz. sand, gravel, shingle, aggregate, boulder are kept in abeyance and extraction of these minerals is regulated only by grant of mining permits, that too not exceeding 3000 cubic meter in one permit. 6. For scientific mining of sand and other minor minerals Guideliness has been prepared and accordingly Geo-Technical Committee has been constituted under the chairmanship of ADC/SDO in the district level to determine the quantity of quarriable mineral that can be safely removed and also to give technical clearance for notification of quarries of smaller size, preferably within one hectare.
03	Chhattisgarh	<ol style="list-style-type: none"> 1. While attempting to prepare a model Guidelines / policy for the country, the differences that exist in different states may be taken into account. It may be tried to take all stakeholders along.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
		<p>2. To ease the process of EC granting, SEIAA may have benches across the State with each bench having a SEAC under it. Time bound clearance with ease of access and grant.</p> <p>3. Sand mining with use of machinery should be allowed.</p> <p>4. Road construction material like murrum should be exempted from EC considering their local / pocket occurrences and impossibility of obtaining EC.</p> <p>5. Considering the traffic issue at urban areas and to reduce intermediaries like storage point dealers, night mining with adequate lighting should be allowed.</p> <p>6. To make the availability of sand from local rivulet / streams the river bank to in-stream mine area distance should be reduced from 10 meter to 3 meters.</p>
04	NCT of Delhi	<p>1. Location of sand mining should be identified by a committee comprising of revenue deptt., Irrigation Deptt., CGWB, SPCB, Forest Department and mining department. Mining area should distinctly be marked at site, before allowing mining.</p> <p>2. Depth of mining should be restricted to 3 mtrs or water level, whichever is less and that to from aggradation areas. The side slope of excavation should be less than 3:1.</p> <p>3. Requirement of sand and gravel should be reduced by utilization of construction and demolition waste. It requires not only legislative support but also awareness campaign among the society.</p> <p>4. Guidelines should be distinctly clear and easy to understand covering do's and don't during mining operation.</p> <p>5. Sufficient safe distance should be left between mining site and adjoining engineering structures like embankment, spurs, bed bars, bridges, reservoir and regulator etc.</p> <p>6. Security amount should be sufficient enough to compel the agency to carry out rehabilitation, corrective measures and to ensure strict compliance of conditions of lease. S.D. should be released after inspection of committee and recording of certificate that agency complied with the lease conditions.</p> <p>7. Mining may be carried out by state agency instead of private agencies.</p>

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
05	Himachal Pradesh	<ol style="list-style-type: none"> 1. Working cum Environment Management Plan has been made mandatory. The mining activities are allowed after submission of environment clearance. 2. In compliance of order of Hon'ble Supreme Court dated 27.02.2012 in Deepak Kumar case, the Himachal Pradesh has repealed its rules called the Himachal Pradesh Minor Mineral (Concession) and Mineral (Prevention of illegal mining, transportation and Storage) Rule, 2015 in accordance to the recommendation of the Ministry of Environment & Forest and rules circulated by the Ministry of Mines. Hence the State of Himachal Pradesh has complied with the above directions of the Hon'ble Apex Court, 3. Therefore the condition of applicability of Environment Clearance on the area less than 5 hectare shall be exempted. 4. Further keeping in view, the peculiar topography, geography and socio-economic fabric of the State, the condition for the minimum size of the lease should be exempted as the rivers are in youth stage forming different land forms, land holdings are less, population is thin and scattered and the demand of minor mineral is limited, which could be met out locally by exploiting local resources on the small scale.
06	Jammu & Kashmir	<ol style="list-style-type: none"> 1. Uniform Guidelines be framed for sand mining and river bed mining as they cannot be segregated. 2. Identification of sand belts be made in consultation with CGWB and while framing Guideliness CGWB may be taken on board. 3. Sand mining leases less than 5 hectare be exempted from EC and comprehensive policy may be made for hilly states for easing the process of grant of lease.
07	Jharkhand	<ol style="list-style-type: none"> 1. Machine should not be used in sand mining. Only manual mining should be done. 2. The depth of mining shall be restricted to 3 meter / water level whichever is less. 3. No mining should be carried out in proximity of any bridge / embankment. 4. In-stream mining should not be allowed. 5. Mining should be done in accordance with an approved mining plan.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
		6. EC should be valid for settlement period subject to ceiling of five years.
08	Karnataka	<p>1. Undertaking sand mining activity through a Government agency to be governed by District Level Sand Monitoring Committee headed by Deputy Commissioner.</p> <p>2. The area should be properly surveyed and mapped with the help of GPS to assign geo coordinates and accordingly erect boundary pillars so as to avoid illegal and unscientific mining.</p> <p>3. Depth of sand available may be indicated in a contour map using suitable drilled holes to ensure sand mining do not exceed one meter depth.</p> <p>4. Once thickness is established sand mining may be permitted to one meter depth where the thickness of sand is more than three meter deep. If the thickness of sand is less than three meter, sand mining shall not be permitted.</p> <p>5. Sufficient spacing shall be ensured from one block to another block and sufficient time gap shall be provided for replenishment before undertaking mining activity in the same block.</p> <p>6. Mining activity shall be restricted to only non-monsoon season and in the area that is exposed.</p> <p>7. No in-stream mining shall be permitted.</p> <p>8. No stream should be diverted for the purpose of sand mining. No natural water course and/ or water resources are obstructed due to mining operations.</p> <p>9. Site specific plan with eco-restoration should be in place.</p> <p>10. Sand mining shall be undertaken only by manual method without use of earth moving equipment such as JCB etc. Use of mechanized boats for sucking sand from in-stream area shall be strictly prohibited.</p> <p>11. Appropriate safety zones shall be maintained in proximity to any bridge / and / or embankment and other permanent structures. No sand mining shall be undertaken in such safety / buffer zones. Guideliness issued by the Ministry of Mines in this regard shall also be adhered to.</p> <p>12. The quarrying activity shall not intersect subterranean water level and ground water table.</p>

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
		13.The top soil in case of surface land mining shall be stored temporarily in an earmarked site and concurrently used for land reclamation.
		14.Use of alternate material such as M-sand in place of natural river sand shall be encouraged in order to reduce stress on natural eco-system.
09	Madhya Pradesh	1. Geographical location of the state should be taken care of.
		2. Keep provision for extraction of sand from forest areas.
		3. Expedite the EC process.
		4. In inter-state boundary leases sand mining EC be giver by the SEIAA.
		5. Clear Guidelines for B-1, B2 be issued.
		6. Simplify cluster cases.
		7. Exempt mining leases of less than 5 hectare from EC.
10	Meghalaya	1. No sand mining within 3 kilometer from Protected area and Reserved Forest area.
		2. Advance royalty etc for entire quantity of mineral be realized in full.
		3. Only loose boulder and sand are allowed to be removed from the mid river stream leaving 15 meter on either side untouched.
		4. No collection of sand is allowed on 15 meter of either side of structures like bridge, culvert etc.
		5. No blasting allowed.
		6. No extraction of stone / boulder / sand in landslide prone areas.
		7. No stacking allowed on road side along national highways.
		8. No felling of tree near quarry is allowed.
		9. No transportation of forest produce (sand from forest area) is allowed after sunset.
		10.Export fee realized if sand is sent outside the state.
		11.Stone crusher cannot be installed without permission of DFO.
		12.Tree should be planted at quarry after completion of mining.
		13.Violation of above conditions will result in cancellation of permit and forfeiture of advance royalty already paid.
11	Mizoram	1. Extraction of sand from the forest may be permitted strictly as per mining plan approved by the Competent Authority and after getting necessary clearance under various acts related to the forest and environment.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
12	Odisha	1. EC may be exempted for leases less than 5 hectare.
		2. EC should not be required for earth mining.
		3. Minor minerals even close to inter-state borders should be allowed to be cleared by the SEIAA.
		4. In case a river is forming boundary of states and mechanized mining of sand is causing tension in states it should be resolved at the national level.
13	Puducherry	1. Environment Clearance is issued by SEIAA, Puducherry strictly under the provisions of the EIA Notification, 2006 and subsequent amendments.
14	Rajasthan	1. The bajari mined out from river bed is filled back by the river itself during the next rainy season. So, nature itself reclaims the mined out area every year. The formation of bajari is a natural process in the river and it is also essential to remove bajari from the river bed to avoid silting. If the sand deposited in the river bed is not removed, it may cause change of river course and may also results in flood plains will be developed.
		2. Price control system adopted in Rajasthan. Sand is a essential commodity.
		3. The depth of mining should be restricted to 3 meters or above water table.
		4. Machinery having boom height more than 3 meter shall not be allowed in extraction of bajari.
		5. Size of mining leases be allowed below 5 hectare.
		6. In streams with low deposit of sand and if use is mostly local no mechanized mining should be allowed and EC should not be required.
		7. In larger deposits there should be semi-mechanised mining with EC.
		8. The sand (river and stream) in different categories, with their availability, use and size of the deposit. Category A: Small deposits in river and stream where thickness of sand bed is very less and sand is used locally in villages and towns only and no mechanical mining is done, in such areas restriction of obtaining Environment Clearance can be relaxed for manual mining.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
		<p>Category B: Large deposits, where in rivers and streams having thickness of sand bed is medium to large, sand mining, shall be allowed with semi mechanized manner after obtaining Environment Clearance.</p> <p>Bikaner District: Bikaner district is a desert terrain where ground water table is very deep. Bajari is excavated above water table and it does not affect the water table. In addition to this boulder, gravel and waste generated due to bajari mining is used in reclamation of pits. Hence environment is not adversely affected due to bajari mining.</p>
15	Sikkim	<ol style="list-style-type: none"> 1. Forest department is the nodal department for sand and stone extraction from the riverbed. 2. Use of machines is prohibited. 3. Quarrying sites are allotted to village youth cooperatives. 4. For bigger companies quarry sites in forest area are allotted after FC. 5. State Government has considerations for allotment of quarries for Border Road Organization and MoD. 6. GoI can monitor mining in states through GIS.
16	Tamil Nadu	<ol style="list-style-type: none"> 1. Excess sand deposits identified in the flood plains and in-stream areas only to be mined in order to safeguard and maintain ground water table. 2. Sand mining operation has to be carried out between 6 am to 7 pm. 3. Mining operation should be carried out in a systematic manner without affecting environment and ecology of the area.
17	Uttar Pradesh	<ol style="list-style-type: none"> 1. Depth of mining cannot be more than 3 meter or water table whichever is less. 2. Mining can be done in slices forming benches where bench height cannot be more than 1 meter and bench width cannot be less than 10 meter. 3. A width of not less than 50 meter or 10% width of river can be restricted for mining activities from river bank. A condition can be imposed that mining will be done from river activities from river bank. 4. SEIAA should be decentralized to expedite EC process. It can be decentralized to district or zonal level.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	SUGGESTIONS / RECOMMENDATIONS FOR ENVIRONMENTALLY SUSTAINABLE SAND MINING
		5. Make EC conditions practical.
		6. Requirement of mining plan in river bed mining be done away with.
		7. There should not be requirement of EC for short term permit.
		8. The quantity of sand should not be fixed in EC as it leads to loss in revenue and illegal mining.
		9. Semi-mechanised form of sand mining be allowed.
		10. Sand mining to be exempted from EC as it takes 6-8 months and environment department do not have requisite work force to enforce EC conditions. A Guidelines for environmentally sustainable sand mining be framed and it can be complied by imposing it in the lease condition.
18	Uttarakhand	1. Area less than 5 hectare be exempted from EC.
		2. Use of machine be allowed for scientific mining and reducing the cost of production.
		3. RBM deposition in the lease should not be fixed for the entire lease period. RBM in lease area be assessed after rains every year.
		4. 70% of leases in state not operating for want of EC and these vacant lots are source of illegal mining.

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE - 7

BEST PRACTICE OF SAND MINING ADOPTED IN DISTRICT / STATE / UT

Sl.No.	STATE / U.T	DESCRIPTION OF BEST PRACTICES
01	Andaman & Nicobar	Institute of Ocean Management has been entrusted the task of identification of sand accreting sites.
02	Arunachal Pradesh	Mining of sand is restricted to foothills only that too for a very short period.
03	National Capital Territory of Delhi	In Delhi sand mining lease is granted by Revenue department. NOC from I&FC Deptt. Were issued with condition of limitation of depth, area of mining, operation timing limitation and limited period of NOC. Compliance of laid down conditions and monitoring is ensured by collector.
04	Himachal Pradesh	<ol style="list-style-type: none"> 1. The mining activities on river beds are allowed strictly as per the provisions of river / stream bed mining policy as under. 2. No river / stream bed mining shall be allowed without the recommendation of the Sub Divisional Level Committee constituted under the Chairmanship of Sub Divisional Magistrate having XEN PWD, Irrigation and Public Health, SPCB, DFO and Mining Officer as its member. 3. Nor river / stream bed mining shall be allowed within 75 meter from the periphery of soil conservation works, nursery plantations, check dams or within the distance as recommended by the Sub-Divisional Committee whichever is more. 4. No river / stream bed mining shall be allowed within 1/10th of its span or 5 meters from the banks or as specified by the Sub-Divisional Level Committee, whichever is more. 5. Nor river / stream bed mining shall be allowed within 200 meters upstream and downstream of water supply scheme or as specified by the Committee whichever is more. 6. Nor river / stream bed mining shall be allowed within 200 meters upstream and 200 to 500 meters downstream of bridges depending upon the site specific conditions.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	DESCRIPTION OF BEST PRACTICES
		<p>7. No approach road from PWD road shall be allowed to lease area unless lessee / contractor obtains written permission from XEN, PWD for making road leading to all intake places from the PWD road.</p> <p>8. No boulders/ cobbles/ hand broken road ballast shall be allowed to be transported outside the State from river/stream beds.</p> <p>9. No digging for more than 3 feet shall be allowed in river/ stream beds.</p> <p>10.No blasting shall be allowed in river/stream beds.</p>
05	Madhya Pradesh	1. In some districts the Cooperative Societies of Labour are doing the sand collection, loading and unloading work.
06	Tamil Nadu	Permission has been granted in favour of PWD for quarrying sand in the river Poramboke lands in 16 districts in the state of Tamil Nadu. Sand mining is being carried out by the PWD in the entire State.
07	Uttar Pradesh	U.P. Minor Mineral Concession Rules, 1963.

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE - 8

STATUS OF PROMULGATION OF RULE ON SAND MINING IN THE STATE / UT

Sl.No.	STATE / U.T	NAME OF RULE WITH YEAR OF PROMULGATION
01	Andaman & Nicobar	Indian Forest Act, 1927 as sand has been included as forest produce.
02	Arunachal Pradesh	APMMCR 2002 and made effective from 1.01.2003
03	Himachal Pradesh	1. River/Stream bed Mining Policy-2004. 2. Himachal Pradesh Minor Mineral Policy-2013. 3. Himachal Pradesh Minor Mineral (Concession) and Mineral (Prevention of illegal mining, transportation and storage) Rule, 2015.
04	Jharkhand	Rule 12 of Jharkhand Minor Mineral Concession (Amendment) Rule 2014.
05	Karnataka	Karnataka Sand Policy was brought out in the year 2011 and as such amendment to the Karnataka Minor Mineral Concession Rule 1994 were made in the year 2011 and a separate chapter IV B for sand mining was introduced under Rule 31-R. Further, as per the Hon'ble Supreme Court orders sated 27.02.2012 in SLP No. 19628-19629 between Deepak Kumar and State of Haryana and others and as per the model Guideliness issued by the Government of India for Environmental Management of Mining of Minor Minerals, amendment to the Karnataka Minor Mineral Concessions Rule 1994 were brought out on 16.12.2013 incorporating a new chapter II A applicable to all minor minerals on Systematic, Scientific Mining and Protection of Environment, wherein Quarrying Plan, Environmental Management Plan and Environment Clearance was made mandatory. Amendments to Rule 31- R were also made wherein the Government, PWD Department was entrusted with sand mining, storage and transportation, under the District Sand Monitoring Committee and Taluk Sand Monitoring Committee.
06	Madhya Pradesh	Rules have been framed as per the orders of Hon'ble Supreme Court for sand mining under M.P. Minor Mineral Rules 1996 and Sand Mining Policy 2015 is also formulated in the State.

* States/UTs not mentioned have not provided the data.



Sl.No.	STATE / U.T	NAME OF RULE WITH YEAR OF PROMULGATION
07	Meghalaya	No rules notified by the state on sand mining
08	Mizoram	Mizoram Forest Act, 1955, which came into force on 1.01.1956.
09	Puducherry	Puducherry Minor Minerals (Concession) Rules, 1977.
10	Rajasthan	RMMCR, 1986 Notification dated 2.11.2012: 1. First proviso of Rule 8(2) and first proviso of 17 (1) - Renewal of Bajari Mining Leases is not allowed. 2. Rule 16 (3) - Mining Leases of Bajari to be granted for 5 years. 3. Rule 18 (18) - Part surrender of lease area of Bajari not allowed. Notification dated 3.4.2013 - (First proviso Rule 7 (1)- Mining leases of Bajari to be granted only by way of tender or auction. Notification dated 12.07.2013 - (First proviso Rule 11 (2)) - Maximum area limit of 10 sq. km. not applicable for Bajari Mining Leases. Bikaner District: Chapter II of RMMCR, 1986 (last amended 12.07.2013).
11	Sikkim	Sikkim Forest (Allotment of Areas for Quarrying of Sand and Stone), 2006.
12	Tamil Nadu	1. As per G.O. Ms. No. 95 Industries (MMCI) Department dated 1.10.2003, a new Rule 38 A has been introduced in the Tamil Nadu Minor Mineral Concession Rules, 1959. Accordingly quarrying and sale of sand is being carried out by PWD in the state of Tamil Nadu since October 2003. 2. As per G.O. Ms. No. 158 Industries (MMIC) Department dated 25.08.2008, a new Rule 38 B has been introduced in the Tamil Nadu Minor Mineral Concession Rules, 1959. Accordingly transportation of sand outside the state not to be made. To regulate storage and transportation of sand a new Rule 38 C B has been introduced in the Tamil Nadu Minor Mineral Concession Rules, 1959 vide G.O. No. 32 Industries (MMIC) Department dated 11.02.2011.

* States/UTs not mentioned have not provided the data.



APPENDIX: TABLE -9

NORMAL DATES OF ONSET AND WITHDRAWAL OF SOUTH-WEST MONSOON

The India Meteorological Department, Nagpur, vide letter No. NAGPUR RMC /CS-312, dated 18th January, 2016 has provided the period of Rainy Season viz. Normal dates of Onset and Withdrawal of Southwest Monsoon over India as state-wise and union territory- wise which are as below:-

States	Normal date of Onset of SW-Monsoon	Normal date of Withdrawal of SW-Monsoon
Andhra Pradesh	1st June	15th October
Arunachal Pradesh	5th June	15th October
Assam	5th June	15th October
Bihar	10th June	15th October
Chhattisgarh	10th June	15th October
Goa	5th June	15th October
Gujarat	15th June	15th September
Haryana	1st July	15th September
Himachal Pradesh	1st July	15th September
Jammu & Kashmir	1st July	15th September
Jharkhand	10th June	15th October
Karnataka	5th June	15th October
Kerala	1st June	15th October
Madhya Pradesh	15th June	1st October
Maharashtra	10th June	1st October
Manipur	1st June	15th October
Meghalaya	1st June	15th October
Mizoram	1st June	15th October
Nagaland	5th June	15th October
Odisha (Orissa)	5th June	15th October
Punjab	1st July	15th September
Rajasthan	1st July	1st September
Sikkim	5th June	15th October
Tamil Nadu	1st June	15th October
Telangana	5th June	15th October
Tripura	1st June	15th October



States	Normal date of Onset of SW-Monsoon	Normal date of Withdrawal of SW-Monsoon
Uttar Pradesh	15th June	1st October
Uttarakhand	15th June	1st October
West Bengal	10th June	15th October
Union territory	Normal date of Onset of SW-Monsoon	Normal date of Withdrawal of SW-Monsoon
Andaman and Nicobar Islands	20th May	15th October
Dadra and Nagar Haveli	10th June	1st October
Daman and Diu	10th June	1st October
Lakshadweep	1st June	15th October
Delhi	1st July	15th September
Puducherry	1st June	15th October

Note: The District Environment Impact Assessment Authority (DEIAA) in consultation with District Expert Appraisal Committee (DEAC) can make necessary changes as per local meteorological variations in this period of rainy season with respect to prohibition of River Sand Mining in the District.

ENSURING SUSTAINABLE SAND MINING FOR SUSTAINABLE DEVELOPMENT

A Major Initiative of Ministry of Environment, Forest and Climate Change for ensuring Environmentally Sustainable Sand Mining and Prevention of illegal Sand Mining.

{Notification No: SO No. 141 (E) dated 15.01.2016 and S.O. No. 190 (E) dated 20.01.2016 available at www.envfor.nic.in}

- ◆ Use of Satellite imagery to decide the site suitable for mining and quantity of sand which can be mined.
- ◆ Transit permit with tamper proof security features and tracking of mined out mineral.
- ◆ Monitoring of mined out mineral to prevent mining in excess of environmental clearance capacity.

- ▶ Delegation of power to grant environmental clearance for sand mining to an authority headed by District Magistrate.

- ▶ Intergration of power with District Authorities to grant environmental clearance and prevent illegal mining.



Note : Any information of mining without environmental clearance or against the norms prescribed in these notifications be reported at e-mail id: sandmining-moef@gov.in

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1.0 INTRODUCTION

The Ministry of Environment Forest & Climate Change formulated the Sustainable Sand Management Guidelines 2016 which focuses on the Management of Sand Mining in the Country. But in the recent past, it has been observed that apart from management and systematic mining practices there is an urgent need to have a guideline for effective enforcement of regulatory provision and their monitoring.

Section 23 C of MMDR, Act 1957 empowered the State Government to make rules for preventing illegal mining, transportation and storage of minerals. But in the recent past, it has been observed that there was large number of illegal mining cases in the Country and in some cases, many of the officers lost their lives while executing their duties for curbing illegal mining incidence. The illegal and uncontrolled illegal mining leads to loss of revenue to the State and degradation of the environment.

India is developing at a faster pace and much technological advancement has already been taken place in the surveillance and remote monitoring in the field of mining. Thus, it is prudent to utilize the technological advancement for the effective monitoring of the mining activities particularly sand mining in the country.

Use of latest remote surveillance and IT services helps in effective monitoring of the sand mining activity in-country and also assist the government in controlling the illegal mining activity in the country. Thus, there is a need for an effective policy for monitoring of sand mining in the Country which can be enforced on the ground. These guidelines focus on the effective monitoring of the sand mining since from the identification of sand mineral sources to its dispatch and end-use by consumers and the general public. Further, the effective monitoring and enforcement require efforts from not only Government agencies but also by consumers and the general public.

It is the responsibility of every citizen of India to protect the environment and effective monitoring can only be possible when all the stakeholders viz. Central Government, State Government, Leaseholders/Mine Owners, Distributors, Dealers, Transporters and Consumers (bulk & retail) will contribute towards sustainable mining, and comply with all the statutory provisions. It is felt necessary to identify the minimum requirements across all geographical region to have a uniform protocol for monitoring and enforcement of regulatory provision prescribed for sustainable sand and gravel mining.

This document will serve as a guideline for collection of critical information for enforcement of the regulatory provision(s) and also highlights the essential infrastructural requirements necessary for effective monitoring for Sustainable Sand Mining.

The document is prepared in consideration of various orders/directions issued by Hon'ble NGT in matters pertaining to illegal sand mining and also based on the reports submitted by expert committees and investigation teams.

Further, this document is supplemental to the existing "Sustainable Sand Mining Management Guideline-2016" (SSMG-2016), and these two guidelines viz. "Enforcement & Monitoring Guidelines for Sand Mining" (EMGSM-2020) and SSMG-2016 shall be read and implemented in sync with each other. In case, any ambiguity or variation between the provision of both these document arises, the provision made in "Enforcement & Monitoring Guidelines for Sand Mining-2020 "shall prevail.

2.0 NEED FOR POLICY GUIDELINES

The Ministry of Environment, Forest & Climate Change (MoEF&CC) published Environmental Impact Assessment Notification 1994 which is only applicable for the Major Minerals more than 5 ha. In order to cover the minor minerals also into the preview of EIA, the MoEF&CC issued EIA Notification 2006 for Major & Minor Mineral more than 5 Ha. The Hon'ble Supreme Court in its Judgment dated the 27th February 2012 in I.A. No.12- 13 of 2011 in Special Leave Petition (C) No.19628-19629 of 2009, in the matter of Deepak Kumar etc. Vs. State of Haryana and Others etc. made prior environment clearance mandatory for mining of minor minerals irrespective of the area of mining lease. In order to comply with the judgment of Hon'ble Supreme Court, the Ministry issued S.O.141 (E) dated 15.01.2016. Further, MoEF&CC published Sustainable Sand Mining Management Guidelines 2016 for scientific and sustainable sand mining in the Country. The recommendations for the management of sustainable sand extraction are the key objective of the Guidelines. Special emphasis is given on monitoring of the mined out material, which is key to the success of the environmental management plan. Use of IT and IT-enabled services for effective monitoring of the quantity of mined out material and transportation along with process re-engineering has been made a part of the Guidelines. Guidelines support the fundamental concept, promote environmental protection, limit negative physiological, hydrogeological and social impacts underpinning sustainable economic growth.

The Hon'ble NGT in its order dated 04.09.2018 in O.A. 173/2018 in the matter of Sudarsan Das vs. State of West Bengal & Ors. Inter-alia observed that ***"There can be no two views that an effective institutional monitoring mechanism is required not only at the stage when Environmental Clearance is granted but also at subsequent stages". "The guidelines focus on the preparation of District Survey Report and the Management Plan" ... We are of the view that all the safeguards which are suggested***

in sustainable sand mining guidelines as well as notification dated 15.01.2016 ought to be scrupulously followed.” ...It is a known fact that in spite of the above-suggested guidelines being in existence, on the ground level, illegal mining is still going on. The existing mechanism has not been successful and effective in remedying the situation.” ...” Since there is an utter failure in the current monitoring mechanism followed by the State Boards, SEIAAs and DEIAAs, it is required to be revised for effective monitoring of sand and gravel mining and a dedicated monitoring mechanism be set up.”

The Hon’ble NGT in its order dated 04.09.2018 in O.A. 173/2018 in the matter of Sudarsan Das vs. State of West Bengal & Ors. directed that ***MoEF&CC has issued directions from time to time under Section 3 and 5 of the Environment (Protection) Act, 1986. The MoEF&CC needs to revise its directions keeping in mind the following:***

- *Mining Surveillance System discussed in para 23 above be finalized in consultation with ISRO Hyderabad.*
- *Safeguards suggested in Sustainable Sand Mining Guidelines published by the MoEF&CC in the year 2016.*
- *Suggestions in the High Power Committee Report.*
- *The requirement of demarcation of boundaries being published in respect of different leases in the public domain.*
- *Need to issue SOP laying down mechanism to evaluate loss to the ecology and to recover the cost of restoration of such damage from the legal or illegal miners. Such evaluation must include the cost of mining material as well as the cost of ecological restoration and the net present value of future ecosystem services forgone.*
- *Need to set up a dedicated institutional mechanism for effective monitoring of sand and gravel mining which may also take care of mining done without any Environmental Clearance as well as mining done in violation of Environmental Clearance conditions.*

- *The Mining Department may make a provision for keeping apart at least 25% of the value of mined material for the restoration of the area affected by the mining and also for compensating the inhabitants affected by the mining.*
- *One of the conditions of every lease of mine or minerals would be that there will be independent environmental audit at least once in a year by reputed third party entity and report of such audit be placed in the public domain.*
- *In the course of such an environmental audit, a three-member committee of the local inhabitants will also be associated. Composition of three members committee may preferably include ex-servicemen, a former teacher and former civil servant. The Committee will be nominated by the District Magistrate.*

The Hon'ble NGT in its order dated 05.09.2018 in O.A. 44/2016 in the matter of Mushtakeem Vs. MoEF & CC & Ors. Inter-alia observed the following:

"Para 20. In Original Application No. 481/2016, the allegation is that there is the connivance of the District Administration with the miners and mining is going in violation of conditions of Environmental Clearance. According to the applicant, an effective mechanism is required to be evolved so that illegal mining does not place."

*"Para 22. We proceed to consider the main question proposed for the consideration stated earlier hereinabove as to **how to ensure the protection of the environment by checking illegal mining.**"*

"Para 23. We have dealt with the identical issue relating to the illegal sand mining in the border districts in the State of West Bengal and Odisha in the order dated 04th September 2018 in Sudarsan Das Vs. State of West Bengal & Ors., Original Application No. 173 of 2018. We have directed the MoEF&CC to revise the guidelines on the subject for an effective mechanism for sand mining, relevant portions of which are reproduced below: -..."

The Hon'ble NGT in its order dated 10.09.2018 in O.A. 304/2015 in the matter of Jai Singh & Anr.Vs. Union of India Ors. inter-alia observed the following:

*"Para 6. After disposal of the above matters, a disturbing event widely reported in media which took place on 07th September 2018 has been brought to our notice. **A Deputy Ranger who tried to stop illegal mining was killed by mining mafia at Morena in the State of M.P.***

"Para 7. The above disturbing event may also be kept in mind by the MoEF, while considering the issuance of revised guidelines in light of the judgment dated 05th September 2018 (Supra)."

The Hon'ble NGT in its order dated 05.04.2019 in O.A. 360/2015 in the matter of National Green Tribunal Bar Association & Anr.Vs. Union of India & Ors. inter-alia observed the following:

"The 2016 Guidelines need revision in the light of the report of High Powered Committee in September 2016, failure of Monitoring mechanism followed by State Boards, SEIAs, DEIAs and MSS system developed by Ministry of Mines & IBM with the assistance of BISAG and MAITY and other observations quoted in paras 12 to 15 above.

50. As noted earlier in paras 17, 23, 27, 31 and 35, States of West Bengal, Odisha, Gujarat, Karnataka, Maharashtra, Punjab, Haryana and Uttar

Pradesh are required to follow SSMG, 2016 as may be revised by MoEF&CC and even other States where illegal sand mining is taking place.

The States may review the monitoring mechanism in terms of several directions of the Tribunal and guidelines of MoEF&CC.

The international conservation concern regarding natural wealth is a universal demand. Article 51(a) subsection (G) of the constitution requires every citizen of India to protect and improve the natural environment including forest, lakes, rivers, wildlife and to have compassion for the living creature.

The Hon'ble Supreme Court in the case of M.C. Mehta Vs. Kamal Nath (1997) 1 SCC 388 held that under Article of Indian Constitution incorporates the "Public Trust Doctrine" and as such extents to the protection of all-natural resources which includes the protection of flora and fauna.

The Hon'ble Supreme Court in the case of Vellore Citizens Welfare Forum Vs. Union of India & Ors (1996) held that the precautionary principle is part of the Environmental Law in India. It further stated that onus of proof is on the actor of the developer/industrialize to show that its actions are environmentally benign."

3.0 OBJECTIVE OF GUIDLINES

- Identification and Quantification of Mineral Resource and its optimal utilization.
- To regulate the Sand & Gravel Mining in the Country since its identification to its final end-use by the consumers and the general public.
- Use of IT-enabled services & latest technologies for surveillance of the sand mining at each step.
- Reduction in demand & supply gaps.
- Setting up the procedure for replenishment study of Sand.
- Post Environmental Clearance Monitoring.
- Procedure for Environmental Audit.
- To control the instance of illegal mining.

4.0 REQUIREMENTS FOR MONITORING & ENFORCEMENT

Sustainable Sand Mining Management Guidelines (SSMMG) 2016 and past experience suggest that the source of sand in India are through

- a) River (riverbed and flood plain),
- b) Lakes and reservoirs,
- c) Agricultural fields,
- d) Coastal / marine sand,
- e) Palaeo-channels and
- f) Manufactured Sand (M-Sand).

The SSMMG-2016 highlights the identification of the sand mining sources, replenishment of the River Bed Material (Sand, Boulder, Gravel, Cobble etc.), preparation of Districts Survey Report, and Standard Environmental Conditions suitable for sand mining projects.

The necessary requirements to comply with the direction of Hon'ble NGT and to facilitate effective monitoring and enforcement of regulatory provision for sand mining in the country are as follows:

- i) Identification of sand mining sources, its quantification and feasibility for mining considering various environmental (proximity of protected area, wetlands, creeks, forest etc.) and other factors such as important structures, places of archaeological importance, habitation, prohibited area etc.
- ii) The mining lease auctioned by State government as per their Minor Mineral Concession Rules are granted of Letter of Intent (LoI), but it has been observed that many of the sites are not suitable w.r.t environmental aspects. In most of the cases, the unplanned grant of mining lease leads to formation of cluster and/or contiguous cluster

of small mining leases which sometimes is difficult to regulate and monitor. In order to address such issues, more emphasis is required on the preparation of District Survey Report and its format for reporting,

- iii) Mining Plan is an important document to assist the mine owner to operate the mine in a scientific manner. States have their own format for preparation of mining plan and it is observed that recording of the initial level of mining lease at shorter interval say 25m X 25 m grid interval is not present.
- iv) There is no practice for regular replenishment study to ascertain the rate of depositing, plan and section needs to be prepared based on the restrictions provided in letter of intent and provisions of Sustainable Sand Mining Management Guidelines 2016.
- v) Environmental Clearance is a process wherein the regulatory authorities after considering the potential environment impact of mining clearance is granted with a set of specific & standard conditions to carry out mining operations, but often it is observed that letter of intent is granted for a location which has less potential for mining and not feasible for environment-friendly mining. This leads to an unnecessary financial burden on the mine owners and litigations. Thus, LoI should be preferably granted for those locations which have the least possibility of an impact on the environment and nearby habitation.
- vi) It is the responsibility of the mine owner to obtain all the statutory clearance and comply with the conditions stipulated in the clearance letter. Mining should be carried out within the mining lease area as per

approved mining plan or mining plan concurred by other regulatory authorities.

- vii) Mining operation also involves transportation of mineral from the mining area to end-user and its necessary that movement of the mineral needs to be monitored.

The State Government already have power under section 23c of MMDR, Act 1957 to make rules for preventing illegal mining, transportation and storage of minerals. However, there are instances of illegal mining which shows that there is a need for strengthening the system of mineral dispatch and its monitoring. This document provides good practices already under implementation by various states for regulating the mineral sale, dispatch, storage, transportation and use.

- viii) The river reaches with sand provide the resource and thus it is necessary to ascertain the rate of replenishment of the mineral. Regular replenishment study needs to be carried out to keep a balance between deposition and extraction. This document provides the procedure to be followed for conducting replenishment study.
- ix) Even after all the regulatory procedure and policy being in place, there are instances where illegal mining is taking place. There is a need for regular surveillance of the sand mining reaches. The monitoring agencies can monitor the sites remotely by using Unmanned Artificial Vehicles (UAVs)/Drone which is now a viable option. The drone can also be used for reserves estimation, quantity estimation, land use monitoring. This document highlights possible use of IT/Satellite/Drone technology for effective monitoring of sand mining.

4.1 Identification of possible sand mining sources and preparation of District Survey Report (DSR)

4.1.1 Preparation of District Survey Report.

“Sustainable Sand Mining Guidelines, 2016” issued by MoEF&CC requires preparation of District Survey Report (DSR), which is an important initial step before grant of mining lease/Lol. The guidelines emphasize detailed procedure to be followed for the purpose of identification of areas of aggradation/ deposition where mining can be allowed and identification of areas of erosion and proximity to infrastructural structures and installation where mining should be prohibited. Calculation of annual rate of replenishment, allowing time for replenishment after mining, identification of ways of scientific and systematic mining; identifying measures for protection of environment and ecology and determining measures for protection of bank erosion, benchmark (BM) with respect to mean Sea Level (MSL) should be made essential in mining channel reaches (MCR) below which no mining shall be allowed.

The Hon’ble NGT in its Judgment dated 08.12.2017 in the matter of Anjani Kumar vs State of Uttar Pradesh & Ors. inter-alia mentioned the following regarding sand mining in the Uttar Pradesh.

“It states that the main object of preparation of District Survey Report is to ensure identification of areas of aggradation/deposition where mining can be allowed and identification of areas of erosion and proximity to infrastructural structures and installation where mining should be prohibited and calculation of annual rate of replenishment and allowing time for replenishment after mining area. Thus, the environmental protection requires a strictly regulated mining in terms of area, quantity as well as most importantly replenishment thereof.”

"The data collection and declared for preparation of DSR shall take precedence over other data and would form the foundation for providing mining lease in terms of Appendix- x to the Notification dated 15th January 2016 must be prepared by the statutory authority stated therein i.e. DEIAA prior to awarding of permits for carrying on mining activity in any part of the State of UP."

The Hon'ble High Court of Jharkhand at Ranchi in its orders dated the 11th April 2018 and 19th June 2018 in W.P. (PIL) No. 1806 of 2015, in the matter of Court on its Own Motion Versus the State of Jharkhand & Others with W.P. (PIL) No. 290 of 2013, in the matter of Hemant Kumar Shilkarwar Versus the State of Jharkhand & Others, has inter-alia directed the preparation of District Survey Report for minor minerals other than Sand and Bajri or delegation of the powers for preparation of format of District Survey Report of minor minerals other than sand and Bajri to the State Government and/or District Environment Impact Assessment Authority and District Expert Appraisal Committee. To comply with the direction of Hon'ble High Court the Ministry has issued S.O. 3611(E) dated 25.07.2018, wherein, the procedure of preparation of DSR is mentioned. But it is felt that still there is other information that needs to be reported in DSR to make it a comprehensive DSR.

Therefore, preparation of District Survey Report is a very important step and sustainable sand mining in any part of the country will depends on the quality of District Survey Report.

Considering the importance of district survey report, the Ministry of Environment Forest and climate change, after consultation with experts dealing with mining-related matters, formulated the following guidelines for the preparation of comprehensive District Survey Report for sand mining.

- a) District Survey Report for sand mining shall be prepared before the auction/e-auction/grant of the mining lease/Letter of Intent (LoI) by Mining department or department dealing the mining activity in respective states.
- b) The first step is to develop the inventory of the River Bed Material and Other sand sources in the District. In order to make the inventory of River Bed Material, a detailed survey of the district needs to be carried out, to identify the source of River Bed Material and alternative source of sand (M-Sand). The source will include rivers, de-siltation of reservoir/dams, Patta lands/Khatedari Land, M-sand etc.

The revenue department of Kerala already conducted river mapping and sand auditing of around 20 rivers of Kerala which is a good example wherein the profile of rivers was created at regular intervals and aggradation/deposition was identified along with water level. In the same study, benchmarks were also created at a prominent location at regular interval for future surveying. Such study helps the mining departments to identify the source of sand.

Thus, it is proposed that for preparation of district survey report, the auditing of rivers needs to be carried out. There is already a provision under MMDR Act 2015 for National Mineral Exploration Trust (MET) wherein a 2% of royalty amount to be deposited in the trust. This fund is used for mineral exploration in the country. The Sand Auditing is also a sort of identification of mineral and State Government may request Central Govt. for proving funds for river auditing. The Central Govt. (Ministry of Mines) may also explore the possibilities for providing the funds for river auditing. The other option is that State Govt. may conduct such studies by its own fund and the same may be recovered from the leaseholders to whom the mining lease will be allocated.

- c) District Survey Report is to be prepared in such a way that it not only identifies the mineral-bearing area but also define the mining and no mining zones considering various environmental and social factors.
- d) Identification of the source of Sand & M-Sand. The sources may be from Rivers, Lakes, Ponds, Dams, De-silting locations, Patta land/Khtedari lands. The details in case of Rivers such as [name, length of river, type (Perennial or Non-Perennial), Villages, Tehsil, District], in case of Lakes, Ponds, Dams, De-silting locations [Name, owned/maintained by (State Govt./PSU), area, Villages, Tehsil, District] in case of Patta land/Khtedari lands [Owner Name, Sy No, Area, Agricultural/Non-Agricultural, Villages, Tehsil, District], in case of M-Sand Plant [Owner Name, Sy No, Area, Quantity/Annum, Villages, Tehsil, District], needs to be recorded as per format given in **Annexure-I**.
- e) Defining the sources of Sand/M-Sand in the district is the next step for identification of the potential area of deposition/aggradation wherein mining lease could be granted. Detailed survey needs to be carried out for quantification of minerals. The purpose of mining in the river bed is for channelization of rivers so as to avoid the possibility of flooding and to maintain the flow of the rivers. For this, the entire river stretch needs to be surveyed and original ground level (OGL) to be recorded and area of aggradation/deposition needs to be ascertained by comparing the level difference between the outside riverbed OGL and water level. Once the area of aggradation/deposition are identified, then the quantity of River Bed Material available needs to be calculated. The next step is channelization of the river bed and for this central $\frac{3}{4}$ th part of the river, width needs to be identified on a map. Out of the $\frac{3}{4}$ th part area, where there is a deposition/aggradation of the material needs to be identified. The remaining $\frac{1}{4}$ th area needs to be kept as no mining zone for the

protection of banks. The specific gravity of the material also needs to be ascertained by analyzing the sample from a NABL accredited lab. Thus, the quantity of material available in metric ton needs to be calculated for mining and no mining zone.

Note: As physical survey with conventional method is time-consuming, use of unmanned aerial vehicle (UAV) may be explored to carry out the survey and finalizing the original ground level and for developing a 3D model of the area.

- f) The permanent boundary pillars need to be erected after identification of an area of aggradation and deposition outside the bank of the river at a safe location for future surveying. The distance between boundary pillars on each side of the bank shall not be more than 100 meters.
- g) Identifying the mining and no mining zone shall follow with defining the area of sensitivity by ascertaining the distance of the mining area from the protected area, forest, bridges, important structures, habitation etc. and based on the sensitivity the area needs to be defined in sensitive and non-sensitive area.
- h) Demand and supply of the Riverbed Material through market survey needs to be carried out. In addition to this future demand for the next 5 years also needs to be considered.
- i) It is suggested that as far as possible the sensitive areas should be avoided for mining, unless local safety condition arises. Such deviation shall be temporary & shall not be a permanent feature.
- j) The final area selected for the mining should be then divided into mining lease as per the requirement of State Government. It is suggested the mining lease area should be so selected as to cover the entire deposition area. Dividing a large area of deposition/aggradation into smaller

mining leases should be avoided as it leads to loss of mineral and indirectly promote illegal mining.

- k) Cluster situation shall be examined. A cluster is formed when one mining lease of homogenous mineral is within 500 meters of the other mining lease. In order to reduce the cluster formation mining lease size should be defined in such a way that distance between any two clusters preferably should not be less than 2.5 Km. Mining lease should be defined in such a way that the total area of the mining leases in a cluster should not be more than 10 Ha.
- l) The number of a contiguous cluster needs to be ascertained. Contiguous cluster is formed when one cluster is at a distance of 2.5 Km from the other cluster.
- m) The mining outside the riverbed on Patta land/Khatedari land be granted when there is possibility of replenishment of material. In case, there is no replenishment then mining lease shall only be granted when there is no riverbed mining possibility within 5 KM of the Patta land/Khatedari land. For government projects, mining could be allowed on Patta land/Khatedari land but the mining should only be done by the Government agency and material should not be used for sale in the open market. Cluster situation as mentioned in para k above is also applicable for the mining in Patta land/Khatedari land.
- n) The State Government should define the transportation route from the mining lease considering the maximum production from the mines as at this stage the size of mining leases, their location, the quantity of mineral that can be mined safely etc. is available with the State Government. It is suggested that the transportation route should be selected in such a way that the movement of trucks/tippers/tractors from the villages having habitation should be avoided. The transportation route so

selected should be verified by the State Government for its carrying capacity.

- o) Potential site for mining having its impact on the forest, protected area, habitation, bridges etc, shall be avoided. For this, a sub-divisional committee may be formed which after the site visit shall decide its suitability for mining. The list of mining lease after the recommendation of the Committee needs to be defined in the following format given in as **Annexure-II**. The Sub-Divisional Committee after the site visit shall make a recommendation on the site for its suitability of mining and also records the reason for selecting the mining lease in the Patta land. The details regarding cluster and contiguous cluster needs to be provided as in **Annexure-III**. The details of the transportation need to be provided as in **Annexure IV**.
- p) **Public consultation**-The Comments of the various stakeholders may be sought on the list of mining lease to be auctioned. The State Government shall give an advertisement in the local and national newspaper for seeking comments of the general public on the list of mining lease included in the DSR. The DSR should be placed in the public domain for at least one month from the date of publication of the advertisement for obtaining comments of the general public. The comments so received shall be placed before the sub-divisional committee for active consideration. The final list of sand mining areas [leases to be granted on riverbed & Patta land/Khatedari land, de-siltation location (ponds/lakes/dams), M-Sand Plants (alternate source of sand)] after the public hearing needs to be defined in the final DSR in the format as per **Annexure-V**. The details regarding cluster and contiguous cluster needs to be provided in **Annexure-VI**. The details of the transportation need to be provided in **Annexure-VII**.

4.2 Grant of Letter of Intent to those mining leases which are falling in potential mining zone

The State Government shall issue letter of intent as per procedure laid down in their Minor Mineral Concession Rules with due consideration of final district survey report. The State Government shall ensure that all the letter of intent shall have complete details of the mining lease including geo-coordinate of the corner points, the involvement of forest land, distance from the forest land, distance from the protected area, distance from other sites of archaeological importance, details of the cluster situation etc. The demarcation of the boundaries of Lol/Lease area shall be placed in public domain along with Lol/lease deed details.

The LOI should not be granted for mining area falling on both riverbed and outside riverbed. Therefore, in the same lease, both types of area should not be included.

The authority responsible for grant of lease for sand mining shall ensure that annual audit of the sand mining process, production and compliance of the imposed conditions by regulatory authority (Environmental clearance or mine plan) shall be one of the essential condition of the lease agreement. The annual audit report shall be submitted to the district administration, which shall be put in public domain through the district website. Any deviation observed shall be appropriately and in accordance with applicable law shall be dealt by the concerned authority and corrective measures shall also be taken to restoration of ecological/environmental damage, if observed.

4.3 Mining Plan

The preparation of Mining Plan is also very important. The mining plan should include the original ground level recorded at an interval not more than 10M x 10M along & across the length of the river. In addition to this-levels, outside the mining lease and bank of the river up to meters needs to be recorded. In the mining plan, there should be 3 plates for each year production & development planning (pre-monsoon, monsoon and post-monsoon). The time period of monsoon should be defined in the DSR. At the time of review of the mining plan, the details of the replenishment study conducted for all the years needs to be included in the mining plan. The Mining Plan should include the certificate from PCCF on forest land, distance from the protected area, past production details for mining leases seeking expansion.

Following considerations shall be kept in mind for sand/gravel mining while approving mining plan

- a) Parts of the river reach that experience deposition or aggradation shall be identified. The Leaseholder/ Environmental Clearance holder may be allowed to extract the sand and gravel deposit in these locations to manage aggradation problem.
- b) The distance between sites for sand and gravel mining shall depend on the replenishment rate of the river. Sediment rating curve for the potential sites shall be developed and checked against the extracted volumes of sand and gravel.
- c) Sand and gravel may be extracted across the entire active channel during the dry season.

- d) Abandoned stream channels on the terrace and inactive floodplains be preferred rather than active channels and their deltas and flood plains. The stream should not be diverted to form the inactive channel.
- e) Layers of sand and gravel which could be removed from the river bed shall depend on the width of the river and replenishment rate of the river.
- f) Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank.
- g) Segments of the braided river system should be used preferably falling within the lateral migration area of the river regime that enhances the feasibility of sediment replenishment.
- h) Sand and gravel shall not be extracted up to a distance of 1 kilometre (1 km) from major bridges and highways on both sides, or five times (5x) of the span (x) of a bridge/public civil structure (including water intake points) on up-stream side and ten times (10x) the span of such bridge on down-stream side, subjected to a minimum of 250 meters on the upstream side and 500 meters on the downstream side.
- i) The sediment sampling should include the bed material and bed material load before, during and after the extraction period. Develop a sediment rating curve at the upstream end of the potential reach using the surveyed cross-section. Using the historical or gauged flow rating curve, determine the suitable period of high flow that can replenish the extracted volume. Calculate the extraction volume based on the sediment rating curve and high flow period after determining the allowable mining depth.

- j) Sand and gravel could be extracted from the downstream of the sand bar at river bends. Retaining the upstream one to two-thirds of the bar and riparian vegetation is accepted as a method to promote channel stability.
- k) The flood discharge capacity of the river could be maintained in areas where there is a significant flood hazard to existing structures or infrastructure. Sand and gravel mining may be allowed to maintain the natural flow capacity based on surveyed cross-section history. Alternatively, off-channel or floodplain extraction is recommended to allow rivers to replenish the quantity taken out during mining.
- l) The Piedmont Zone (Bhabhar area) particularly in the Himalayan foothills, where riverbed material is mined, this sandy-gravelly track constitutes excellent conduits and holds the greater potential for groundwater recharge. Mining in such areas should be preferred in locations selected away from the channel bank stretches.
- m) Mining depth should be restricted to 3 meters and distance from the bank should be $\frac{1}{4}$ th or river width and should not be less than 7.5 meters.
- n) The borrow area should preferably be located on the riverside of the proposed embankment because they get silted in the course of time. For low embankment, less than 6 m in height, borrow area should not be selected within 25 m from the toe/heel of the embankment. In the case of the higher embankment, the distance should not be less than 50 m. In order to obviate the development of flow parallels to the embankment, crossbars of width eight times the depth of borrow pits spaced 50 to 60 meter center-to-center should be left in the borrow pits.

- o) Demarcation of mining area with pillars and geo-referencing should be done prior to the start of mining.
- p) A buffer distance /un-mined block of 50 meters after every block of 1000 meters over which mining is undertaken or at such distance as may be the directed/prescribed by the regulatory authority shall be maintained.
- q) A buffer distance /unmined block of 50 meters after every block of 1000 meters over which mining is undertaken or at such distance as may be the directed/prescribed by the regulatory authority shall be maintained.
- r) River bed sand mining shall be restricted within the central 3/4th width of the river/rivulet or 7.5 meters (inward) from river banks but up to 10% of the width of the river, as the case may be and decided by regulatory authority while granting environmental clearance in consultation with irrigation department. Regulating authority while regulating the zone of river bed mining shall ensure that the objective to minimize the effects of riverbank erosion and consequential channel migration are achieved to the extent possible. In general, the area for removal of minerals shall not exceed 60% of the mine lease area, and any deviation or relaxation in this regard shall be adequately supported by the scientific report.
- s) Mining Plan for the mining leases(non-government) on agricultural fields/Patta land shall only be approved if there is a possibility of replenishment of the mineral or when there is no riverbed mining possibility within 5 KM of the Patta land/Khatedari land. For government projects mining could be allowed on Patta land/Khatedari land but the mining should only be done by the Government agency and material should not be used for sale in the open market.

The minerals reserve for river bed area is calculated on the basis of maximum depth of 3 meters and margins, width and other dimensions as mentioned in para (s) above. The area multiplied by depth gives the volume and volume multiplied with bulk density gives the quantity in Metric Ton. In case of river bed, mineable material per hectare area available for actual mining shall not exceed the maximum quantity of 60,000 MT per annum.

4.4 Obtaining Environmental & Other Statutory Clearance

The LOI Holder/Lease Holder to obtain Environmental and Other Statutory Clearances from the concerned authorities as per provision of applicable laws.

4.5 Baseline data before Commencement of Mining Operations

Baseline data in respect of the initial level of mining lease in the interval not more than 25 X 25 meters shall be collected for record by leaseholder. The level of river bed upstream and downstream up to 100 meters also needs to be recorded. The area outside the mining lease/river bank (if lease boundary coincides with mining lease) up to 100 meters from both the banks/mining lease needs to surveyed for initial level.

4.6 Additional measures where project proponent is selected by a bidding

In those states where sand plots are auctioned to the highest bidder, the following is suggested:

It has been observed that bidders try to form a cartel and bids are received for certain plots where legal mining is done, and bids for certain other plots don't elicit any response. Sand from these un-

auctioned plots is then excavated using the same machinery deployed for the excavation of adjacent plot which might have been auctioned off. It is not easily possible for the field machinery to prevent such illegal activities. This may be prevented by having plot of larger size. plots are large in size as possible are identified for auction. Care may be taken to ensure that no continuous stretch of plot in the river bed is divided for auction. A continuous stretch of plot shall be preferred for auction, and the attempt may not be made to auction it off in pieces.

5.0 REPLENISHMENT STUDY

The need for replenishment study for river bed sand is required in order to nullify the adverse impacts arising due to excessing sand extraction. Mining within or near riverbed has a direct impact on the stream's physical characteristics, such as channel geometry, bed elevation, substratum composition and stability, in-stream roughness of the bed, flow velocity, discharge capacity, sediment transport capacity, turbidity, temperature etc. Alteration or modification of the above attributes may cause an impact on the ecological equilibrium of the riverine regime, disturbance in channel configuration and flow-paths. This may also cause an adverse impact on in-stream biota and riparian habitats. It is assumed that the riparian habitat disturbance is minimum if the replenishment is equal to excavation for a given stretch. Therefore, to minimize the adverse impact arising out of sand mining in a given river stretch, it is imperative to have a study of replenishment of material during the defined period.

5.1 Generic Structure of Replenishment Study

Initially replenishment study requires four surveys. The first survey needs to be carried out in the month of April for recording the level of mining lease before the monsoon. The second survey is at the time of closing of mines for monsoon season. This survey will provide the quantity of the material excavated before the offset of monsoon. The third survey needs to be carried out after the monsoon to know the quantum of material deposited/replenished in the mining lease. The fourth survey at the end of March to know the quantity of material excavated during the financial year. For the subsequent years, there will be a requirement of only three surveys. The results of year-wise surveys help the state government to establish the replenishment rate of the river. Based on the replenishment rate future auction may be planned.

The replenishment period may vary on nature of the channel and season of deposition arising due to variation in the flow. Such period and season may vary on the geographical and precipitation characteristic of the region and requires to be defined by the local agencies preferable with the help of the Central Water Commission and Indian Meteorological Department. The excavation will, therefore, be limited to estimated replenishment estimated with consideration of other regulatory provisions.

5.2 Methodology for Replenishment Study

The replenishment estimation is based on a theoretical empirical formula with the estimation of bedload transport comprising of analytical models to calculate the replenishment estimation. The iso-pluvial maps of IMD can be used for estimation of rainfall. Catchment yield is computed using different standard empirical formulas relevant to the geographical and channel attributes. eg. Strange's Monsoon runoff curves for runoff coefficient). Peak flood discharge for the study area can be calculated by using Dickens, Jarvis and Rational formula at 25, 50 and 100 years return period. The estimation of bed load transport using Ackers and White Equation or similar can be made. A simulation model is used with basic data generated from the field in the pre-study and post-study period (preferably pre-monsoon and post-monsoon) to estimate the volume of replenished material. The particle size distribution and bulk density of the deposited material are required to be assessed from a NABL recognized laboratory. Considering the bulk density and the volume, the estimation of replenishment in weight will be calculated after considering safeguards and stability of the slopes and riverine regime. Some of the common methods used for field data acquisition for replenishment study

5.2.1. Physical survey of the field by the conventional method

- i. The conventional survey technical using DGPS and other survey tools are used to define the topography, contours and offsets of the lease area. The survey should clearly depict the important attributes of the stretch of the river and its nearby important civil and other feature of importance. Such information will provide the eligible spatial area for mining. The contour and the elevation benchmarks will provide the baseline data for assessing the pre and post-study period scenario.
- ii. Physical benchmarks are to be fixed at appropriate intervals (preferable 1 in 30 m) and the Reduced Level (RL) shall be validated from a nearby standard RL. These RL should be engraved on a steel plate (Bench Plate) and shall be fixed and placed at locations which are free from any damages and are available in pre and post-study period. The bench plates shall be available for use during the mining period as reference for all mining activity. Reference pillar may also be used in place of Bench Plates with visible and readable demarcation on the ground as common reference points to control the topographic survey and mining activity.
- iii. Baseline data on elevation status for a grid of 10 m x 10 m is preferred to have accuracy in the assessment. It is expected that two consecutive cross-sections in longitudinal and lateral direction should not be more than 10-meter distance apart, however, the regulatory authority may fix these intervals depending on the geographical and site-specific conditions, only and after providing the scientific reason for such deviation.
- iv. The changes observed in the elevation in pre and post scenario at each node should be depicted in graphical forms with an appropriate scale to estimate the area of deposition and erosion. These graphical

presentations should depict the active channel regime and the flow bed elevation with other important features required to be considered for estimation of the mining area. The area of deposition and erosion shall be calculated for each cross-section after giving due regard to the stability and safety of active channel banks, and other features of importance. The elevation level shall be in reference to the nearest bench-plates established for the purpose.

- v The levels (MSL & RL) of the corner point of each grid should be identifiable and safety barriers (Non-Mining) demarcated as restricted in consensus with Mineral Concession Rules of respective State, and the provision mentioned in this Sustainable Sand Mining Management Guidelines.
- vi A clear identification is required to be highlighted between grids under mineable and grids under the non-mineable area. These baseline data (pre and post) be subjected to stimulation with the help of data mine software to derive at the replenishment area and corresponding volume and estimated weight.
- vii The database should be structured in a tabulated form clearly depicting the nomenclature of the section lines, latitude and longitude of the starting point, chain-age and respective levels of all the points taken on that section line.
- viii Net area shall be derived after the summation of the area of deposition minus area of erosion for each cross-section. The volume will be estimated by multiplying the distance between two cross-sections with the average of net area of these two consecutive cross-sections.
- ix One sample per 900 square meters (30 m x 30 m) shall be preferred sample density for assessment of bulk density for estimation of deposition rate. Care should be taken that the sample for assessment

of bulk density is taken from the deposition zone and not from erosion. However, depending on the site condition, river morphology and geographical condition, sample density may be adjusted. Reason for such deviation shall be appropriately highlighted in the report with supporting scientific data.

5.2.2. Use of UAV/Drone and other image data processing techniques

With the development in image data processing tools and its accuracy acceptability, Drone/UAV fitted with the advance camera are used for survey purposes. Such technology has promising potential in the survey of sand mining zones due to its fast and reliable output deliveries. The survey is conducted using a set of instruments and compatible software to utilized the properly referenced data for depicting the topography of the study area. Instrument calibration and software compatibility and its validation with the ground data are an essential requirement for using this technique.

The details of the instruments their limitation and software used shall be demonstrated in the form of the accuracy assessment report, through a chapter in the replenishment study report. Other details to be incorporated in the report with regard to the study using such imaginary techniques shall highlight the followings:

- a) **Flight Planning:** - The lease co-ordinates and the flight plan devised to capture the front and side overlap percentages for in each flight in reference to global coordinates (Kml or SHP file) system. The software used for the purpose and its details along with limitations with basic analytical assumptions.
- b) **Block file generation:** - This operation concerns the selection of the sensor model and the definition of block properties, the addition of

imagery to the block file, marking of GCPs, generation of tie points and refining of the model.

- c) **Interior orientation:** - The interior orientation of the stereo pair rational polynomial coefficients (RPC) used, which should be bundled with the scenes. RPCs are coefficient, which is used by photogrammetric software to represent the ground to-image viewing geometry.
- d) **Exterior orientation:** For exterior orientation, ground control points shall be used, which are collected from the DGPS survey.
- e) **Aero Triangulation:** - A critical phase in photogrammetric mapping is to rectify the satellite imagery at an appropriate tract on the surface of the earth. This is accomplished by collecting horizontal and vertical data [GCP's] to ascertain the spatial location of a number of features that are visible and measurable on the aerial images – this process is often called control bridging, which refers to passing horizontal and vertical information from one aerial image to the next.
- f) **Ortho Generation:** - After running the above steps; the software shall automatically generate orthorectified imagery.
- g) **DTM extraction:** For extraction of DTM, Generated point cloud data classified manually to extract bare earth.

5.2.3 Accuracy Assessment of Aerial Data:

To check the accuracy of DTM generated by Aerial data, few points are selected and compared with on-site by using DGPS instrument for the ground-truthing purpose. It is preferred to do ground-truthing at minimum 5 locations spread evenly across the lease area. The readings from the DGPS instrument are then compared with the Drone data for accuracy assessment

purpose. A comparative chart will be prepared in comparison of Data related to ground-truthing (by DGPS) and from Drone. Such accuracy assessment report shall a chapter of the replenishment study.

5.2.4 Replenishment study shall have the details of

- List of instruments
- List of software
- Establishment of Benchmark by putting No. of pillar points and various Ground Control Points (GCP) at the site.
- Ground Control Points (GCP) Collection: - Various GCPs were observed by using DGPS for Permanent Benchmarks and for control points.
- The summary of the elevation data from each section's profile based on the post-monsoon the survey should have mentioned in the table form.
- The detail of post-monsoon survey data in the tabular form shall be
- The detailed comparison of both pre-monsoon and post-monsoon elevation data shall be attached
- Cross-sectional depiction of deposition and erosion for each section in pre and post-deposition season shall be given supported by relevant field study data and plan.

6.0 ENFORCEMENT

6.1 Mining Operation:

The mining operations should be strictly carried out in accordance with the approved mining plan and after complying with all the conditions stipulated in Environmental & Other Statutory Clearance. Mine owner shall follow the operational procedure (for sale, dispatch, storage, reserve reconciliation and transportation) as may be defined by the concerned state government in its monitoring guidelines. Mine owner should comply with the recommendation and suggestion made by the High Power Committee as applicable.

6.2 Post Environment Cleanace Monitoring:

It's the responsibility of the EC Holder to comply with the Environmental Clearance conditions and upload the six-monthly EC compliance report on the website of the Ministry. For the category, 'A' mines (>100 Ha individual & cluster) Regional Office of the MoEF&CC are entrusted to carry out EC Monitoring and for the Category 'B' Mines by SEIAA. The monitoring shall be carried out as per the procedure/schedule suggested by MoEF&CC from time to time. MOEF&CC vide its notification S.O. 637(E) dated 28.02.2014 has delegated the power to State/Union Territory Environmental Impact Assessment Authority to issue show cause notice to project proponent in case of violation of Conditions of Environmental Clearance issued by the said authority and to issue direction for keeping the said EC in abeyance or withdrawing it. Thus, for category 'B' (0 to 100 Ha) projects SEIAAs are responsible for EC monitoring.

6.3 Environment Audit:

The Hon'ble NGT in its order dated 04.09.2018 in O.A. 173/2018 in the matter of Sudarsan Das vs. State of West Bengal & Ors. Inter-alia directed

that "One of the conditions of every lease of mine or minerals would be that there will be independent environmental audit at least once in a year by reputed third party entity and report of such audit be placed in the public domain. In the course of such an environmental audit, a three-member committee of the local inhabitants will also be associated. Composition of three member's committee may preferably include ex-servicemen, a former teacher and former civil servant. The Committee will be nominated by the District Magistrate.

The gazette notification on environmental audit has been issued by the Ministry of Environment and Forests on March 13, 1992 (amended vide notification GSR 386 (E) dated April 22, 1993). This notification applies to every person carrying on an industry, operation or process requiring consent to operate under Section 25 of the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974) or under section 21 of the Air (Prevention and Control of Pollution) Act, 1981 (14 of 1981), or both, or authorization under the Hazardous Waste (Management and Handling) Rules, 1989, issued under the Environment (Protection) Act, 1986 (29 of 1986). The notification requires that an Environmental Statement for the financial year ending the 31st March be submitted to the concerned State Pollution Control Board, on or before the 30th September of the same year.

It is suggested that NABET Accredited consultant may be engaged for Environment Audit and during the course of the audit, a three-member committee nominated by District Magistrate shall be associated.

6.4 Monitoring of Sale & Purchase of Sand:

6.4.1 In order to curb illegal mining it is very necessary that the general public is aware of the legal source of sand and RBM suppliers. The Ministry of Mines issued **Sand Mining Framework 2018** wherein it has proposed two mechanisms for the online sale of sand depending on whether there is a free market for sand in the State or the prices are regulated by the Government.

Para 1.2.12.2 Under the market model

In the case of the market model, all the lessees/ certified dealers in the State should register themselves on the online portal/ mobile app. For registering, the lessee/ certified dealer will have to enter the details of its concession/ stockyard, location, the quantity of sand expected on a weekly basis, as per the approved mining plan. Once registered, the online portal/ app will display the name of the reach/ stockyard and sand could be booked by the consumer from those leases/ stockyards and prices up to the delivery level. Further, the lessee/ certified dealer needs to regularly update the sand available in the reach/ stockyard, and they can decide the price at which they want to sell their sand. Anyone who wishes to purchase sand in the State will have the following options for buying:

- 1. Mobile app*
- 2. Online portal*
- 3. Customer care/ telephone call*
- 4. Licensed traders*

The consumer needs to register on the portal and log in using his/her credentials (Aadhar card based only). After logging in, the portal will display the entire list of reaches/ stockyards along with the quantity of sand available in those reaches/ stockyards and the quality and price of

sand. The consumer can filter/ sort the reaches/ stockyards based on such parameters as location, quality and price, and book from the lease/ stockyard he/she wishes to. The consumer should also have the option to purchase the sand by ordering at customer care. Also, stockyards should be made around all the major consumption hubs in the State based on their estimated demand.

Para 1.2.12.3 Controlled market prices

In case the prices are regulated by the State Government, the only difference from the previous model is that the price of sand at the river reach/ stockyard shall be uniform across the State/ district based on the quality and transportation lead. A consumer after logging in may choose the reach/ stockyard from which he/she wishes to purchase the sand. The payment for booking the sand in both the cases should be made on the portal/ app so that proper accounting of the sale of sand can be maintained by the Government. Also, stockyards should be made around all the major consumption hubs in the State based on their estimated demand.

It is suggested that the State Government should develop an online portal for sale and purchase of Sand & RBM. In addition to this State Government shall decide on the model viz. *Under market model or Controlled market prices or both* to be adopted for their respective States. The State Government shall accordingly modify their Minor Mineral Concession Rules within 6 months of publication of these guidelines. It is suggested that the controlled price model is more effective in controlling illegal sand mining. Because if the State Government is the only agency to provide the sand in the State, then price and supply of sand can be controlled more effectively. There will be no confusion in the consumers about legality of the purchase as the only source of sand provider is the State Government through its network of registered stockiest, retailers and transporters. The consumers

can fill the online request, pay the amount, select the transporter and give its feedback after the receipt of the sand. The transportation can also be controlled as the tippers used for transportation is registered tippers with GPS facility, the transportation route is well defined for easy monitoring, control over overloading of tippers, control over spillage of mineral etc. The State Govt. shall also make provision for penalizing the persons/agency buying the sand and RBM from the illegal sources.

6.4.2 The Ministry of Mines in its Sand Mining Framework also mentioned the following different level of monitoring:

Para 1.2.13.1 Level 1- Reach/ Stockyard level monitoring

For monitoring of the active reaches:

- a. *Quantity of sand to be extracted from the reach should be based on the quantity of sand assessed in the reach by the Joint Inspection Team.*
- b. *The lease boundary should be demarcated with geo-coordinates or geo-fenced to ensure that sand extraction is going on only within the permitted area.*
- c. *De-casting from river beds should be monitored on a regular basis to keep a track of excavated quantity.*
- d. *After every two years, a mandatory audit of the quantity extracted and quantity permitted along with the replenishment rate.*
- e. *Mandatory e-pass/ e-permit should be made available at reach level for transportation of any sand by any GPS enabled vehicle with the provision of entering the vehicle number of the sand carrying vehicle and expected delivery address and customer name/ mobile number. Also, provision should be made available for stockyards/ stockiest of sand. In the case of*

nomination based (controlled pricing) business model, the margin of private stockist should be capped over a fixed percentage of notified prices.

- f. At the stockyard, the stock supervisor should verify the authenticity of online payment receipt before issuing the transit pass. The loading of sand should be monitored electronically and all transporting vehicles should pass through an electronically monitored weighbridge. g. Real-time data capture for transportation*

Para 1.2.13.2 Level 2 - Transportation monitoring

To make transportation monitoring effective and useful, all the sand carrying vehicles (tractors/ trucks) should be registered with the department and GPS equipment should be installed in all the sand carrying vehicles. Weighbridges with CCTV should be installed at all the stockyards, active reaches to ascertain the exact quantity of sand being transported in the vehicle. Check posts with CCTV cameras should be established near all major consumption centres to check if all the transporting vehicles are carrying a valid transport permit. The transport permit generated should contain the security features mentioned under section 5.11 so that one permit cannot be re-used by generating photocopies of the permit.

Para 1.2.13.3 Level 3 - End consumer monitoring/ bulk consumer

For end consumer monitoring, a customer grievance redressal center should be established to enquire about the grievances faced by the sand consumers. The telephone number of the call center should be advertised so that it reaches the general public through which anyone in the State can register his/her complain related to the sand, be it in terms of price or any other grievance. Additionally, profiles of customers should be analyzed such as the delivery of sand at the same address, usage pattern and its comparison with the estimated usage, as mentioned in purpose, etc. Further, surprise checking

should be conducted by the district level committee staff as per instructions of the monitoring agency.

Para 1.2.13.4 Level 4 - Indirect monitoring

Indirect monitoring can be done by determining sand consumption through the quantum of cement sales in the State, as the sale of cement is quite organized and data is easily available at the State level and district levels for the same. From district-wise cement consumption, the further trend of sand consumption can be derived. Any anomalies in the sand consumption/demand can be analyzed further.

Note: *The above monitoring mechanism is just a suggestion and the States may visit Andhra Pradesh and Telangana to study the monitoring mechanism in greater detail.*

It is suggested that State Government may consult with concern department of State of Telangana and Tamil Nadu to have better understanding on their experience and knowledge in adopting best sand mining enforcement provisions and monitoring practices and frame their own regulatory regime and monitoring framework. The framework of monitoring should essential include online sale & purchase of River Bed Material/ Auction of leases, Sand from rivers and other sources, online monitoring of excavation, storage and transportation of mineral for control of illegal mining.

The respective State Governments shall develop the online Sale & Purchase System after defining the model viz. Under market model or Controlled market prices model. The level of monitoring needs to be defined and guidelines need to be finalized by the respective State Governments as per their requirement with due consideration of suggestive guideline in this document. These all measure will help in curbing illegal mining.

7.0 Recommendations of High Power Committee:

A high power committee (HPC) was constituted by Hon'ble National Green Tribunal to assess the status of illegal mining the stretch of River Yamuna, under the chairmanship of Secretary, Ministry of Environment Forest & Climate Change. The committee after exhaustive field survey and interaction with stakeholders and having surprise visits submitted a comprehensive report on river sand mining along with certain recommendations on enforcement requirements and monitoring essentials. The same is provided in the following section for consideration of monitoring / regulatory authority to adopt applicable provisions in their monitoring framework and also to ensure that the infrastructural requirements recommended by the HPC are put in use at all locations including the lease area.

7.1 Recommendations of High Power Committee (HPC)

The following recommendation of the High Power Committee shall be considered while framing the monitoring mechanism by the State Government.

- i.* Project Proponent must ensure that following security features are included in the Transport Permission/Permits (TP) so that duplicate/fraudulent/forged TPs for transport, not accounted for in the IT-based system, is not possible.:
 - (a) Printed on Indian Bank Association (IBA) approved
 - (b) Magnetic Ink Character Recognition Code (MICR) paper;
 - (c) Unique Barcode;
 - (d) Unique Quick Response Code (QR);
 - (e) Fugitive Ink Background;
 - (f) Invisible Ink Mark;
 - (g) Void Pantograph;
 - (h) Watermark.

- ii. Project Proponent must ensure that CCTV camera, Personal Computer (PC) or laptop, Internet Connection, Power Back up, access control of mine lease site; and arrangement for weight or approximation of weight of mined out mineral on basis of volume of the trailer of vehicle used at mine lease site are available.
- iii. The PP has to enter the destination, distance between plot and destination, vehicle number etc in the system. After scanning, unique bar code number, invoice date time and validity date-time are generated by the software which gets printed individually on each TP Validity of TP is calculated based on the distance between plot and destination. After validity time is over the TP stands invalid.
- iv. The officers involved in monitoring should be provided with mobile application and/or bar code scanners using which the TP can be checked anywhere on road. As soon as the bar or QR code on TP gets scanned through using the mobile application and/or scanner or vehicle number is entered into the application or sent by SMS to a predefined number, all details of TP such as plot details, vehicle details, validity time, etc. should be fetched from the server. This means if anything is re-written on TP and attempt is made to reuse the same, it can be traced immediately. Various reports can be generated using the system showing daily lifting reports and user performance report. This way the vehicles carrying sand can be tracked from source to destination.
- v. The facility to fetch details using mobile app, website and SMS may be made available to the general public as well. However, they shall not be allowed to stop the vehicles to check the transportation. The only option that they should have is to check vehicle numbers of the passing vehicle in the mobile app or SMS for the validity of the pass. The only result that should be available to them should be if the vehicle carrying sand has a

valid permit at the relevant point of time or not. If the citizen finds that the vehicle doesn't have such a permit, as ascertained from mobile app or website or SMS, he should alert local authorities, who shall then take further action as per the law.

- vi. In case, the vehicle break-down, the validity of Transport Permit or Receipt shall be extended by sending SMS by the driver in specific format to report the breakdown of the vehicle. The server will register this information and register the breakdown. The State can also establish a call center, which can register breakdowns of such vehicles and extend the validity period. The subsequent restart of the vehicle also should be similarly reported to the server/call center.
- vii. The route of the vehicle from source to destination shall be tracked through the system using checkpoints, Radio-frequency identification (RFID) tags, and Global Positioning System (GPS) tracking.
- viii. The system shall enable the Authorities to develop a periodic report on different parameters like daily lifting report, vehicle log/ history, lifting against allocation, and total lifting. The system can be used to generate auto mails/SMS. This will enable the District Collector / Magistrate and other authorities to get all the relevant details and will enable the authority to block the scanning facility of any site found to be indulged in irregularity. Whenever any authority intercepts any vehicle transporting illegal sand, it shall get registered on the server and shall be mandatory for the officer to fill in the report on action taken. Every intercepted vehicle should be tracked.
- ix. It is necessary to prevent any truck/vehicle from transporting sand out of the identified plot bypassing the strong IT enabled system. Therefore, at each of the sand plot, the following additional measures should be taken.

- (a) There shall be one entry and exit point provided for trucks/vehicles. The said entry point should have facilities as mentioned above. In case, it is necessary to have more than one entry/exit points, all such points shall have checkpoints with facilities as mentioned above. All other possible ways of entry/exit should be closed using barriers like compound, trench, etc. All provisions shall be made to not make it possible for any vehicle to enter or exit without entry into the computerized system.
- (b) All such points should have 24X7 CCTV coverage, the footage of which should be made available online to the district administration. In cases, where sufficient internet bandwidth is not available, it may be deposited with the district administration on a weekly basis. If possible, the entry/exit points should have boom barriers which will record the vehicles entering and exiting the plot.

8.0 GENERAL APPROACH TO SUSTAINABLE SAND MINING

8.1 Pre-requisite for starting sand mining operation

- i)** All district to prepare a comprehensive mining plan for the district as per the provision of District Survey Report. These reports shall be put on the website of District Administration. No mining shall be allowed in the area which has not been identified in the comprehensive mining plan of the District.
- ii)** Replenishment study should be conducted on regular basis.
- iii)** All potential rivers mining zone/area shall be identified and put for auction with proper geo-tagged details by the auctioning authority concerned.
- iv)** The latitude and longitude of each mining lease shall be clearly mentioned in Letter of Intent issued to the potential mine lease. Such information shall be provided on the website of the district administration.
- v)** The provision of these guidelines shall be considered while identifying the potential stretches /locations and boundaries of the leases for the minable area.
- vi)** The Lol holder shall seek Environmental Clearance as per the provision of EIA Notification, and the regulatory authority shall ensure that the provision suggested in "Sustainable Sand Mining & Management 2016" and in this documents, as applicable are part of the clearance conditions.
- vii)** There shall be no river bed mining operation allowed in monsoon

period. The period as defined by IMD Nagpur for each state shall be adhered with.

- viii) The monitoring infrastructures including weighbridge and adequate fencing of the lease area, CCTV, Transport permits, etc, as suggested in this document shall be ensured in order to reduce unrecorded dispatch.
- ix) Regular monitoring of mined minerals and its transportation and storage shall be ensured and all information shall be captured at centralized database so that easy tracking of illegal material can be done.
- x) Annual audit of each mining lease shall be carried out wherein three independent member of repute, nominated by District administration shall also participate.

8.2 Mining of Sand from Agricultural Fields

This practice is prevalent in Haryana; to ensure that mining from outside doesn't affect rivers, no mining is permitted in an area up to a width of 100 meters from the active edge of embankments or distance prescribed by Irrigation department whichever is critical. The top layer of soil varying between 1 and 2 meters is removed and stacked separately and thereafter the sand deposit which maybe 10-15 meter deep is mined. After removing the sand layer up to a maximum depth of 09 meters or the maximum mineable minerals, as permitted by competent authority. The topsoil stacked is spread out on the field and the same is brought under the cultivation. Though the level of this land (mined out area) is lowered to the depth of the excavation and in initial years of cultivation the productivity is low, but the productivity of the fields improves with continued cultivation and addition of organic manure in the field. In Haryana, some leases are of large area

(ranging from 1000 hectare to 2000 hectare) and agricultural fields and river bed both are included in the same lease for mining.

The following recommendations should be kept in mind for mining in such leases:

1. Mining of sand in such mine leases will require environment clearance.
2. The lease should be of sand mining either from the agricultural field or river. In the same lease, both types of area should not be included.
3. The sand mining from the agricultural field is being done in Haryana for a long time and it can be done in a more sustainable manner without adverse impact on agricultural productivity if proper environmental safeguards are taken.
4. The slope of mining area adjacent to agricultural fields should be proper (preferably 45 degree) and adequate gap (minimum 10 feet) be left from adjacent agricultural field to avoid erosion and scouring.

The provision for sand mining in agricultural field may be permitted, whenever replenishment of sand occurs due to natural phenomena.

Permission may also be granted by competent authority (District administration) for excavation of sand/Soil from agricultural fields, after due diligence of this prevailing condition in order to avoid any unacceptable impact on the environment and nearby livelihood from agriculture provided such objective of such excavation mining of Soil/Sand in limited increase the productivity of sand agricultural field.

9.0 MONITORING MECHANISM

9.1 Illegal Mining

The Hon'ble Supreme Court in its Judgment dated 2.08.2017 in W.P 114 of 2014 in the matter of Common Cause Vs Union of India & Ors, inter-alia passed the following:

Para 128. *The simple reason for not accepting this interpretation is that Rule 2(ii-a) of the MCR was inserted by a notification dated 26th July 2012 while we are concerned with an earlier period. That apart, as mentioned above, the holder of a mining lease is required to adhere to the terms of the mining scheme, the mining plan and the mining lease as well as the statutes such as the EPA, the FCA, the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981. If any mining operation is conducted in violation of any of these requirements, then that mining operation is illegal or unlawful. Any extraction of a mineral through an illegal or unlawful mining operation would become illegally or unlawfully extracted mineral."*

In view of above Judgement, any mining activities which are not governed under the provision of Environment (Protection) Act, 1985, The Water (Prevention & Control of Pollution Act, 1974, The Air (Prevention & Control of Pollution) Act, 1981, Forest Conservation Act-1980, Wildlife Protection Act - 1972, shall be considered as illegal mining within the provision of section 21(5) of Mines and Minerals (Development & Regulation) Act, 1957 (MMDR Act) and the concerned authority shall take necessary action within the provision of MMDR Act.

As per the provision of 23(C) of MMDR Act, the State Government is empowered to make rules for preventing illegal mining, and transportation

& storage of Illegal minerals. All such mining which qualifies under illegal, shall be dealt with in the provision of MMDR Act by the concern authorities.

State Pollution Control Board (SPCB) is the nodal authority in the State for dealing with cases related to pollution or environment management coming under the purview of the Water (Prevention and Control of Pollution) Act, 1974, the Air (Prevention and Control of Pollution) Act, 1981 and the Environment Protection Act 1986. SPCB shall initiate appropriate action under the provision of these acts for non-compliance or violation of the provisions.

9.2 Environmental Damage due to illegal mining

The environmental damages incurred or resulting due to illegal mining shall be assessed by a committee constituted by District Administration having expertise from relevant fields, and also having independent representation of locals and State Pollution Control Board. Guidelines for assessment of ecological damages prescribed by the State Government or Concerned Pollution Control Boards or any other authority shall be applicable and compensation as fixed shall be paid by the project proponent, in light of Hon'ble National Green Tribunal orders.

9.3 Monitoring of Mining near Inter-district or inter-state boundary

There are situations where bifurcated river becomes district boundaries or state boundaries in such situation it is difficult to assess the mining potential, or to have close monitoring and enforcement of the regulatory provision. Such challenges have been identified and dealt with in SSMG-2016. However, in the absence of any standardized procedure, the monitoring has not been effectively practiced. This has been highlighted by the High Power Committee constituted by NGT in the matter pertaining to illegal mining.

The districts/state sharing the boundary shall constitute the combined task force for monitoring of mined materials, mining activity and also should actively participate in the preparation of DSR by providing appropriate inputs. In such cases, the draft DSR so prepared shall be put up for public consultation in both the districts through respective district administration website.

The task force shall meet every quarter to reconcile the data collected during the period and identify any gap/ lapses based on the outcome of such meeting. The respective district shall take action/ corrective measures. Effort shall be made for real-time data sharing between both the district.

The task –force shall include essentially the representative of respective districts from the mining department, transport department, regional office of SPCB concerned and a reputed citizen nominated by district administration. The Taskforce shall be headed by officer not less than ADM rank and quarterly outcome shall be submitted to District administration.

In addition to the above, there is a need for strict surveillance, particularly at night. The State of Gujarat has already initiated a program called '*Trinetra*' for night surveillance by using night-vision drones to control illegal mining incidents. This program is giving satisfactory results. Such type of system may also be developed by each State within a reasonable time.

A typical standard operating procedure for assessing illegal mining by the committee constituted shall, but not limited to, include the steps given in the following table. However, the process of assessing can be modified based on site-specific conditions and any deviation shall be recorded in the report with proper justification.

Suggestive standard Practice for assessing illegal mining

Step 1	The assessment team should collect the information and documents prescribed in the Pre-Requisite section.
Step 2	The assessment team should verify the applicability/validity of statutes under EPA-1986, Air and Water Act, MMDR 1957, State Mines and Mineral Rules, etc.
Step 3	Field visit should be conducted for identification of mining lease area (in hectare) and boundary pillar constructed to indicate the same.
Step 4	With the help of GPS instrument, the team should assess the area where any extraction or mining have been carried out on the day of visit and calculate the mined-out area in a hectare.
Step 5	If available, the team may avail the use of latest satellite images for calculating the total mined out area.
Step 6	The team should verify the Ground / Surface Level (in meter above MSL) of at least 04 highest points in or around the area where mining has been done. The Ground/surface level will then be computed based on averaging of 04 highest points verified by the team.
Step 7	With the help of Depth Measurement kit or any depth measuring instruments, the depth should be measured for at least 04 points in the mined-out area. For computing, the depth, averaging of the value obtained at 04 points should be done.
Step 8	Verification of compliance conditions of Environmental Clearance and Consent to operate, mining methodology under Mining Plan
Step 9	Identification of vulnerable impacts observed on the field and non-compliance of conditions of Environmental Clearance and Consent to Operate.

Step 10	Field Survey for identification, monitoring and verification of ecological species based on the information available and documents mentioned in the Pre-requisite section.
Step 11	Preparation of inventory of machinery used/observed on the field (optional)
Step 12	Preparation of inventory of hydraulic structures observed on the field (optional)
Step 13	Water sampling for assessment of water quality including physical and biological parameters. (optional)
Step 14	Reconciliation collation of data/information and compilation to maintain violation.
Step 15	Identification of restoration plan and computation of cost of the restoration plan.

9.4 Monitoring Mechanism

A uniform monitoring mechanism is required to assess the regulatory provision in quantitative terms, with robust institutional and legal framework. Based on past experience and suggestions available, the following requirements are suggested for defining a mechanism for monitoring of mining activities which will help in identification of mining which is operating either illegally or are violating the regulatory provisions. Some suggestion will facilitate direct or indirect information to help in such an assessment.

1. All precaution shall be taken to ensure that the water stream flows unhindered and process of Natural river meandering doesn't get affected due to mining activity.
2. River mining from outside shall not affect rivers, no mining shall be permitted in an area up to a width of 100 meters from the active edge of embankments or distance prescribed by the Irrigation department.

3. The mining from the area outside river bed shall be permitted subject to the condition that a safety margin of two meters (2 m) shall be maintained above the groundwater table while undertaking mining and no mining operation shall be permissible below this level unless specific permission is obtained from the Competent Authority. Further, the mining should not exceed nine-meter (9 m) at any point in time.
4. Survey shall be carried out for identifying the stretches having habitation of freshwater turtles or turtle nesting zones. Similarly, stretches shall be identified for other species of significant importance to the river ecosystem. Such stretch with adequate buffer distance shall be declared as no-mining zone and no mining shall be permitted. The regulatory authority as defined for granting Environmental Clearance, while considering the application of issuance of ToR and/or EC for the adjacent block (to non-mining zone) of mining shall take due precaution and impose requisite conditions to safeguard the interest of such species of importance.
5. District administration shall provide detailed information on its website about the sand mines in its district for public information, with an objective to extend all information in public domain so that the citizens are aware of the mining activities and can also report to the district administration on any deviation observed. Appropriate feedback and its redressal mechanism shall also be made operational. The details shall include, but not limited to, lease area, geo-coordinates of lease area and mineable area, transport routes, permitted capacity, regulatory conditions for operation including mining, environmental and social commitments etc.

6. A website needs to be maintain to track the movement of centralised sand mining and a Centralised server system should be made to manage the data related to sand mining across India.
7. The mineral concession holders shall maintain electronic weighbridges at the appropriate location identified by the district mining officer, in order to ensure that all mined minerals from that particular mine are accounted for before the material is dispatched from the mine. The weighing bridge shall have the provision of CCTV camera and all dispatch from the mine shall be accounted for.
8. The mineral movement shall be monitored and controlled through the use of transit permit with security features like printing on IBA approved MICR papers, Unique bar/QR, fugitive ink background, invisible ink mark, void pantographs and watermarks papers or through use of RFID tagged transit permits and IT /IT-enabled services. Such monitoring system shall be created and made operationalised by State Mining department and district level mining officer shall be responsible for ensuring that all legal and operational mines are connected and providing the requisite information on the system. Regular check and associated report shall be submitted to DLTF and uploaded on the website.
9. State Government shall constitute a District Level Task Force (DLTF) under the Chairmanship of Deputy Commissioner/District Magistrate/Collector with Superintendents of Police and other related senior functionaries (District Forest Officer, District transport officer, Regional officer- SPCBs, Senior Officer of Irrigation Department, District Mining Officer) with one/two independent member nominated by the Commissioner concerned. The independent member shall be retired government officials/teacher or ex-serviceman or ex-judiciary member.

The DLTF shall keep regular watch over the mining activities and movement of minerals in the district. The DLTF shall have its regular meeting, preferably every month to reconcile the information from the mining activity, and other observations made during the month and take appropriate corrective and remedial action, which may include a recommendation for revoking mining lease or environmental clearance. The DLTF may constitute an independent committee of the expert to assess the environmental or ecological damage caused due to illegal mining and recommend recovery of environmental compensation from the miner's concern. The recommendation may also include action under the provision of E(P) Act, 1986.

10. The area not identified for mining due to restriction or otherwise are also to be monitored on a regular basis by the DLTF. Any observations of mining activity from the restricted area shall be reported and corrective measures shall be initiated on an urgent basis by the DLTF.
11. The dispatch routes shall be defined in the Environmental Clearance and shall be avoided through densely habituated area and the increase in the number of vehicle movement on the road shall be in agreement with the IRC guidelines / carrying capacity of the road. The alternate and dedicated route shall be explored and preferred for movement of mining to avoid inconvenience to the local habitat. The mining production capacity, by volume/weight, shall be governed by total permissible dispatch calculated based on the carrying capacity of dispatch link roads and accordingly, the production should be regulated.
12. The movement of minerals shall be reconciled with the data collected from the mines and various Naka/check posts. Other measures may also include a general survey of the potential mineable area in the district

which has not been leased/auctioned or permitted for mining due to regulatory or other reasons.

13. The location and number of check post requirement shall be reviewed by DLTF on a regular basis so that appropriate changes in location/number could be made as per the requirement. Such review shall be carried out on a regular basis for the district on inter-state boundary or district providing multiple passages between two districts of different states.
14. The district administration shall compile the information from their district of the permitted and legal mined out minerals and other details and share such information and intelligence with the officials of the adjoining district (Inter or/and Intra State) for reconciliation. The information shall include the area of operation, permissible quantity, mined out minerals (production) the permitted route etc., and other observations, especially where the mine lease boundary is congruent with the district boundary. Such coordination meeting shall be held on a quarterly basis, alternatively in two district headquarters or any other site in two districts decided mutually by the District Magistrate.
15. The mining department shall include submission of an annual environmental audit report as one of the conditions in the mining lease agreement. The annual audit for each river bed mining lease shall be carried out and the audit report shall be uploaded on the website of district administration. The audit shall be carried out by an independent team of 3 members nominated by District Collector/Magistrate/Commissioner comprising of Ex-Serviceman, Ex-Government officials of repute, Professor or Person having experience of mining/environment. The guidelines and method of the audit shall reflect adequately the monitor-able parameters and output and reflect

the compliance status with respect to the conditions imposed by the regulatory authorities including conditions of Environmental clearance.

16. The in-situ and ex-situ environmental mitigative measures stipulated as EMP, CER, CSR and other environmental and safety conditions in mines including the welfare of labours shall properly reflect in the audit report.

9.5 Suggestive additional requirements are

i. The requirement at the Mine Lease Site:

- a. Small Size Plot (Up to 5 hectares): Android Based Smart Phone.
- b. Large Size Plots (More than 5 hectares): CCTV camera, Personal Computer (PC), Internet Connection, Power Back up.
- c. Access control of mine lease site.
- d. Arrangement for weight or approximation of the weight of mined out mineral on the basis of the volume of the trailer of vehicle used.

ii. Scanning of Transport Permit or Receipt and Uploading on Server:

- a. Website: Scanning of receipt on mining site can be done through barcode scanner and computer using the software;
- b. Android Application: Scanning on mining site can be done using Android Application using a smartphone. It will require internet availability on SIM card;
- c. SMS: Transport Permit or Receipt shall be uploaded on the server even by sending SMS through mobile. Once Transport Permit or Receipt get uploaded, a unique invoice code gets generated with its validity period.

iii. Proposed working of the system:

The State Mining Department should print the Transport Permit or Receipt with security features and issue them to the mining leaseholder through the District Collector. Once these Transport Permits or Receipts are issued, they would be uploaded on the server against that mine lease area. Each receipt should be preferable with pre-fixed quantity, so the total quantity gets determined for the receipts issued. When the

Transport Permit or Receipt barcode gets scanned and invoice is generated, that particular barcode gets used and its validity time is recorded on the server. So all the details of transporting of mined out material can be captured on the server and the Transport Permit or Receipt cannot be reused.

iv. Checking On Route:

The staff deployed for the purpose of checking of vehicles carrying mined mineral should be in a position to check the validity of Transport Permit or Receipt by scanning them using the website, Android Application and SMS.

v. Breakdown of Vehicle:

In case the vehicle break-down, the validity of Transport Permit or Receipt shall be extended by sending SMS by the driver in specific format to report the breakdown of the vehicle. The server will register this information and register the breakdown. The State can also establish a call center, which can register breakdowns of such vehicles and extend the validity period. The subsequent restart of the vehicle also should be similarly reported to the server or call center.

vi. Tracking of Vehicles:

The route of the vehicle from source to destination can be tracked through the system using checkpoints, RFID Tags, and GPS tracking.

vii. Alerts or Report Generation and Action Review:

The system will enable the authorities to develop a periodic report on different parameters like daily lifting report, vehicle log or history, lifting against allocation, and total lifting. The system can be used to generate auto mails or SMS. This will enable the District Collector or District Magistrate to get all the relevant details and shall enable the authority to block the scanning facility of any site found to be indulged in irregularity. Whenever any authority intercepts any vehicle transporting illegal sand, it shall get registered on the server and shall be mandatory for the officer to fill in the report on action taken. Every intercepted vehicle shall be tracked.

The monitoring of mined out mineral, environmental clearance conditions and enforcement of Environment Management Plan will be ensured by the regulatory authority and the State Pollution Control Board or Committee. The monitoring arrangements envisaged above shall be put in place. The monitoring of enforcement of environmental clearance conditions shall be done by the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change and the agency nominated by the Ministry for the purpose.

Some of the State has followed the SSMMG-2016 and has also improvised or customized on the provisions given therein, and are successfully in operation. Salient provision adopted at different stages of sand mining in the state of Tamil Nadu is given as **Annexure VIII**.

9.6 Actions against illegal excavation and transport

Solapur district administration in Maharashtra had adopted a multi-pronged strategy to penalize the persons involved in illegal excavation and transport which resulted in a significant increase in revenue earned by the state. Following rules and procedures as mentioned in these guidelines will add to the costs of PP. Those involved in illegal activities are not required to bear these costs and this will make their supply in the market cheaper (though illegal). This will put the players running their business by following rules and procedures laid down by the government to disadvantage as far as the selling price is considered. Therefore, it is necessary to come down heavily on those involved in illegal excavation/transport, so that there is no incentive for players to abide by the rules.

The following action may be taken to achieve this deterrence against illegal business:

1. The action should be taken under all legal options available simultaneously. Thus, after identifying the case of illegal excavation, storage and/or transport of minor minerals (including sand), fine should be levied as per the land revenue laws/code(s) of the state. In addition, FIR should be lodged in the police station under relevant sections of law including sec 379 IPC. In addition, action under the Motor Vehicle Act, 1989 and relevant rules should initiate to cancel/suspend the driving license of the driver and permit of the vehicle. Further, action should be initiated under provisions in the Income Tax Act, 1961 for unaccounted income and under the Central Goods and Services Act, 2017 for non-payment of GST. (Earlier this was done under the state act pertaining to Value Added Tax/Sales Tax). Habitual offenders should also be taken up under local state laws for externment and/or preventive action. It is clarified that as per law, it is possible to take all actions under various laws

simultaneously for one offence. What is prohibited in law is an action under the same law for the same act more than once.

2. The action should be taken against all persons responsible. Often, there is a tendency to penalize only the drivers of the vehicles. The mafia of illegal mining and transport is much bigger and drivers are only one part of the system. It is necessary to identify all those involved in the offence. It is usually not possible to reach the place of excavation without creating a motorable pathway up to the same through land which may be private land. Such role of such landowners needs to be looked into for each offence and proceeded against simultaneously. Further, the role of vehicle owners needs to be probed. Role of the person who allowed his land to be used for illegal excavation and storage should also be examined. Lastly, the person who purchases such sand should also be probed. The legal proceedings stated above needs to be initiated against all of these together. An attempt should be made to fix the financial responsibility in joint and several ways so that recovery is easier.
3. There may be discretion available in law about the extent of the penalty to be levied. If such discretion is very wide, then it is advisable that guidelines may be laid down to reduce such discretion in law for levying penalties. For example, in Maharashtra, Land Revenue Code, fine of any amount of penalty up to thrice the value of the sand can be levied. Solapur district administration had instructed Tahsildars and SDMs not to use discretion and levy the fine of three times the value. Availability of discretion makes junior level functionaries susceptible to pressures and it may also lead to corrupt practices.
4. It is emphasized that actions, as stated above, are most important to ensure that the IT-based system works. If these exemplary actions are not taken against everyone, it shall create a strong disincentive to those

involved in legal excavation and transportation. For IT-based (or any other) legal system to work, it is necessary to ensure that illegal system stops working altogether.

Annexure-I**Details of Sand/M-Sand Sources****a) Rivers:**

River Name/M-Sand Plant	Total Stretch of River (in KM)	Type of River (Perennial or Non-Perennial)

b) De-Siltation Location: (Lakes/Ponds/Dams etc.)

Name of Reservoir/Dams	Maintain/Controlled by State Govt./PSU etc.	Location	District	Tehsil	Village	Size(Ha)

c) Patta Lands/Khatedari Land:

Owner	Sy. No	Area (Ha)	District	Tehsil	Village	Agricultural Land (Yes/No)

d) M-Sand Plants:

Plant Name	Owner	District	Tehsil	Village	Geo-location	Quantity Tonnes/Annum

Note: For inclusion of M-Sand Plant/Patta Land in DSR the plant/landowners need to submit the request to the Mining Department with complete details. Inclusion in DSR does not give them the right to operate the M-Sand Plant/Sand Mining lease.

Annexure-II

List of Potential Mining Leases (existing & proposed)

Rivers

River Details	Lease Details	Area (in Ha)	Distance (in KM) from PA/BR/WC/	Distance from Forest Area (in KM)	Mining leases within 500 meters (if yes cluster area)	Total excavation in Tonnes /Annum considering digging depth max as 3 meters	Mineral to be mined (Sand/ Bajri/ RBM etc.)	Existing / Proposed

Patta Lands/Khatedari Land: (existing & proposed)

Owner	Sy. No	Area	District	Tehsil	Village	Total Reserve (MT)	Total Mineral to be mined (MT)	Existing /Proposed

De-Siltation Location: (Lakes/Ponds/Dams etc.) (Existing & proposed)

Name of Reservoir /Dams	Maintain /Controlled by State Govt./PSU etc.	Location	District	Tehsil	Village	Size (Ha)	Quantity MT / Year	Existing /Proposed

M-Sand Plants :(existing & proposed)

Plant Name	Owner	District	Tehsil	Village	Geo-location	Quantity Tonnes/Annum	Existing/Proposed

Annexure-III**Cluster & Contiguous Cluster details****Clusters:**

River Name	Cluster No.	Lease No	Location (Riverbed / Patta Land)	Village	Area (in Ha)	Total Excavation (Ton)	Total Mineral Excavation (Ton)

Contiguous Clusters:

River Name	Contiguous Cluster No.	Cluster No	Number of leases in the cluster	Location (Riverbed / Patta Land)	Distance between clusters	Village	Area of Cluster (Ha)	Total Mineral Excavation (Ton)

Annexure-IV

Transportation Routes for individual leases and leases in Cluster

Lease No	Transportation Route No	Number of tipper s /day of lease	Number of tipper s /day of all the lease on route	Length of Route in KM	Type of Road (Black Topped/ unpaved)	Recommendation for road (Black Topped/ unpaved)	The road will be Constructed by Govt/ Lease Owner	Route Map & Location

Cluster No	Transportation Route No	Number of tipper s /day of cluster	Number of tipper s /day of all the clusters on route	Length of Route in KM	Type of Road (Black Topped/ unpaved)	Recommendation for road (Black Topped/ unpaved)	The road will be Constructed by Govt/ Lease Owner	Route Map & Location

Annexure-V**Final List of Potential Mining Leases (existing & proposed)****Rivers**

River Details	Lease Details	Area (in Ha)	Distance (in KM) from PA/BR/WC/	Distance from Forest Area (in KM)	Mining leases within 500 meters (if yes cluster area)	Total excavation in (MT/Yr) (Mine depth max as 3 m)	Mineral to be mined (Sand/Bajri/RBM etc.)	Existing /Proposed

Patta Lands/Khatedari Land: (existing & proposed)

Owner	Sy. No	Area	District	Tehsil	Village	Total Reserve (MT)	Total Mineral to be mined (MT)	Existing /Proposed

De-Siltation Location: (Lakes/Ponds/Dams etc.) (Existing & proposed)

Name of Reservoir/ Dams	Maintain/ Controlled by State Govt./PSU etc.	Location	Distt.	Tehsil	Village	Size(Ha)	Quantity MT/Year	Existing/ Proposed

M-Sand Plants :(existing & proposed)

Plant Name	Owner	District	Tehsil	Village	Geo-location	Quantity MT/Annum	Existing/Proposed

Annexure-VI**Final List of Cluster & Contiguous Cluster****Clusters:**

River Name	Cluster No.	Lease No	Location (Riverbed / Patta Land)	Village	Area (in Ha)	Total Excavation (Ton)	Total Mineral Excavation (Ton)

Contiguous Clusters:

River Name	Contiguous Cluster No.	Cluster No	Number of leases in the cluster	Location (Riverbed /Patta Land)	Distance between clusters	Village	Area of Cluster (in Ha)	Total Mineral Excavation (Ton)

Annexure-VII

Final Transportation Routes for individual leases and leases in Cluster

Lease No	Transportation Route No	Number of tippers /day of lease	Number of tippers /day of all the lease on route	Length of Route in KM	Type of Road (Black Topped/unpaved)	Recommendation for road(Black Topped/unpaved)	The road will be Constructed by Govt/Lease Owner	Route Map & Location

Cluster No	Transportation Route No	Number of tippers /day of cluster	Number of tippers /day of all the clusters on route	Length of Route in KM	Type of Road (Black Topped/unpaved)	Recommendation for road(Black Topped/unpaved)	The road will be Constructed by Govt/Lease Owner	Route Map & Location

Annexure VIII**Salient provision for sand mining in the state of Tamil Nadu****STEPS TO BE FOLLOWED BEFORE EXECUTION:**

- The state as a policy should endeavor to have single authority/agency responsible for all river sand mining in the state with an objective to ease the gap in demand and supply and accordingly, take necessary measures including planning, monitoring of mined material and its transport, and to curb illegal mining and sale of materials.
- The prospective site for sand quarry may be identified based on the availability of adequate sand deposits along the river beds, which hinders the free flow of water and results in flooding during monsoon seasons. Emphasis may be given to such quarry sites which is more viable for replenishment.
- A detailed study may be conducted by engaging expert from reputed Institutions to identify prospective sand reaches, assessment of the impact of sand quarrying on the Ground Water Table and water availability, conduct bore log details and study the social and environmental aspects. The generic requirement for replenishment study is to be followed.
- Once the site is identified for prospective sand quarry site based on the detailed replenishment study, the concerned department shall submit the proposal with the geo-tagged boundary of the proposed mining Precise Area Proposal to the District Collector for approval.
- A joint inspection may be carried out by the RDO/Sub-Collector, Assistant/Deputy Director,

- Executive Engineer, TWAD Board and the PWD officials to consider the various factors before giving consent to the proposal.
- The RDO concerned along with Revenue officials may verify the revenue records of the proposed sand quarrying area and give the NOC.
- The AD/DD Mines may verify the presence of permanent structures such as tower line, bridge, monuments if any, in the vicinity of the proposed mining site as per Tamil Nadu Minor Mineral Concession Rules, 1959 (As per Rule 36 " there shall be no quarrying of sand in any river bed or adjoining area or any other area which is located within 500 meter radial distance from the location of any bridge, water supply system, infiltration well or pumping installation of any of the local bodies or Central or State Government Department or the Tamil Nadu Water Supply and Drainage Board head works or any area identified for locating water supply schemes by any of the above mentioned Government Department or other bodies" and " The distance of 50 meter shall be measured in the case of railway, reservoir or canal horizontally from the outer toe of the bank or the outer edge of the cutting, as the case may be "). Also, the availability of minerals may be cross verified with the available DSR.
- The TWAD officials may verify the drinking water schemes located nearby the proposed quarry site and the minimum distance required as per statutory norms.
- Based on the feasibility report of the joint inspection by the Revenue, Tamil Nadu Water Supply and Drainage Board and Mining officials/experts, the District Collector may give consent for the Precise Area proposal.

- After getting Precise Area approval, a detailed Mining Plan and sketch shall be prepared by the Executive Engineer, PWD using the services of a NABET accredited consultant who holds the pivotal role in the preparation of mining plan. Due responsibility will be expected on the concerned consultant in the mining plan preparation taking care of adhering to all mining rules, existing as on date. The mining plan shall contain the details of quantity to be excavated, the period of mining, method of excavation, deployment of required machinery, Environment Management Plan (EMP), proposed number of laborers to be deployed and Conceptual Mining Plan, as per Rule 41 of TNMMC Rules 1959. It is also the duty of the consultant to give the safe distance of 50 m or twice the bank height from the toe of the riverbank, whichever is higher and fixing the Geo coordinates for boundaries using DGPS instruments.
- The concerned Executive Engineer, PWD shall submit the Mining Plan prepared by the NABET accredited consultant to the concerned Assistant/Deputy Director, Department of Geology and Mines for approval, as per Rule 42 of TNMMC 1959. After scrutiny, the Assistant/Deputy Director, Department of Geology will present the Mining plan before the State Level Environment Impact Assessment Authority (SEIAA) for granting Environmental Clearance.
- The Executive Engineer, PWD shall prepare Form I and Pre-feasibility report with the help of the consultant and submit to SEIAA for an area less than 50 Ha. or to the Ministry of Environment and Forest and Climate Change (MoEF&CC) for the area more than 50 Ha.
- The State Expert Appraisal Committee (SEAC) under SEIAA, consisting of experts from renowned fields such as Mines, Environment, Sociology etc. shall conduct a site inspection of the proposed sand quarry site and after intense scrutiny, may recommend the proposal to SEIAA for approval.

- SEIAA shall grant Environmental Clearance for the sand quarry proposal after analyzing all the statutory provisions and based on the recommendation of the SEAC.
- The Environmental Clearance shall be informed to the public with basic details through advertisement in at least two widely circulated local newspapers with at least one in the vernacular language of the locality, within 7 days of the receipt of the clearance.
- On receipt of the Environmental Clearance, the Executive Engineer, PWD shall apply for Consent to Establish (CTE), from the Tamil Nadu Pollution Control Board as per the Air and Water Act, to enter upon the sand quarry site and commence the preliminary works such as construction of temporary sheds, bio-toilets, formation of biodegradable road using sugar cane leaves etc., drilling of bore wells etc. as per the statutory requirements. After all the preliminary works are completed, the Executive Engineer, PWD shall apply for the Consent to Operate (CTO) from the Tamil Nadu Pollution Control Board. Earmarking boundary of the identified land site through the concrete posts along with red flags need to be established.
- On receipt of the CTO, the Executive Engineer, PWD shall request the consent of the District Collector to commence the quarries. The District Collector shall request the Taluk Level Task Force comprising of Tahsildar, Inspector of Police, Officials from the Departments of Geology and Mining, Transport and Forest, Assistant Engineer, PWD and the Village Administrative Officer concerned, to verify the compliance of all preconditions mentioned in the Environmental Clearance and grant necessary permission to start the functioning of new sand quarries.

II. STEPS TO BE FOLLOWED DURING EXECUTION:

- Before the commencement of mining operations, the depth of sand quarrying needs to be measured accurately using Advanced technology and new gadgets like Total Stations, Global Positioning System (GPS) instruments etc. The Total Station and GPS instruments also need to be calibrated before measurement. Both the traditional and modern techniques may be infused in the right blend to get an accurate measure of the depth. A clear contour map (0.25m interval) of the levels within 2Km (one Km U/s and one Km D/s) needs to be prepared and submitted to both the Project Director, Sand Quarrying Operations and all the Monitoring Committee members. The depth of sand quarrying shall be restricted to 1 m from the theoretical/design bed level.
- The mining area must be demarcated at a minimum distance of at least 50 m away from the river embankment on either side. The boundaries of the quarries may be fixed with reference to the existing survey marks from the survey fields adjacent to the river. Sand quarrying lease area shall be demarcated on the ground with pucca stone or concrete pillars to show the present natural bed level and the depth of mining allowed.
- Modern techniques such as drone survey may be adopted to assess the depth and quantity of the mined area. Boundary pillars shall be erected at an interval of 50 m each on all four sides of the sand quarry site with red flags on every pillar and also in site pillars. The levels of shoal height, river bed height and depth to be excavated up to one meter downwards shall be marked in the pillars to avoid any deviation from the approved depth of excavation.
- It shall be ensured that no sand quarrying of any type is undertaken within 50m of the distance mentioned in the proposal (whichever is higher)

from both the banks of the river to control and avoid erosion of river banks.

- Temporary access roads or Katcha roads shall be formed between the banks of the river and the mining area with locally available bio-degradable materials such as sugarcane waste (bagasse), hay, etc.
- Proper entry and exit point for the movement of loading vehicles in and out of the sand quarry site shall be carefully located taking into consideration the habitations/settlements in the area.
- To monitor the groundwater level during sand quarrying operations, a network of existing wells may be established around the sand quarrying area and new piezometers must be installed at all sand quarry sites. Monitoring of Ground Water Quality in the vicinity (one Km radius from the sand quarrying site) shall be carried out once in two months.
- Periodic Monitoring (at least four times in a year – pre-monsoon, Monsoon, Post monsoon and winter) once in each season shall be carried out by PWD and the data thus collected may be sent regularly to SEIAA/TNPCB. If at any stage, it is observed that the groundwater table is getting depleted due to the mining activity; necessary corrective measures shall be carried out, which includes immediate stopping of mining.
- Similar to the Baseline studies for data on water, soil and air etc., that is being done before the sand quarrying operations, the air and water quality may be checked periodically by Tamil Nadu Pollution Control Board to ensure that no pollution is caused due to Sand Quarrying Operations. 10. Safety gadgets such as earplugs, goggles, respiratory

devices, luminescent vests etc. may be provided to the workers at the sand quarry site.

- First aid kit with all essentials shall be kept ready at all quarry/depot site, in case of any emergency.
- To prevent air pollution due to the dust during sand quarrying operations and safeguard the persons in the sand quarry and depot site, constant water sprinkling on the pathways and dust prone areas may be done. The sand loaded vehicles are to be covered with a tarpaulin before moving out of the quarries/depots.
- Suitable depots shall be located in the vicinity of the sand quarry site to facilitate the sale of sand. While selecting the site for depots, it must be ensured that the site is within 25 km from the sand quarry site and has an area of around 10-15 Acres with parking facilities and proper entry and exit for smooth movement of the vehicles. The depot site shall preferably be a Government poramboke land, foreshore area of tank bund etc., near an NH/SH/MDR/ODR. In the absence of any Government land in the vicinity, private Patta land may be leased out and rent fixed as per the approved Government rates applicable therein.
- Permission must be obtained from the Electricity Board for power supply to operate the CCTV cameras at sand quarry site and depots.
- Minimum of two CCTV cameras, one each at the entry and exit point and one PTZ camera may be installed at all quarries/depots to monitor illegality if any taking place in the sand quarry/depot.
- To ensure uninterrupted seamless live streaming of videos from the surveillance cameras, a high-speed Internet Lease Line connection may

be made available at all quarries/depots. Arrangements may also be made for online monitoring of the sand quarrying, Centre for Assessing Real-Time Sand Mining (CARS) that could be located at the office of the Project Director in Chennai.

- The live streaming of the videos shall be monitored at a Centralised control room and the data shall be stored in the Server for future references. A robust Customer Care may also be functional 24 x 7 at the Control Room, to redress the grievance of the public.
- Drop gates shall be installed at the entry and exit points of all quarries/depots.
- Display boards shall be erected in local vernacular language at sand quarry/depot site, in the nearest village by which sand transportation will be carried and at the entrance of the village road from the main road.
- The concerned authority of PWD shall call for e-tender to select the contractors for loading/raising of sand at the quarry site, transporting contractors to transport sand from the quarry site to depots and loading/maintenance contractors at depots.
- Sand shall be loaded in the quarries in the PWD tendered GPS fitted vehicles and online transmit permit shall be issued by the competent authorities in PWD to the transporting vehicles to transport sand from the quarry to depots.
- On the arrival of the sand shunting vehicles from quarry to the depot, an online authentication shall be done to confirm the arrival of the

appropriate quantity of sand mentioned in the transport permit into the depot.

- The loading of sand from the depots shall be carried out by booking through the online portal "www.tnsand.in" as done presently. Online transit passes will also be issued to the loaded vehicles which could be verified by using an Android app "TNsand Investigator".
- During operation of the quarries, the PWD officers shall ensure that at no point in time, the depth of quarry exceeds 1 m depth from the river bed level and quarrying is done in a uniform manner over the entire mining area to avoid overexploitation and formation of pits at fixed places.
- Proper registers may be maintained at the entry and exit points of the sand quarry/depot sites and a Loading Register may be made available during inspection. An Inspection Register and a Complaint Register may be made available at the sand quarry/depot site.
- The functioning time of quarries/depots shall be from 7.00 AM to 6.00 PM. No sand transporting vehicles to be parked inside the quarry/depot site during night time.
- A copy of the approved mining plan may be kept at the quarry site for ready reference.
- Photographs and sketch showing the pit dimensions, depth etc. may be recorded every week and maintained in the sand quarry. The Executive Engineer, PWD may inspect each sand quarry on a weekly basis and ensure that mining activities are taking place within the approved boundaries/depth.

- The sand quarrying activity shall be stopped if the entire quantity is quarried even before the expiry of the sand quarry lease period and the same shall be mentioned by the PWD authorities.
- The Taluk Level Taskforce shall inspect the quarries every fortnight, as per G.O. (Ms) No. 135 of Industries Department, dated 13.11.2009 and record the status of the compliance in the registers maintained at the sand quarry site.
- The Taluk Level Task Force has to submit its inspection report to the District Level Task Force chaired by the District Collector. The District Level Task Force has to be convened every month to discuss cases of illegal quarrying. An Environmentalist from reputed State / Central Institution and a legal expert on environmental matters may be part of the District Level Task Force. The District Level Task Force shall also dispose of the petitions on illegal sand quarrying after due enquiry and scrutiny, and pass orders within a period of two months from the date of receipt of the complaint. If any person is aggrieved with the orders passed by the District Level Task Force, an appeal may be preferred before the Appellate Forum.
- The District Collector shall take necessary steps to strengthen the existing District and Taluk Level Committees and act on the complaints received, if any, on illegal sand quarrying and take strict remedial measures to rectify the same in a time-bound manner. The District Level Task Force may send its monthly report to the Appellate Forum formed as per G.O. (Ms) No. 27 of Industries Dept. dated 17.02.2015.
- The Appellate Forum shall hear the appeals filed against the orders passed by the District Level Task Force. The Appellate Forum comprises

of the Secretaries to Government from Industries Department, Public Works Department, Revenue Department, Environment and Forests Department, Commissioner of Geology and Mining and an Expert from a reputed Government Institution.

- The Appellate Forum may convene once in 2 months to deliberate on the reports from the District Level Task Force and shall dispose of the appeals made by the petitioners aggrieved with the orders passed by the District Level Task Force.
- Periodical Capacity building and sensitization of PWD officials on the environmental and legal aspects of sand quarrying may be made mandatory. Continuous training and awareness programs shall be scheduled and conducted by IIT/Anna University for the PWD staff to keep themselves aware of the best practices in this field. It may be ensured that the enforcement officials from the Departments of Revenue, Police, Geology and Mining and Transport in the districts where quarries are situated are given adequate training and capacity building on their duties and responsibilities with respect to inspection of sand quarries and sand transporting vehicles at specified time intervals.
- No blasting shall be carried out any point in time.
- It is the obligation of the Public Works Department to run the quarry in an environmentally friendly and ecologically sustainable manner.
- The Hon'ble High Court-appointed Monitoring Committee shall inspect the sand quarries periodically and submit a report to the Hon'ble High Court.

- The PWD should explore/take necessary steps to introduce Mining Surveillance System (MSS) in line with MSS evolved by the Indian Bureau of Mines and Bhaskaracharya Institute for Space Applications and Geo-informatics (BISAG).

III. STEPS TO BE FOLLOWED AFTER EXECUTION:

- A Judicious mine closure plan may be formulated once the quarry is closed after exhaustion of the quantity of sand.
- Reclamation works may be factored into the contract agreement and strict monitoring by the PWD officials may be initiated to scrupulously follow up the mine closure plan.
- It may be ensured that the total quantity of sand permitted in the EC shall not be exceeded in any case.
- After the exhaustion of the quantity of sand, the sheds constructed at the quarry site may be removed. All the roads and pathways may be levelled so that there is no obstruction for the normal flow in the river.
- All the records/registers may be carefully maintained by the PWD for future reference.

Report on
EIA/EMP and modelling studies for the sand mining
clusters in the rivers of Goa

Report on Chapora Estuary

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EXECUTIVE SUMMARY

Chapora Estuary is one of the nine major rivers of Goa flowing from the east (Western Ghats) to the west (Arabian Sea) and is in the northern part of Goa. It is between the latitudes 15° 42' 42.3" and 15° 35' 53.1"N and longitudes 73° 51' 31.5" and 73° 42' 01.3"E. The present study was undertaken to study the following aspects of the Chapora estuary: Hydrodynamic modelling of flow dynamics; Numerical modelling of replenishment and recharge related aspects / issues of clusters - including dynamics of accretion and erosion; Hydrological study of the area under consideration; the diversity and abundance of phytoplankton, zooplankton and benthos in the study area; fish diversity; to evaluate the impact of sand extraction on the riverine ecology and biodiversity and to calculate the biodiversity index of the rivers.

The results of all the above aspects have been incorporated in the chapters of this report as baseline studies. The overall biological results suggest moderate to poor conditions considering the diversity indices. The overall survey also reveals that several parts of the estuary are impacted due to cumulative activities in the region. The lower reaches of the estuary show good growth of mangroves and the mangrove cover has doubled in couple of decades. Many riparian zones in the lower half of the Chapora have shown change in land use wherein paddy fields have been converted into saline marshlands and subsequently this area has proliferation of mangroves. The major reason for this is saline water intrusion due to tidal surges, flooding, and other anthropogenic activities such as sand extraction close to the banks as well as deterioration of embankment. The upper stretches of the river shows bank erosion and breaching of bunds, due to non-maintenance. Hence, the banks are vulnerable and may experience erosion in the future.

Considering the physical baseline parameters, modelling studies have been carried out. The Hydrodynamic Module is the basic computational component of the entire MIKE21 Flow Model FM modelling system. The MIKE 21 Flow Model FM is a modelling system based on a flexible mesh approach providing the hydrodynamic basis for the Sediment transport Module. The modelling system is based on the numerical solution of the two-dimensional shallow water equations i.e., depth-integrated incompressible Reynolds Averaged Navier-Stokes equations. The Sediment transport module calculates the resulting transport of non-cohesive materials based



on the flow conditions found in the hydrodynamic calculations. The model output consists of bed level changes, amongst other parameters. The comparisons of the current speed between Case 1 (present scenario) and Case 2 (scenario after mining) at each section A-G are also included. The comparisons of the bed level changes between Case 1 and Case 2 are presented in the morphology model results.

Following the results, all the anticipated impacts have been delineated along with the mitigation measures. A comprehensive Environmental Conservation & Management plan has been prepared covering all the aspects of sand extraction and its impacts. A monitoring plan also has been formulated to ensure that all the activities fall within the legal framework and the best practices in the industry. Following are the recommendations from the study:

- Considering the results of the baseline, Chapora estuary has been impacted by cumulative anthropogenic activities and natural riverine and coastal processes.
- These effects have changed the geo-morphology and bathymetry at many stretches of the river/estuary. Geomorphologic studies indicate, over the years sand extraction has caused many pits and deep gorges in the lease areas as well as outside the lease areas.
- The lower stretches of the estuary are influenced by higher salinity regime thus the adjacent banks have been protected by traditional embankments. These embankments allow the locals to carry out agriculture- predominantly paddy. These traditional embankments consistently face the problem of saline water intrusion and require continuous repair and maintenance, which has not been carried.
- Salinity intrusion has changed the land use, converting many paddy fields and riparian zones and mudflats into mangrove areas.
- The upper stretches of river banks have experienced bank erosion at many locations and many more areas are vulnerable and are prone to bank erosion.
- Based on the SSMG (2016) & Hon'ble NGT recommendations, certain areas in the stretches of the river have been demarcated where sand extraction from the river bed cannot be carried out. These sites identified as sensitivities include islands, bridges- piers, embankments, eroded and erosion prone banks, ecological sensitive areas viz; mangroves.



- In the Chapora estuary the bed level changes for the post-mining scenario are mostly around -0.15 m to 0.15 m. The changes in bed morphology in the post-mining scenario at different sections of the river are highly dynamic and patchy in nature.
- The difference between the pre- and post-monsoon seismic data did not show major significant changes in the depth across the Chapora river except in few regions where the local depositions are seen with a maximum depth difference of ~0.3-0.4 m. In few regions localized changes in the river bed morphology and spatial adjustment of sand bar are observed.
- No sand is available in upper stretches of the Chapora estuaries, which is non saline region of the estuary. While majority of sand deposits are in the salinity influenced areas.
- The stretches, which have low sensitivities, can be considered for sand extraction while following the national statutory and legal guidelines. While recommending the lease areas, the authority shall conduct a reconnaissance site survey and a consultative discussion with the stakeholders and accordingly work out areas that do not have conflict of interest.
- Once the lease areas are issued, the delineated “Environmental Conservation and Management Plan” needs implementation. The plan also describes the team/committee, which should be capable to address, execute and monitor all the aspects of the plan. Furthermore, the team/committee should appoint sub-teams, SHG’s, Village committees on requirement basis as per the plan.



CHAPTER 1- INTRODUCTION

1.1. Sand Mining Scenario in the State of Goa

Sand is available in three forms in the State of Goa. They are ordinary sand, silica sand and beach sand. Ordinary sand is brought by the river originating in general from Western Ghats and flows west and joins Arabian Sea. The process of weathering helps deposition of sand. Sand is collected mainly from the river Mandovi, Zuari, Terekhol Chapora and its tributaries. On upstream the sand is collected manually, screened and supplied directly. Where the water column is more the sand extraction is done with the help of canoes and bucket attached to bamboos. Sand is used in making concrete in construction activity.

The extraction of Sand is a traditional activity being carried out in Goa prior to Portuguese regime. The extraction was manually carried out and there are communities who are dependent on sand extraction for livelihood. Post Portuguese regime Goa, Daman and Diu Minor Minerals Extraction and Removal Rules, 1974 were in force and thereafter the Goa Minor Mineral Concession Rules, 1985 were notified. In the year 1979 various references are available in the Form of Application from traditional extractors, letters from cart owners, village Panchayat of Camurlim.

The extraction of sand from the rivers beds in Goa is governed by the Goa Minor Mineral Concession Rules, 1985 and permission were being granted on yearly basis. However after the CRZ Notification dated 6th January 2011, no permission for sand extraction was granted after 2011-2012 onwards as it was declared a non-permissible activity in CRZ. Subsequently some States including Karnataka requested to Ministry of Environment & Forests, Government of India for permission for removal of sand bars naturally formed in rivers by manual methods by traditional communities and an Office Memorandum dated 08/11/2011 of the Dy. Director, Ministry of Environment and Forest was issued which carved out an exception to the CRZ notification. In order to facilitate the grant of sand permits in Goa the State Government has constituted two District Committees under the Chairmanship of the respective District Collectors to deal with the grant of permit for extraction of sand. The said committees are notified in the Official Gazette Series II no. 37 dated 13th December, 2012. Based on studies conducted by the Committees certain zones/stretched were identified in Terekhol, Chapora, Mandovi, in North



Goa and Dudhsagar, Ragada, Kushavati, Ugvem, Zuari and Sal River in South Goa wherein manual extraction by traditional communities could be permitted. Prior Environment Clearance was obtained by the respective District Collectors vide 3-181-2010/STA-DIR/159 dated 01/10/2015, 3-181-2010/STA-DIR/158 dated 01/10/2015 and 3-181-2010/STA-DIR/184 dated 14/12/2015 from the Goa State Environment Impact Assessment Authority.. As per letter no. 39/8/13-MAG/DC-Sand-Ext-NG/9486 dated 04/12/2015 received from District Magistrate, North Goa it was formed that in its meeting held on 02/12/2015 it was unanimously decided that Directorate of Mines & Geology can issue the permission/permits for extraction of sand by local communities by traditional method. Similar decision was recorded in the meeting held on 11/12/2015 by District Magistrate, South Goa. 458 Sand permits were issued by the Directorate starting 2015 onwards For the year 2017-18, 333 permits were renewed for the period 1M October 2017 to 31st May 2018. As per one of the condition in the EC, Sand Extraction is banned from 1st June to 30th September due to monsoon, the sand permit holders for the year 2017-18 are being assessed for payment of royalty and non-filling of monthly returns which is a violation of Goa MMCR. Recovery is being carried and penalties imposed as per rules. On 3rd May 2018 a PIL Writ petition (14 of 2018) was filed in Hon'ble High Court of Bombay at Goa by Federation of Rainbow Warriors regarding Sand Extraction in Goa. Subsequently as per High Court Order dated 3rd October 2018 the learned Advocate General submitted that the State is in the process of examining various conditions and permits will be renewed/ granted after consideration of the same. However as per para 9 of the High Court Order dated 23rd October 2018 the Hon'ble Court has not passed any restraint order against issuance of permits. Further affidavit was filed by the State Environment Impact Assessment Authority (SEIAA) on 31/10/2018, wherein at para no. 4 of the Hon'ble High Court's order various lacunae's are pointed out and has made further observation. Subsequently a note is forwarded to the office of the Learned Advocate General for seeking extension of the time cited in the order of Hon'ble High Court dated 31 October 2018 for the State Government to take a decision on renewal of sand permits as well as seeking modification of the order as approved by the State Government. A MCA application is filled before Hon'ble High Court seeking a time frame of 8 weeks as Directorate of Environment is in process of finalizing the studies to be conducted as required under Sustainable Sand Mining management Guidelines 2016 and MOEFF notification no So. 141(E) and Directorate of Mines and Geology are working out modalities such stacking point of sand, installation of weigh bridges, etc.



Subsequently, In Order dated 4th April 2019, Eight weeks were granted to State Government to decide on renewal of sand permits. Directorate of Environment has decided to incorporate Environment Management Plan for individual cluster in order to capture all possible externalities before renewal of the permits. A proposal for Environmental Management plan is sent for cabinet approval. Hon'ble High Court gave its Judgment in PIL WP No. 14 of 2018 on 18th December 2019. The studies as far as sustainable sand mining as per guidelines of 2016 and MOEF Notification, the Environment Department accorded the work to NIO, Dona Paula. This report presents the EIA/EMP and modelling studies for the sand mining cluster in the Chapora estuary.

1.2 Chapora Estuary

Chapora Estuary is part of the nine major rivers flowing from the east (Western Ghats) to the west (Arabian Sea) in the north of Goa. It is located between the latitudes ($15^{\circ} 42' 42.3''$ and $15^{\circ} 35' 53.1''$ N) and longitudes ($73^{\circ} 51' 31.5''$ and $73^{\circ} 42' 01.3''$ E). The river originates from Sahyadri Mountains in Chandgad Taluka of Kolhapur District, Maharashtra, is known as Tilari River in the up-streams, and enters into Goa where it is popularly known as Chapora. The total flowing distance of the river is 32 km in the State of Goa. The total basin area of the Chapora Estuary is 255 Sq. km and average runoff of 588. 4 MCM (Million cubic meters). Sal, Kalana Virnoda and Parshe are the tributaries of the Chapora Estuary. The NGT / CPCB have declared this stretch of the river between Alorna Fort (Pernem Taluka) and Morjim as a polluted stretch.

Monitoring by GSPCB is carried out on a monthly basis throughout the year under National Water quality Monitoring Programme (NWMP) conducted by Central Pollution Control Board Programme. This stretch of the River Chapora between Morjim and Alorna fort (Pernem Taluka) is classified as SW II (for bathing, water sports and commercial fishing). Central Pollution Control Board (CPCB) has classified Chapora Estuary (Stretch from Morjim to Pernem 32 km) under Priority V, having BOD level range between 3.5 -5.2 mg/lit.

The saline stretch of the river is about 32 km in the State of Goa. Along the 32 km saline stretch of Chapora Estuary, Mangroves are observed in 90 hectares (2001) as per the NIO study of 2013 and the EIA study of NIO of 2018 mangrove forest observed in area of 220 hectares (2018) which indicates that the mangrove forest have doubled in the period of 20 years with the highest density at Camurlim and Tuem villages. Thus the overall forest cover shows increase but with the

replacement of terrestrial vegetation by mangrove forest (wherein the areas might be different). It was also observed during the physical survey that there are extensive coconut orchards /plantation along both the bank of the River.

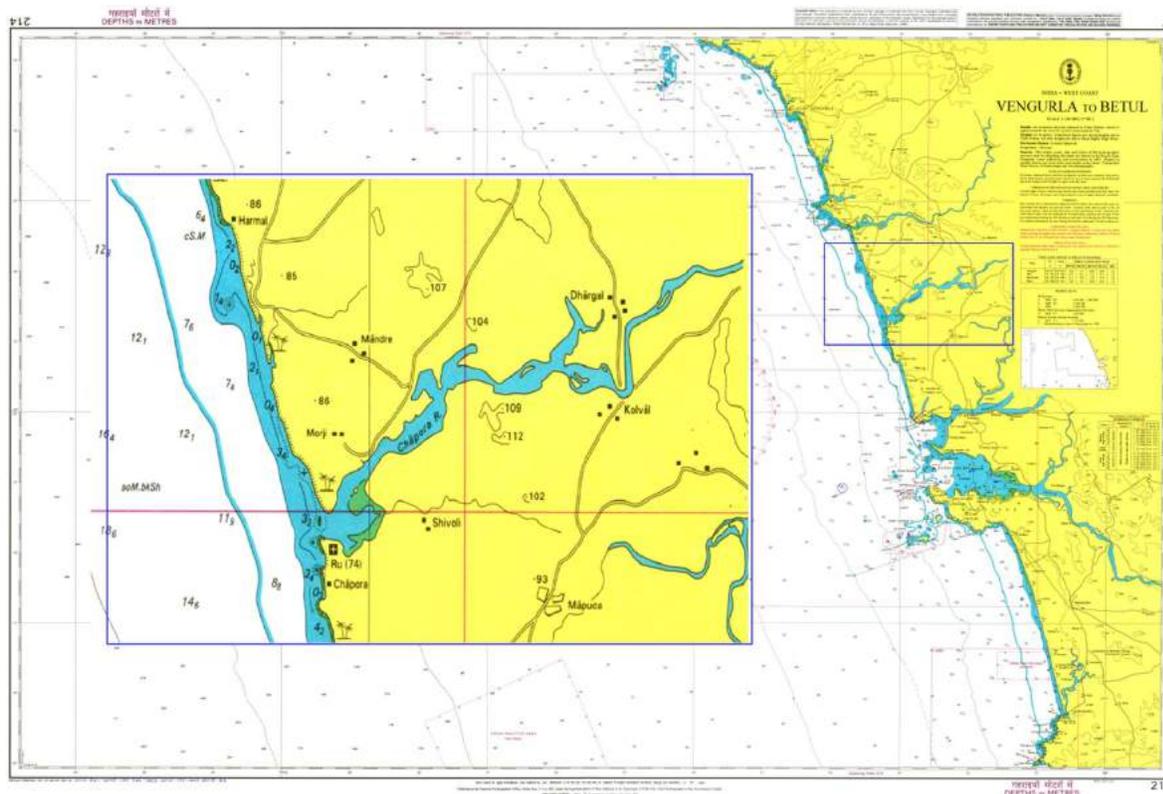


Figure 1.1 Hydrographic Map of Goa. Insight zoom area of Chapora Estuary



CHAPTER 2-METHODOLOGY:

2.1 Measurements of Physical Parameters

Currents: Current measurement was carried out at location CR1 (15°38'58.3" N; 73°50'05.4" E) near Colvale at Chapora Estuary during February-March, 2020 and September-October, 2020. The water depths at the measuring point were 8.5m and 9m at the time of pre-monsoon and monsoon deployment respectively. The Current meter was placed at mid-water depth.

Water level: Water levels were measured at three different locations. Water level was measured near Colvale (15°38'58.3" N; 73°50'05.4" E) (CR1) at Chapora Estuary during February-March, 2020. Water levels were measured at Colvale bridge (15°38'57"N; 73°50'11"E) (CR2) during March-April, September-October, 2020 and (15°36'31"N; 73°44'19"E) (CR3) Chapora jetty at Chapora Estuary for a month during March-April, 2020. Also, water level was measured at a location near Dumacem (15°41'22.9"N 73°54'46.6"E) during September-October, 2020.

River Discharge: The data obtained from secondary sources (Department of Water Resources, Government of Goa and Lina et al. (2018)).

Rainfall: Pernem is the nearest IMD observatory to the Chapora Estuary. Pernem rainfall station data is obtained from IMD. The average annual rainfall (2010-2019) over Pernem, North Goa, is about 3546 mm. The maximum precipitation occurs within June to September.

2.2 Sampling locations for water and sediment

Chapora Estuary was sampled in March 2020 (Figure 2.1). Total 15 locations were selected. Water and sediments were collected from central and peripheral region using standard instruments. Depth was approximately 8m at the central region. In this estuary, sandy silt was observed at central region and silty clay at the periphery of the region. Sampling stations were coded as CH A at the centre and CH B and C at the periphery (Table 2.1).

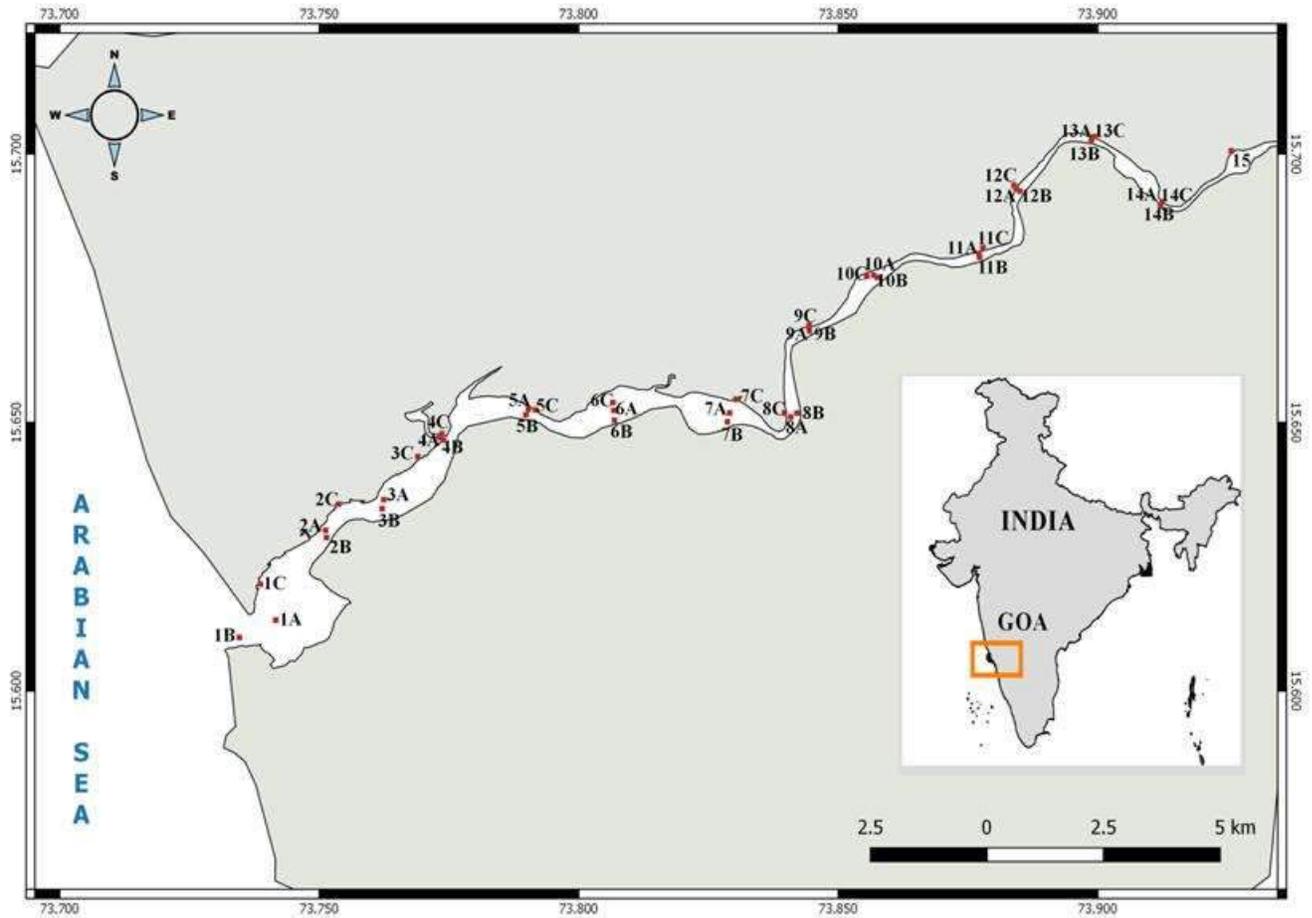


Figure 2.1: Map showing sampling stations of Chapora Estuary



Sampling station	Location		Depth (m)	Sediment texture
	Latitude (°N)	Longitude (°E)		
CH 01 A	15.60945	73.73512	6	Sand
CH 01 B	15.61268	73.74213	2	Sandy silt
CH 01 C	15.6194	73.73918	2	Silty sand
CH 02 A	15.62941	73.75174	4	Sandy
CH 02 B	15.62809	73.75191	2	Sandy
CH 02 C	15.63428	73.75425	2	Silty clay
CH 03 A	15.63541	73.76296	3	Silty sand
CH 03 B	15.63344	73.76263	0	Sandy silt
CH 03 C	15.64313	73.76951	0	Sandy silt
CH 04 A	15.64623	73.77446	8	Silty sand
CH 04 B	15.64741	73.77415	0	Silty clay
CH 04 C	15.64672	73.77374	0	Silty clay
CH 05 A	15.65193	73.79079	7	Sandy
CH 05 B	15.65089	73.79034	5	Sand
CH 05 C	15.65185	73.79217	0.5	Silt
CH 06 A	15.65176	73.8073	3	Sandy silt
CH 06 B	15.64941	73.8074	0.5	Clay
CH 06 C	15.65324	73.80711	1	Silt
CH 07 A	15.65128	73.82957	2	Clay silt
CH 07 B	15.64964	73.82914	0.5	Clay
CH 07 C	15.65382	73.83078	1	Clay
CH 08 A	15.65051	73.84137	4	Clay silt
CH 08 B	15.65125	73.84258	1.5	Clay
CH 08 C	15.65131	73.84017	6	Sandy



CH 09 A	15.66716	73.84493	8	Courser sand
CH 09 B	15.66655	73.84494	6	Clay silt
CH 09 C	15.66759	73.84491	6	Silty clay
CH 10 A	15.67693	73.85734	4	Sandy
CH 10 B	15.67673	73.85601	0	Silty
CH 10 C	15.6765	73.85805	0	Clayey silt
CH 11 A	15.68096	73.87763	6.5	Silty sand
CH 11 B	15.68206	73.87842	0	Silty clayey
CH 11 C	15.68028	73.87776	0	Silty clay
CH 12 A	15.69309	73.88482	8	Silty
CH 12 B	15.69369	73.88438	0	Silty clay
CH 12 C	15.6926	73.8855	0	Silty
CH 13 A	15.7025	73.89944	2.5	Gravel & pebbles
CH 13 B	15.70273	73.89989	3	Silty clay
CH 13 C	15.70273	73.89925	2	Silty clay
CH 14 A	15.67632	73.91286	2	Pebbles
CH 14 B	15.68989	73.91293	2	Silty clay
CH 14 C	15.69058	73.91263	2	Gravel sand
CH 15 A	15.70009	73.92625	1	Gravel & pebbles

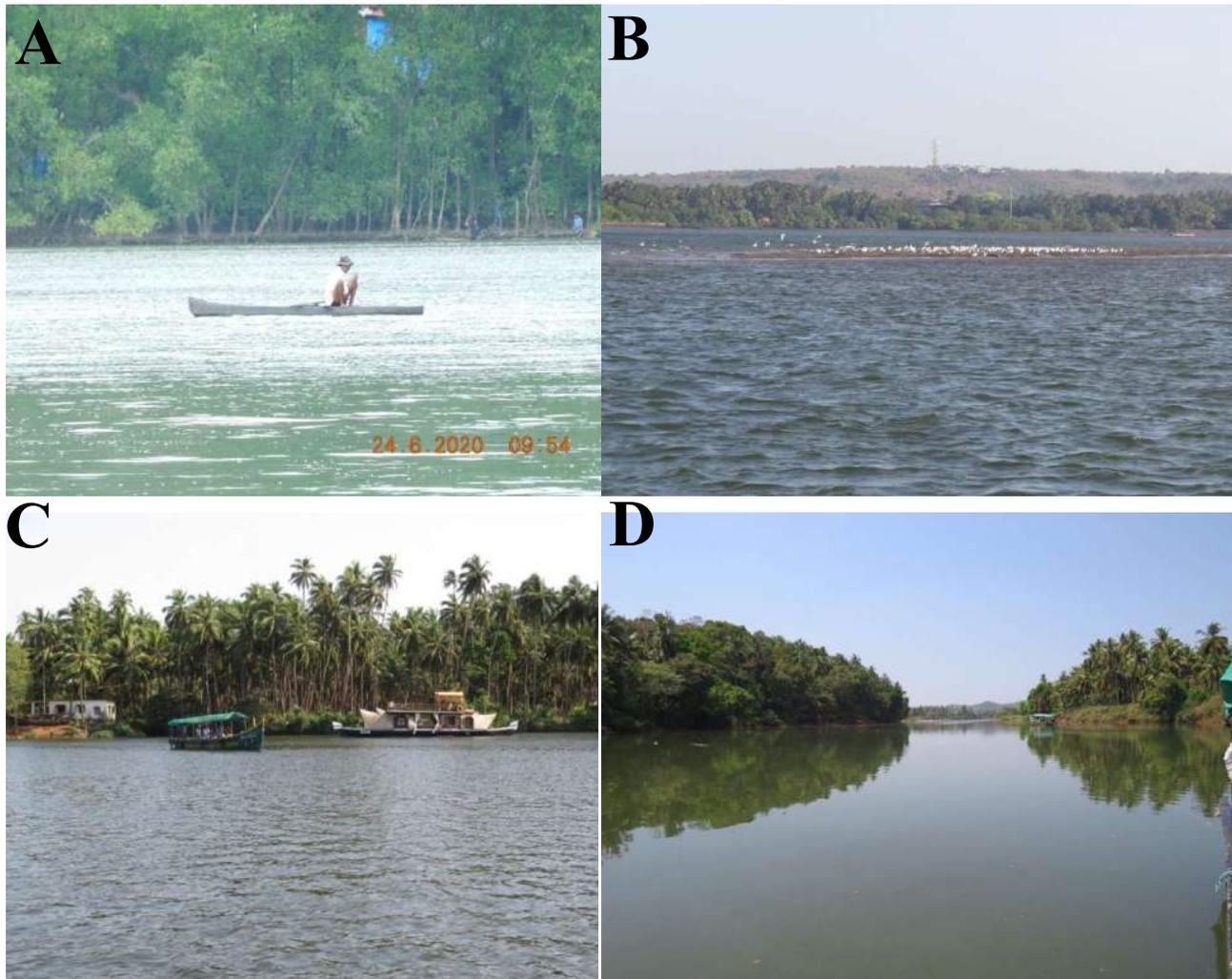


Plate 1: Study area - Chapora Estuary (A- Artisanal fishing in Chapora estuary; B- Mouth region showing exposed sand flat in the estuary; C- Tourism activity in middle stretches of the estuary; D- Upstream region of the estuary.)



CHAPTER 3- PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS:

All sampling sites were sampled using trawler/boat/dinghy. Both biological and hydrological parameters were collected and processed following standard protocol. Hydrological parameters were addressed using standard sensors mounted onto a CTD. Sampling and processing procedure of biological parameters is briefly mentioned below (Figure 3.1).

3.1 Phytoplankton:

Sub-samples of water collected from different depths using Niskin sampler (1L) were fixed with 2% Lugol's iodine and preserved in 3% formaldehyde solution and stored in dark at room temperature until analysis. These samples were concentrated to 20ml using a siphoning tube (fitted with 10micron mesh). After settling and siphoning procedure, 1 ml of concentrated sample were taken in a Sedgwick-Rafter counting cell for enumeration and identification of phytoplankton to the genus/species level. The total number of phytoplankton cells present in a litre of water sample was calculated using appropriate formula.

The data for the phytoplankton analyzed using MS-Excel package. Excel is used for density and correction based on graphical representation. Attempts were made to estimate the natural variability of phytoplankton especially that of diatoms and dinoflagellates, in surface and bottom water.

3.2 Chlorophyll & Phaeophytin:

A known volume of water sample (1L) were used to measure the concentration of chl-a, and phaeophytin. Samples were filtered through Whatman GF/F (nominal pore size 0.7 μ m) under low vacuum. The chlorophyll pigments were extracted for 24 hours in 10ml of 90% acetone in the dark in a refrigerator. Samples were brought to room temperature and measured using a fluorometer.

3.3 Zooplankton:

Meso-zooplankton were collected with Heron Tranter Net (HT net) having mouth area 0.25 m² and mesh size 200 μ m towed horizontally just below the surface for a duration of ~1.5 knots. The



net were fitted with a calibrated flow meter to quantify the volume of water filtered. Zooplankton biomass was measured volumetrically after removing large detritus following which samples were preserved in 4% formaldehyde. In the laboratory, zooplankton samples were divided according to their density by using a Folsom splitter obtaining representative sub-sample containing not less than 300 individuals. The density of individuals were enumerated and identified (species/genus level) with the help of literature.

3.4 Meibenthos:

Sediment samples were collected from 45 sampling stations from Chapora Estuary. Sampling was carried out on a mechanized boat in March 2020 using an acrylic core of 4.5 cm in diameter. The sampling stations were represented as CHA, CHB, and CHC respectively. CHA stations were located at the centre of the river where there is extraction of sand and CHB and CHC at the periphery of the river where there are mangroves and other sensitive areas. Among all stations, 39 stations with duplicate sample had taken but in six samples (CH13A, CH14A, CH14C, CH15A, CH15B, and CH15C) were not collected due to hard substratum. All samples were preserved in 10% formalin mixed with rose-Bengal formalin solution and stored in polythene bags.

3.5 Foraminifera:

The top 2 cm of the sediments were scrapped from the river bed for foraminiferal studies. Half the sediment was immediately stained with ethanol rose-Bengal solution (2 g rose-Bengal in 1 L of 70% ethanol) to preserve living benthic foraminifera. Other half was stored in plastic containers. The stained sediments were processed for picking foraminifera. The volume of the sediment was measured and the wet sediments were poured on a 63 μm size sieve. The sediments were gently washed and the material retained on the sieve (>63 μm , coarse fraction or sand) was dried and stored in plastic containers. An appropriate aliquot of the coarse fraction was taken after coning and quartering. As the foraminiferal abundance was very low, a maximum of 1.5 g of the coarse fraction was taken to pick foraminifera. The coarse fraction taken for picking was weighed and all intact living and dead benthic foraminifera were picked.

3.6 Macro benthos:

A total of 45 stations were sampled for benthic study. The sampling stations were represented as CHA, CHB and CHC respectively. Sampling was carried out on a mechanised boat in March 2020



using a Van veen grab (0.0418m²) for the central stations and metal Quadrant (0.0625 m²) at the periphery of the river. All the sediment samples were washed through a 300µm nylon mesh in the field and then transferred to polythene bags and preserved in 10% formaldehyde containing Rose Bengal stain. CHA stations were located at the centre of the river where there is extraction of sand and CHB and CHC at the periphery of the river where there are mangroves and other sensitive areas. However, sediment samples were recovered only from 38 locations. Sediment could not be retrieved from station CH3A, CH5C, CH13A, CH14A and station CH15 due to hard/rocky substratum. The sand texture at central region was observed mainly sandy whereas as at the periphery it was more silty clayey. Details of the sampling locations are provided (Table 2.1).

Laboratory analysis:

In the laboratory, all samples of meiobenthos were sieved thoroughly on 0.3 mm to remove large fauna (macrofauna) and then 0.04 mm sized mesh sieve for smaller fauna (meiofauna). The fauna retained on 0.04 mm mesh were considered as meiofauna which was collected in beaker and preserved in 5% buffered formalin. The fauna was enumerated and identified up to the group level under the stereo-zoom microscope (Leica) using the guide Introduction to study of meiofauna (Robert P. Higgins et.al, 1988).

In the laboratory, all the sediment samples of macrobenthos were again washed on a 300µm sieve. All the fauna were sorted and preserved in plastic vials containing 5% formaldehyde. The fauna was enumerated and identified up to the family/genus level under the stereo microscope (Olympus SZX10). Faunal abundance was calculated as individual No/ m². Polychaetes were identified to the highest taxonomic level using available identification keys (Fauvel, 1953; Fauchald, 1977; Day, 1967; <http://www.marinespecies.org/>). Abundance of other fauna such as Oligochaeta, Crustacean, Bivalvia, Gastropoda, Ophiuroidea, Platyhelminthes, Nemertea, Sipuncula, Nematoda, Hydroides, Phoronida, Chaetognatha, Fish juveniles were recorded group-wise. Station wise biomass (Wet weight) was done and expressed as g/m².



Figure 3.1: Sample collection of Chapora Estuary

3.7 Diversity indices:

All the raw data was initially processed using Microsoft Excel. Further processing of the ecological data was done using the PRIMER (Plymouth Routine in Multivariate Ecological Research) software package (Clarke and Warwick, 1994) after square root transformation. The univariate as measures such as number of individuals or specimens (N), number of species (S), total abundance (A), Shannon- Wiener diversity index (H'), Margalef species richness (d), Pielou's evenness (J') and Simpson index ($1-\lambda'$) were calculated using log₂ scale at each station (Clarke & Gorley, 2001).

2.10 Biotic indices:

Biotic indices are developed based on indicator species, used as a guide to the level of a particular abiotic factor. For example, the presence of certain invertebrate groups in aquatic ecosystem can be awarded a score that indicates the quality of the water. Such indices like the AZTI Marine Biotic Index (AMBI), Multivariate AMBI (M-AMBI), Bentix index are specialized case of a diversity



index generally considered an important means for assessment of water-pollution, and ecosystem stability.

3.7.1 AMBI index:

The AZTI Marine Biotic Index (AMBI) is software developed by AZTI-Tecnalia for assessing the quality of benthic macro-invertebrates assemblages by calculating the homonymous index. It was developed in order to establish the ecological quality of European coasts and estuaries. This index explores the response of soft-bottom communities to natural and man-induced changes in water quality, integrating long-term environmental conditions. AZTI Marine Biotic Index (AMBI) relies on the calculation of the biotic coefficient (BC), which is based in turn on the proportion of disturbance-sensitive taxa and is expressed on a continuous scale ranging from 0 (best status) to 6 (worst status). The AMBI approach follows a model (Glémarec & Hily, 1981; Grall & Glémarec, 1997) which categorises benthic invertebrates into five ecological groups (EGs), depending on their dominance along a gradient of organic enrichment and oxygen depletion. The software includes near 8.000 taxa from all seas, representative of the most important soft-bottom communities presents at estuarine and coastal systems, from the North Sea to the Mediterranean, North and South America, Asia, etc.

3.7.2 M-AMBI index:

M-AMBI ('Multivariate AMBI', Bald et al., 2005; Muxika et al., 2007) is a multimetric index for assessing the ecological quality status of marine and transitional waters. It is based on benthic macro invertebrates and integrates AMBI, a biotic index based on species sensitivity/tolerance, with diversity and richness, making it compliant with the European Water Framework Directive. It adopts a multivariate (trivariate) approach, integrating the response of three selected metrics, i.e. species richness, the Shannon diversity index (Shannon & Weaver, 1949) and the biotic index AMBI (Borja et al., 2000). The success of AMBI paved the way for the introduction of M-AMBI, which was subsequently incorporated into the regulations of several European countries. The M-AMBI algorithm integrates the metrics by means of factor analysis (FA).

3.7.3 BENTIX index:

The Bentix index (Simboura and Zenetos, 2002) is a marine biotic index based on the concept of indicator species and was developed for the purpose of the ecological status classification of the

marine environment using the macro invertebrates quality element. The index is designed for the assessment of the impact caused by general stress factors and does not discriminate among natural and anthropogenic disturbance. It has been tested successfully in a variety of Hellenic benthic ecosystems (Simboura and Zenetos, 2002) and in case areas subject to organic pollution such as the Athens or Saronikos gulf (Simboura et al., 2005), to oil spills accidents (Zenetos et al., 2004) and is currently tested in other Mediterranean areas within the framework of the EU Water Framework Directive intercalibration exercise (EC, 2003).

3.7.4 AMBI and M-AMBI index:

AMBI relies on the abundance-weighted average disturbance sensitivity of the macrobenthic species in a sample (Borja et al., 2000). Each species were distributed in five ecological groups (EG) as per their sensitivity to an increasing stress gradient as summarized by AZTI's classification (Grall and Glémarec 1997).

EG I: species sensitive to organic enrichment and present only under unpolluted conditions.

EG II: species indifferent to enrichment, present in low densities with non-significant variations.

EG III: species tolerant to high organic matter enrichment.

EG IV: second-order opportunistic species.

EG V: first-order opportunistic species, able to withstand high disturbance.

The index calculation was done by the software provided at AZTI's software, following the guidelines of Borja and Muxika (2005). The index generates a final score on a continuous scale from 1 to 6 (7 in azoic sediments) and the thresholds used to define benthic community health were <1.2 (undisturbed), 1.2–3.3 (slightly disturbed), 3.3–5 (moderately disturbed), 5–6 (heavily disturbed) and >6 (extremely disturbed) (Borja et al., 2000) which were then condensed to a high, good, moderate, poor and bad status respectively. The multivariate AMBI (M-AMBI) combines with AMBI values in a factor analysis multivariate approach (Table 2).



3.7.8 BENTIX Index (Simboura and Zenetos 2002):

BENTIX considers sensitive (GS) and tolerant (GT) taxa based on the reduction of five EG's (as per AMBI) to two EG's, i.e. EG-I, II as EG-I and EG-III,-IV,-V as EG-II for BENTIX. For BENTIX computation, a newly developed add-in BENTIX v.09 (beta version) software package was used.

	AMBI	M-AMBI
High	0.0-1.2	>0.77
Good	1.2-3.3	0.53-0.77
Moderate	3.3-5.0	0.35-0.53
Poor	5.0-6.0	0.20-0.38
Bad	6.0-7.0	<0.2

4. LULC map:

LISS IV data was used for the purpose of classification of Land use Land Cover for the study area. The LISS-4 (Linear Imaging Self-Scanning Sensor-4) multispectral high-resolution camera is the prime instrument of Resourcesat satellite series, with a spatial resolution of 5.8 m and a swath of 70 km.

The study area comprised of the sub scene (A) of path and row 96 and 62 respectively of the LISS IV data. The Red (Band 2, 0.62-0.68), Green (Band 3, 0.52-0.59) and Infrared Red (Band 4, 0.77-0.86) bands were used to prepare the false colour composite for the area.

The land use and land cover for an area of 500 meters around the Chapora Estuary was extracted from the imagery with the help of object oriented classification of the data where a group of pixels were identified as features with the help of factors such as Shape, Texture, Tone, and spatial relation between the surrounding pixels. All the LULC maps of Chapora Estuary were prepared by using ArcGIS.



CHAPTER 4: RESULT:

4.1 Physico-chemical parameters

Total 14 stations were sampled in Chapora Estuary. Salinity varied from 0.2 to 28.8psu. It showed high at station CH3A (28.8psu) and CH4A (28.3). pH range varies from 7.2 to 7.9. Total suspended matter (TSM) showed high at two stations i.e CH3A (16.3mg/L) and CH4A (16.3mg/L) and low at CH12A (4.3mg/L). Total dissolved solid (TDS) was high at CH3A (21.29ppt) and low at CH10A (4.6ppt) respectively (Table 4.1). TSM and TDS showed similar trend from station CH1A to CH14A (Figure 4.1).

Stations	Salinity (psu)	pH	TSM (mg/L)	TDS (ppt)
CH1A	24.5	7.9	12.1	18.8
CH2A	23.9	7.8	12.4	18.35
CH3A	28.8	7.9	16.3	21.29
CH4A	28.3	7.9	16.3	19.8
CH5A	17.5	7.7	9.9	13.88
CH6A	15.1	7.6	8.3	12.1
CH7A	14.2	7.6	7.9	11.76
CH8A	13.0	7.6	6.7	10.18
CH9A	11.2	7.4	7.1	9.03
CH10A	5.6	7.2	5.2	4.6
CH11A	3.4	7.2	4.9	3.09
CH12A	2.0	7.2	4.3	1.91
CH13A	1.8	7.3	5.0	1.63
CH14A	0.2	7.2	9.5	10

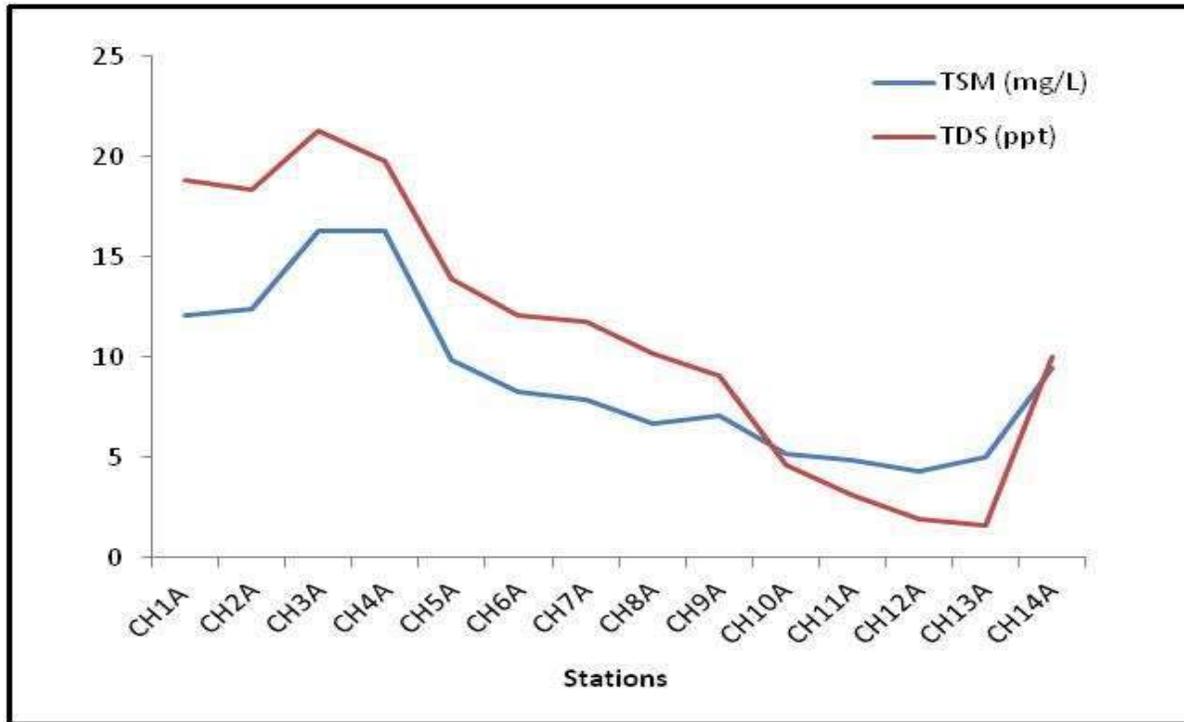


Figure 4.1: Graph depicting TSM and TDS of Chapora Estuary

4.2 Temperature and Salinity

The average depth of the Chapora Estuary was found to vary between 2 and 10m (avg. 5m). River being influenced by the tidal currents, hydrographic variations are thus known to vary accordingly, controlling the temperature and salinity variation, the high temperature during high water level. In general, salinity variations were much larger (0.7-32 PSU) than that of temperature (27.0°C- 29.5°C) (Figure 4.2). Though high saline was generally restricted to Zone-1 (st C1-C5), particularly below 2m water depth, influences of saltwater were found to penetrate even up to the station (C14; ~ 28kms inside). Beyond which river is mainly dominated by freshwater. This hydrographic feature characteristically divides the river into three zones, region under the influence of seawater (Zone 1; stn C1-C5), transitional zone (Zone 2; C6-C8/C9) and region influenced by the freshwater (Zone3; C10-C15)(Figure 4.2)

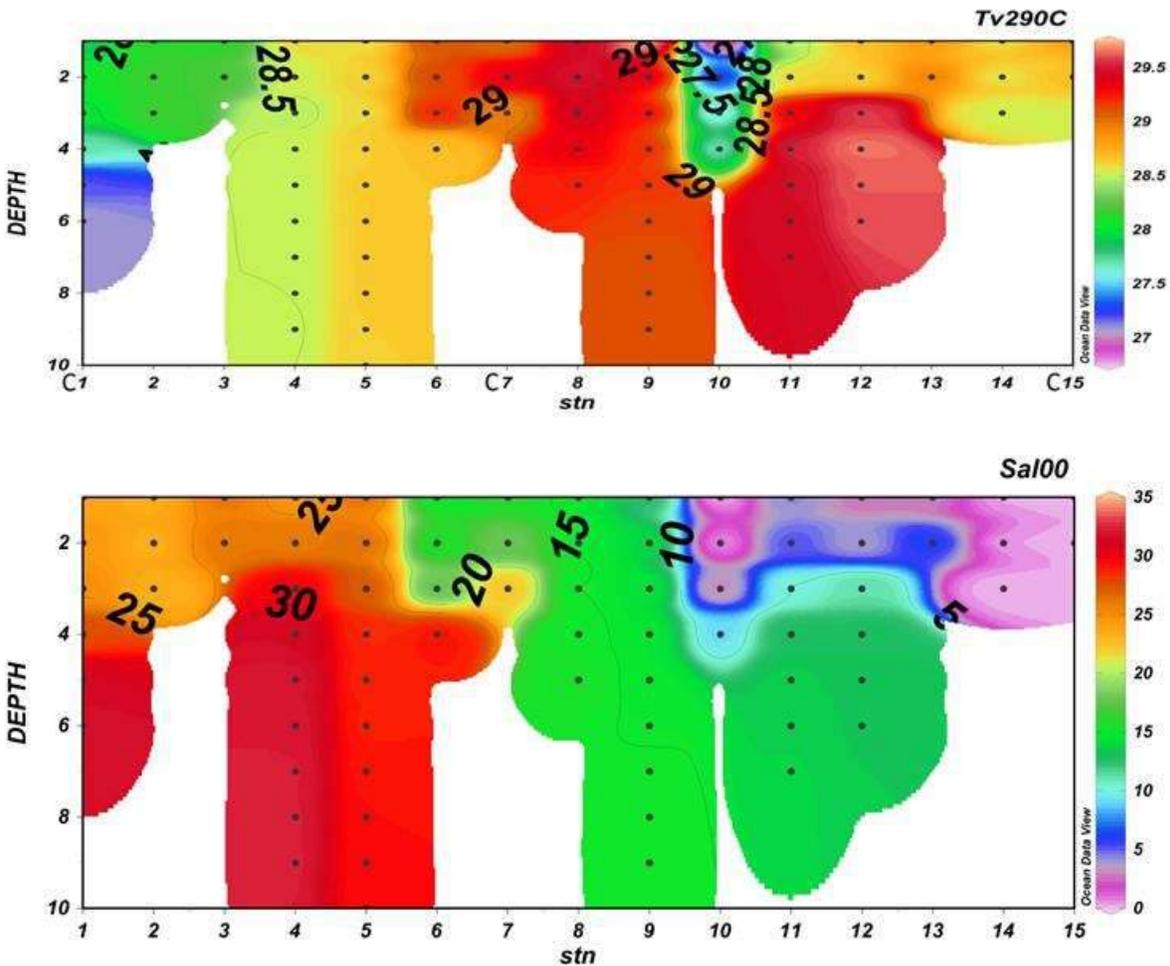


Figure 4.2: Spatial variations in (a) temperature ($^{\circ}\text{C}$), b salinity (psu) in the Chapora Estuary.(C1-river mouth and C15-upstream region)

4.3 Dissolved Oxygen:

The study region to be well oxygenated (2.2-6.6 ml/L). However, spatially dissolved oxygen (DO, ml/L) (and nutrients, see below) found to decrease from mouth to the upstream region, especially at the subsurface, while DO showed an opposite, increasing trend at the surface (Fig.3). Low concentration ($\sim 2\text{ml/L}$) observed at stn C12 has significant implications for nitrogen and carbon mediated by microbial processes (Fig. 4.3).

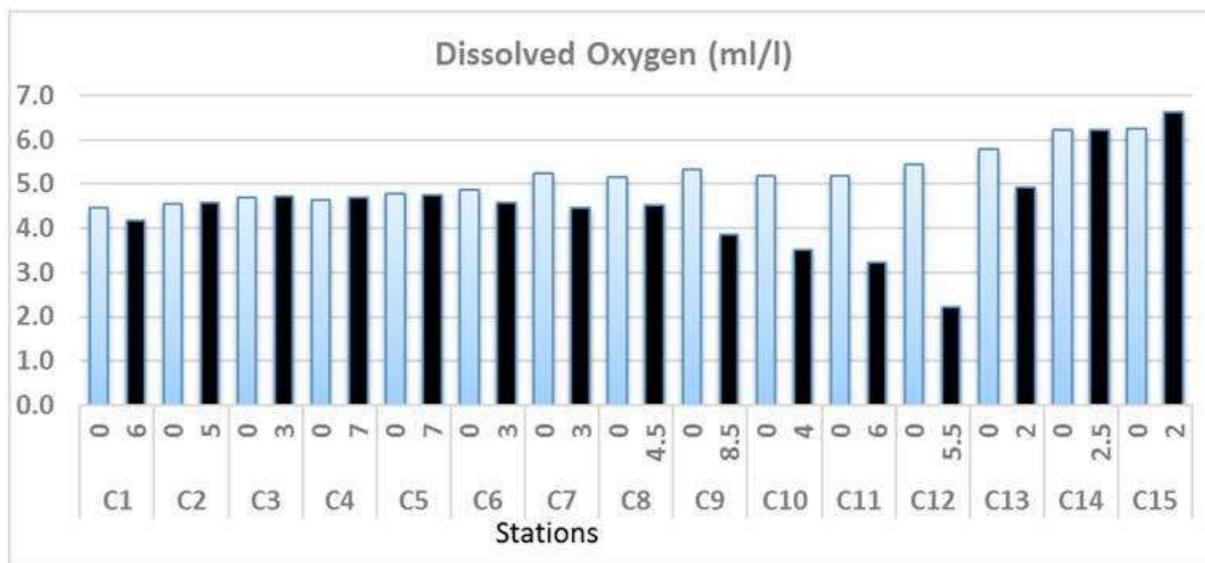


Figure 4.3: Spatial variations (surface and bottom) in dissolved oxygen in the Chapora Estuary.(C1-river mouth and C15-upstream region)

4.4 Nutrient concentration:

Phytoplankton needs nutrients to grow. They are like the fertilizers we add to land plants that are used to make proteins, nucleic acids, and other cell parts by the phytoplankton to survive and reproduce. The two most critical nutrients are nitrogen and phosphorous. In most cases, nitrogen runs out first, and the growth of phytoplankton stops.

Nutrient concentration in the Chapora Estuary estuary varied considerably from the mouth region to the upstream region. Nitrate (NO_3^-) was found to be very low ($0.03\text{-}0.5\mu\text{M}$) from mouth to mid-stream region and increased substantially further upstream to be the highest (Stn C15: $5.8\mu\text{M}$). Similarly, nitrite (NO_2^-) was very low ($0.02\text{-}0.23\mu\text{M}$) between the mouth and mid-stream region. But it attained maxima ($1.97\text{-}2.81\mu\text{M}$) just after stn C10 and then decreased further to $0.07\mu\text{M}$ near stn, C15. Contrary, phosphate (PO_4^{3-}) showed the opposite trend to nitrate. Highest PO_4^{3-} ($0.9\mu\text{M}$) was observed at the mouth region, which progressively decreased to $0.26\mu\text{M}$ in the mid-stream region and further to $0.06\mu\text{M}$ in the upstream region. Silicate (SiO_4^{4-}) showed a similar trend to NO_3^- . It increased from $27\mu\text{M}$ at the mouth region to $76\mu\text{M}$ in the mid-stream region and further to $112\mu\text{M}$ in the upstream region.

Rivers receive nutrients through run-off from terrestrial sources (agriculture fields, sewage discharge from human settlements), and benthic sources (underlying sediments). The above

nutrient concentrations and their trends are typically observed in the Goan rivers during the premonsoon season (February-May). Any massive resuspension of bottom sediments would significantly increase PO_4^{3-} and SiO_4^{4-} concentrations in the water column since sediment porewaters are extremely rich in these two nutrients. Consequently, it would distort the concentration gradient across the riverine length. But our observation neither showed any abnormally high concentration, not any irregular trend. Overall, all nutrients showed the expected levels and trends in the river well oxygenated (2.2-6.6 ml/L). However, spatially dissolved oxygen (DO, ml/L) (and nutrients, see below) found to decrease from mouth to the upstream region, especially at the subsurface, while DO showed an opposite, increasing trend at the surface (Figure 4.4). Low concentration (~ 2 ml/L) observed at stn C12 has significant implications for nitrogen and carbon mediated by microbial processes.

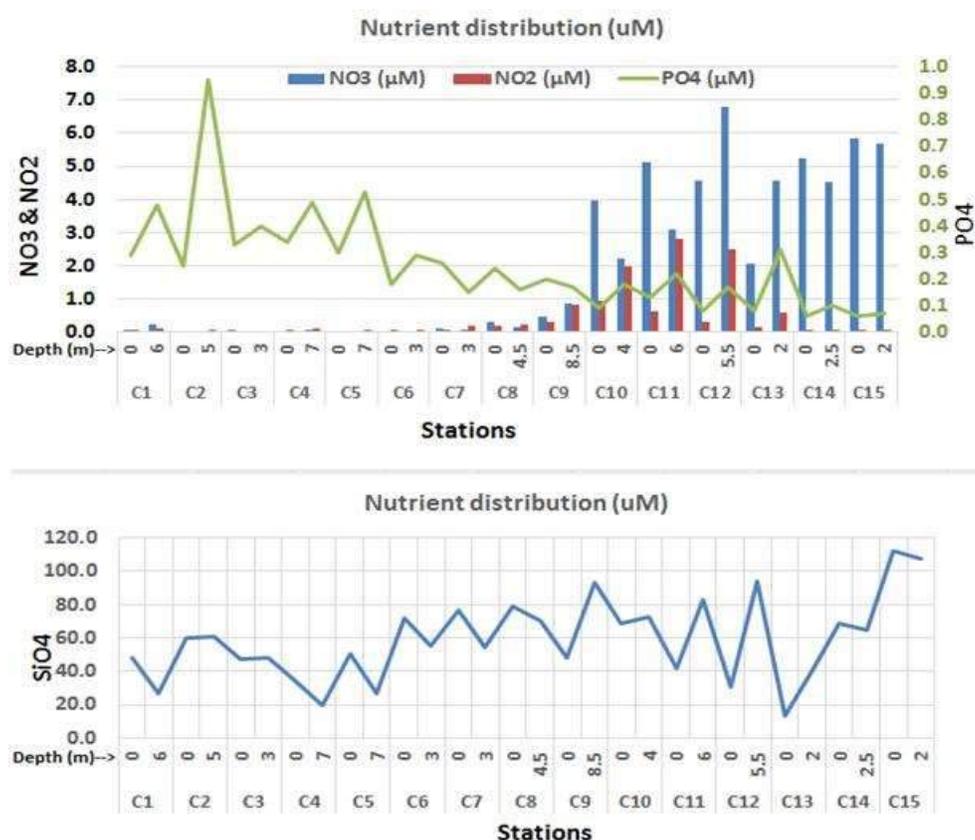


Figure 4.4: Spatial variations in (a) nitrate (NO_3), nitrite (NO_2) and phosphate (PO_4) and (b) silicate (SiO_4) in the Chapora Estuary.(C1-river mouth and C15-upstream region)

4.5 Biological parameters



Planktons are organisms that drift along with the water current. It constitutes both phytoplankton and zooplankton. Phytoplanktons are the primary producers of the aquatic environment and are an essential component of ecosystems functioning. Being the primary producers, they provide a range of ecosystem services from higher trophic levels to acting as a sink of CO₂. Various physico-chemical variables highly influence phytoplankton (and zooplankton, see below) abundance and composition. They are highly patchy both in space and time, reflecting the environmental status. Therefore, they are often accounted for in aquatic ecosystem management/mitigation processes.

4.5.1 Phytoplankton

Chlorophyll a: One of the most widely used proxies of phytoplankton (photosynthesizing microscopic organisms) biomass is the total chlorophyll-a concentration, which was measured following widely accepted fluorometric technique. Phytoplankton creates organic compounds that form the basis of oceanic/freshwater food web. Thus, phytoplankton pigment (chlorophyll a), together with the taxonomic composition of phytoplankton assemblages, was sampled from the entire stretch of the Chapora Estuary covering 15 sites along with mouth to the upstream. Since their production is governing minerals, nutrients such as nitrate, phosphate, and silicic acid were also simultaneously measured.

Phytoplankton biomass (Chl *a*; µg/L) also showed spatial variation that varied between 1.1 and 11.3 (avg. 3.4) with the highest concentration at the mid-stream region (Zone 2) particularly at stn C7. One of the upstream stations (stn C13) also recorded higher chlorophyll value at near bottom depth. (Figure 4.5).

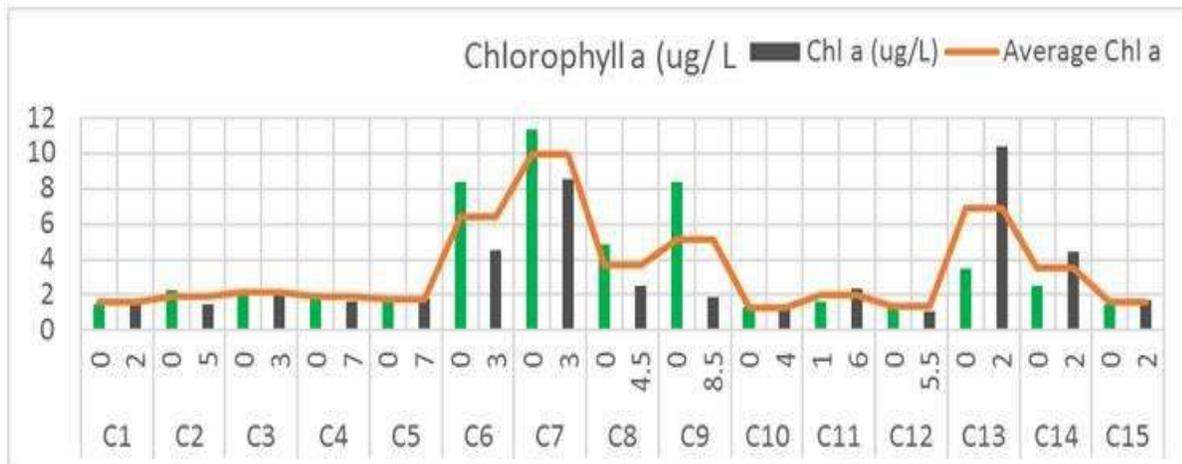


Figure 4.5: Spatial variations in Chlorophyll a (ug/L) in the Chapora Estuary.(C1-river mouth and C15-upstream region)

Species composition and abundance of phytoplankton

Phytoplankton composition and its numerical abundance studied from the Chapora estuary following microscopic technique (>10um in size) showed diverse forms. Phytoplankton represented by 94 genera were mainly comprised of diatoms (71 genera; centric: 35 & pennate: 36), while dinoflagellates were characterized by only 23 genera (Table 4.1).

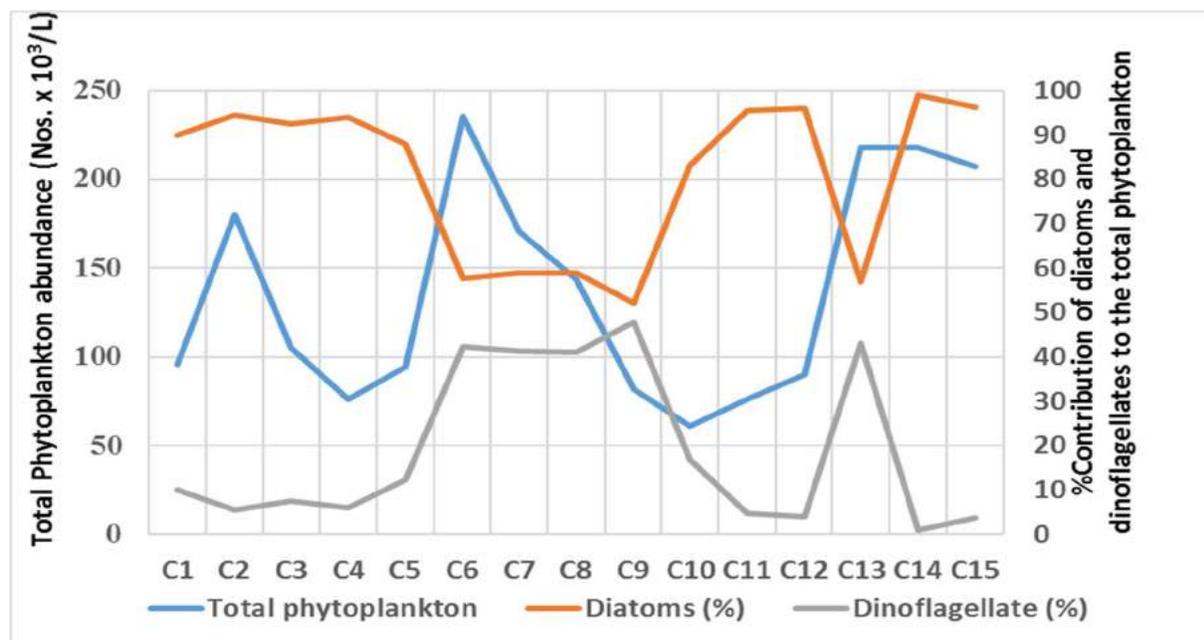


Figure 4.6: Spatial variations in total phytoplankton (Nos./L) and % contribution of diatoms and dinoflagellates in the Chapora Estuary.(C1-river mouth and C15-upstream region)

The most predominant species of the total phytoplankton were *Aulacoseira* Sp., *Chaetoceros Subtillis*, *Skeletonema* Sp., *Melosera Granulate*, *Leptocylindrus* Sp., *Cerataulina Bicornis* (Centric Diatom), *Nitzschia* Sp. *Pseudo-Nitzschia* Sp. *Micrasterias* Sp., *Cylindrothica* Sp., *Staurastrum* Sp., *Ceratoneis* Sp., *Tribonema* Sp. *Actinastrum* Sp. (Pennate Diatoms) While, Dinoflagellates were Represented By *Peridinium* Sp., *Oxyrrhis Marrina*, *Gymnodinium* Sp., And *Gyrodinium* Sp. Few Forms Present At Both Surface (S) And At The Near Bottom (B) Were *Aulacoseira* Sp.,(S>B) *Chaetoceros Subtillis*,(S>B) *Cylindrothica* Sp.(S<B) *Nitzschia* Sp. (S<B) and *Navicula* Sp., (S>B) (Belong To Diatoms) and *Peridinium* Sp.,(S>B) And *Oxyrrhis Marrina* (S>B) Of Dinoflagellates.

Phytoplankton diversity indices:

The phytoplankton diversity index across the length of the river and with respect to its surface and bottom depths are shown in Table 4.2. The total numbers of phytoplankton forms found to be not much varying between the bottom (18-49) and surface (16-47). However, species richness was more in the surface (ranging between 1.19 & 3.92) than bottom (1.44-3.79) similarly to evenness that ranged from 0.35-0.78 (surface) to 0.36-0.88 (bottom). High diversity index that

was relatively higher at the bottom (1.85-3.2) than the surface (0.98-3.02) depicted a decreasing trend across the length of the estuary, particularly in Zone-3 (beyond stn C9) (Table 4.2)

Table 4.2: Distribution of number of species, total abundance, species richness, evenness and diversity of phytoplankton in the Chapora Estuary.

Surface						Bottom					
Stations	S	N	d	J	H(log _e)	Stations	S	N	d	J	H(log _e)
C1	33	127108	2.72	0.76	2.66	C1	26	64480	2.26	0.64	2.08
C2	41	160552	3.34	0.73	2.71	C2	40	199680	3.20	0.64	2.36
C3	39	96840	3.31	0.72	2.66	C3	42	113200	3.52	0.79	2.94
C4	20	34000	1.82	0.71	2.12	C4	44	117720	3.68	0.80	3.04
C5	47	122960	3.93	0.79	3.03	C5	39	65564	3.43	0.88	3.23
C6	42	163584	3.42	0.76	2.84	C6	49	306936	3.80	0.77	3.00
C7	28	131040	2.29	0.68	2.27	C7	38	209880	3.02	0.77	2.80
C8	31	123500	2.56	0.70	2.39	C8	35	164080	2.83	0.83	2.94
C9	19	70460	1.61	0.71	2.09	C9	19	92640	1.57	0.61	1.79
C10	21	35496	1.91	0.80	2.42	C10	25	86060	2.11	0.75	2.42
C11	20	66096	1.71	0.55	1.66	C11	29	85920	2.46	0.81	2.72
C12	22	126000	1.79	0.47	1.46	C12	30	54000	2.66	0.77	2.60
C13	17	106560	1.38	0.48	1.35	C13	27	328900	2.05	0.36	1.18
C14	20	225400	1.54	0.53	1.59	C14	21	210000	1.63	0.47	1.42
C15	16	279864	1.20	0.36	0.99	C15	18	134120	1.44	0.48	1.40

S-Total no. of species; N-total no. of individuals; d-Richness; J- Evenness; H (log e) Diversity index (Shannon-Wiener diversity index).

4.5.2 Zooplankton

Zooplanktons are primary consumers or secondary producers. Hence they form an important link between the primary producers, phytoplankton and tertiary consumers like fishes. Also, they are important contributors and modifiers of the biogeochemical cycle. Thus, knowledge of their abundance and distribution is essential for understanding the ecological balance of any water bodies. In ecological studies, the study on zooplankton communities is essential because different species have different tolerance/adaptive levels to environmental variables, hydrographical conditions (pollutants), and response to changes in their diversity and abundance. Hence, they act as an indicator to monitor aquatic ecosystems (Gannon and Stemberger, 1978; Gajbhiye and Desai, 1981; Telkhade et al., 2008 and Davies et al., 2009).

Total abundance of zooplankton in Chapora Estuary: Present study revealed the spatial variation of zooplankton across the length (West-East direction) of the river dividing the Chapora Estuary broadly into three zones 1) zone -1: Near mouth region (stn C1-C5); Zone -2: Mid-stream region

(stn. C6-C8) and Zone -3: Upstream region (stn. C9-C15). The zooplankton abundance in the riverine region (stn: C9-C15) was much lower (minimum at stn C15; 1173 org./100m³) than the near mouth seaside region (stn. C1-C5) while midstream station (stn. C6-C8) depicted the highest abundance with a maximum at stn C7 (424200 org./100m³) (Figure 4.7). Spatial variability was also found to be significant, across the width of the river, north-south spatial variability depicted maximum in the middle region followed by southern bank of the river (see Figure 4.5 & 4.6) that also showed the variation from the river mouth to the upstream region (611649 Ind. /100 m³ at C3 [B] to 7565.5 Ind./100 m³ at C12 [B]).

These findings clearly classify the Chapora Estuary into three zones 1) Zone -1: Near mouth region (stn C1-C5); Zone -2: Mid-stream region (stn. C6-C8) and Zone -3: Upstream region (stn. C9-C15).

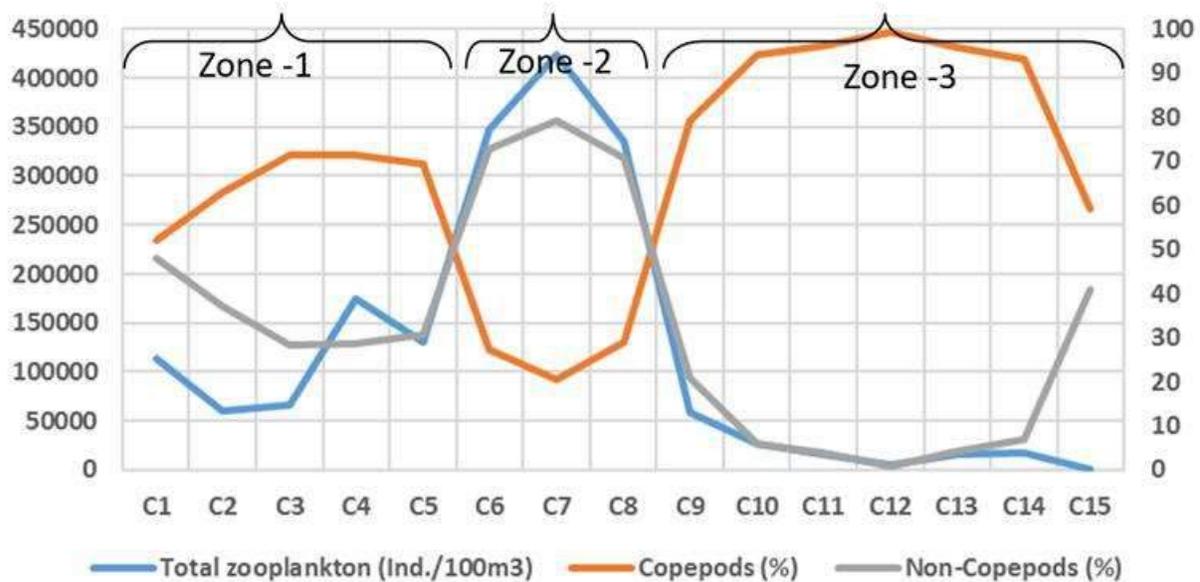


Figure 4.7: Spatial variations in Meso-zooplankton abundance along middle portion of the in the Chapora Estuary.(C1-river mouth and C15-upstream region)

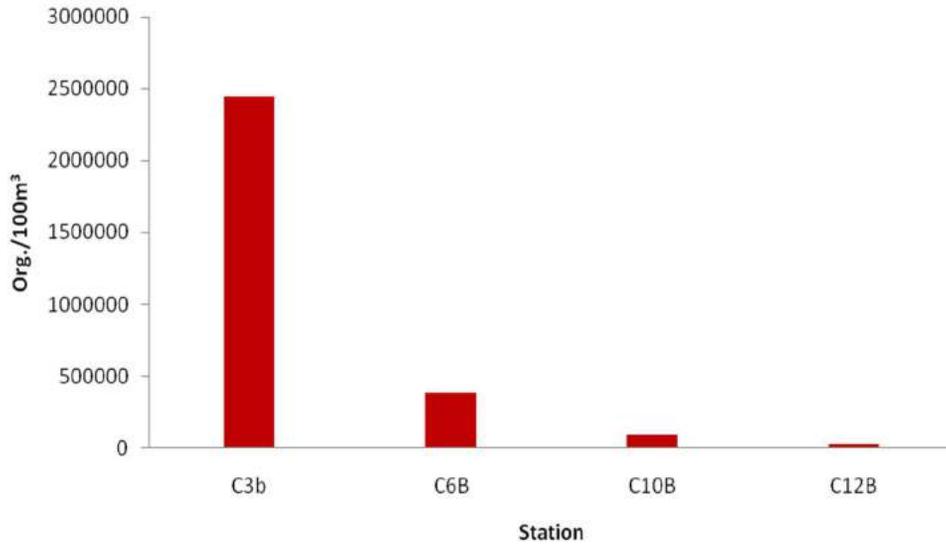


Figure 4.8: Spatial variations in zooplankton abundance along the southern (right side of the river) bank of Chapora Estuary.(C3-near river mouth and C12-upstream region)

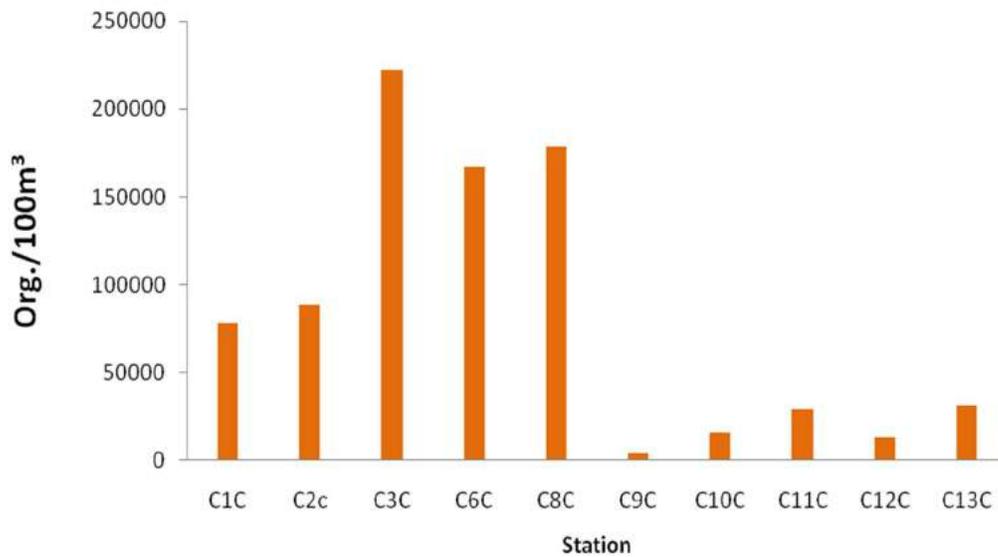


Figure 4.9: Spatial variations in zooplankton abundance along the northern (left side of the river) bank of Chapora Estuary.(C1-river mouth and C15-upstream region)

Distribution of taxonomic groups of zooplankton



Zooplankton community composition, which is broadly divided into two major categories, copepods, and non-copepods, showed spatial variability (Table 4.2). Copepod community dominates over non-copepod groups at Zone -1 (river mouth; 50-76%) and Zone-3 (upstream regions; above 92%) (Figure 4.8). Whereas in the midstream regions (Zone-2) the community was largely dominated by non-copepods. Overall, the percentage composition of copepod varied from 19.7 (C6B) – 98.5% (C12B).

Among non-copepod groups, Chaetognaths, Gastropods, Decapod larvae, and Fish larvae were found throughout the sampling area, whereas the distribution of Fish egg, Ostracod, Echinoderm larvae, Doliolum, Oekopleura are strictly confined to the river mouth. Some unidentified cladoceran were completely absent in the midstream, but present in the river mouth and upstream regions. Also, bivalves and barnacle nauplii were found in the river mouth and midstream region and completely absent in the upstream region. The presence of water mites in certain upstream stations indicated the poor quality of water.



Table 4.3: Depth wise and spatial variation of zooplankton abundance and composition in the Chapora Estuary

Zooplankton Abundance (Ind/100m3)															
Stations-->	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15
Zooplankton Composition															
Calanoida															
Paracalanidae															
<i>Acrocalanus sp.</i>	18177	10805	11802	24276	10459		701					52	10787		
<i>Acrocalanus gibber</i>	3231														
<i>Paracalanus sp.</i>	13329	14903	6910	31487	39924	28063	10859	2606	1658	16552	10658	5344	417	731	53
Acartidae															
<i>Acartia sp.</i>	3635	4844	16616	9254	8660	67150	75663	94895	43928	9037	5018	262	2813	7312	
Pontellidae															
<i>Labidocera spp.</i>		466													
Clausocalanidae															
<i>clausocalanus sp.</i>		93													
Centropagidae															
<i>Centropages furcatus</i>			311	2784	1912										
<i>Centropages sp.</i>															
Calanidae															
<i>Canthocalanus pauper</i>			155	1442	1125				36						
<i>Nanocalanus minor</i>	808		78										35		
Eucalimidae															
<i>Subeucalimus sp.</i>		186	1242	4567	1799										
Temoridae															
<i>Temora discoidata</i>	404			721	562										
<i>Temora turbinata</i>				481	112										
Tortanidae															
<i>Tortanus sp.</i>			155	481	112										
Pseudodiaptomidae															
<i>Pseudodiaptomus sp.</i>	404			481	1125								35	5703	
<i>calanoid unknown</i>												52		292	
Cyclopoida															
Oithonidae															
<i>Oithona sp.</i>	6059	1211	4503	10335	7198		350		108					1316	160
Sapphirinidae															
<i>Sapphirina sp.</i>		93													
<i>copilia sp.</i>															
Harpaeticoida															
Ectinosomidae															
<i>Microsetella sp.</i>		93	78	120	112										146
Macrosetellidae															
<i>Macrosetella gracilis</i>															
Tachidiidae															
<i>Euterpina acutifrons</i>	1212		466	1803	675				36						
Clytemnstridae															
<i>Clytemnestra sp.</i>				120											
<i>Miracia sp.</i>		279		120									12		
<i>harpaeticoid unknown</i>										32					107
Poecilostomatoida															
Oncaidae															
<i>Oncaea spp.</i>	1212	186	2019	5408	3036				108				12		
Corycaecidae															
<i>corycaeus sp.</i>	8482	4844	2562	23074	12258				432				12		
<i>Copepod nauplii</i>	2424	93	621	5889	1687								12	146	
<i>Calanoid copepodite</i>				1682									648	146	
<i>calanoid(damaged)</i>															373
Other Groups															
<i>Barnacle nauplii</i>		2888	699	2884	2137	68152	5955	869	2090	95	41				
<i>Bivalve</i>	4039	2608	621	3125	1462	802		484	324	63					
<i>Bryozoa larva</i>	404	186	155	481					36						
<i>calcareous shell</i>													12		
<i>Chaetognatha</i>	5655	6054	2174	3125	9109	23452	6305	3909	1045	190		52	58		
<i>Cladocera</i>	3635	93	1009	6970	1350								58	146	160
<i>Crab juvenile</i>														23	
<i>Ctenophora</i>			78	120	112		350	217							
<i>Cypris</i>		559	155	240	225				36					146	107
<i>Decapod larva</i>	17773	3260	5746	14902	9784	18040	9458	33224	4288	507	249		35		53
<i>Decapoda</i>	404	186							36				12		
<i>Dololum</i>					112										
<i>echinoderm</i>														23	
<i>Echinoderm larva</i>			78	481	112										
<i>Fish egg</i>	1212	186	699	841	337										
<i>Fish larvae</i>	404	186	155	120	112	601			36	63				146	
<i>Foraminifera</i>	404												12		
<i>Gastropoda</i>	13329	3074	1631	4807	7310	139712	310006	195002	3856	412	290		347	439	53
<i>hydrozooids</i>	1616	373	233										12		
<i>Isopod juvenile</i>				120											
<i>Jelly fish</i>			78		112	200	3503	2606	108	222					
<i>Lucifer</i>			544	721	112	200	701				41				
<i>Oekopleura</i>	1616		466	4927	1125										
<i>Ostracoda</i>		93													
<i>parasitic worm</i>													12		
<i>Polychaete</i>	2424	2422	2795	2283	5960	1604	350	434	180	63				146	
<i>Pteropod</i>		93													
<i>Siphonophora</i>	1616		1553	3726	900			217	36						
<i>stomatopod larva</i>															
<i>water beetle</i>		93													
<i>Water mite</i>													23	146	107
<i>waterfly</i>															
<i>Unidentified arthropod</i>		93													
<i>Unidentified nauplius</i>				120											
<i>unidentified forms</i>									36						



Distribution of copepods

The taxonomic composition and abundance of copepods varied from the river mouth to upstream regions, including calanoida, cyclopoida, harpacticoida, and poicelostomatoida (nauplii and copepodite stages). Amongst, the calanoida dominates the copepod community (contributing >50%) throughout the study area particularly in the midstream and upstream regions (beyond station C6) while, at the near mouth region poicelostomatoida followed by cyclopoida and, harpacticoida were more predominant compared to their distribution in the upstream region (beyond stn C5; Figure 4.10).

The calanoid copepods such as *Crocalanus* sp., *Paracalanus* sp., and *Acartia* sp. were distributed all along the study area. the species such as *Centropages furcatus*, *Temora turbinata*, *Temora discaudata*, *tortanus* sp., *Subeucalanus* sp., *Nanocalanus minor*, *canthocalanus pauper* and *labidocera* sp., etc. were confined to the river mouth region. moreover, the *Pseudodiaptomus* sp was found in the river mouth and upstream regions.

interestingly, a tumor-like out-growth was seen on copepods of mid-streams and upstream (beyond c10(c10b and c10c) regions. the out-growth was noticed on species such as acrocalanus sp., paracalanus sp., acartia sp., and pseudodiaptomus sp. moreover, a similar tumor-like out-growth was reported as a vulnerability to the ecological food web from indian waters (jagadeesan, l., and jyothibabu, r. 2016).

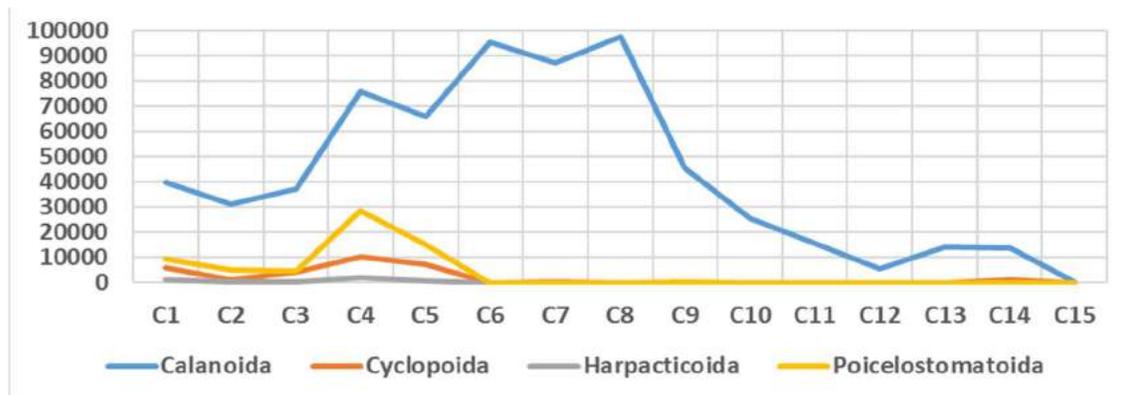


Figure 4.10: Distribution of copepods (Ind/100m³) from the River mouth (C1) to upstream (C15) regions of the Chapora Estuary.



Zooplankton Diversity Indices

Diversity indices are significant aids to characterize diversity, richness, and evenness of the species in the community (Magurran, 1988). The number of species (S) and the range of diversity indices (based on Shannon index) in the Chapora Estuary are given in Table 4.1. The number of species varied as 26-37 (river mouth), 11-12 (midstream), and 5-21 (upstream) depicting more species diversity (H') is more at river mouth followed by midstream region. Species evenness and richness are lower at midstream and upstream on comparing with river mouth.

Table 4.4: Number of species (S), species diversity(H'), species richness (d) and evenness (J') in Chapora Estuary.

Sample	S	H'	d	J'
River mouth	26-37	4.39-4.79	3.43-4.74	0.89-0.94
(C1-C5)	31.6±4	4.55±0.15	4.23±0.49	0.92±0.02
Midstream	11-12	2.55-2.88	1.37-1.53	0.74-0.83
(C6-C8)	11.33±0.58	2.71±0.16	1.44±0.08	0.77±0.05
Upstream	5-21	1.57-3.35	0.84-3.52	0.68-0.98
(C9-C15)	12.29±6.37	2.73±0.73	1.99±0.99	0.79±0.1

4.5.3 Meiobenthos

Central transect: The large variation of meiofaunal abundance was recorded from 15 stations (Table 4.5). Total 10 meiofaunal taxa were identified in the centre region of the river. From all the identified taxa, Harpacticoida was the most abundant group followed by Nematoda, Oligochaeta, Nemertea, Polychaeta, Turbellaria, Bivalvia, Gastropoda larvae, Naupli larvae, Amphipoda (Table 4.5). The highest meiofaunal abundance (424 ind/10cm²) was recorded at station CH3A and lowest (20 ind/10cm²) at station CH11A (Table 4.5). The percent composition of meiofaunal community showed that Harpacticoida (40.3%) was dominant among all other meiofaunal groups followed by Nematoda (36.7%), Oligochaeta (6.0%), Nemertea (4.2%), Polychaeta (3.9%), Turbellaria (3.3%), Bivalvia (2.9%), Gastropoda larvae (1.3%), Naupli larvae (0.9%), Amphipoda (0.5%) (Figure 4.11).



Peripheral transect: Total 13 taxa are identified in the periphery region of the a river from which Nematoda was abundant group followed by Harpacticoida, Polychaeta, Oligochaeta, Bivalvia, Tubellaria, Nemertea, Nauplilarvae, Gastropoda larvae, Amphipoda, Halacarida, Kinoryncha. The percent composition of meiofaunal community showed that Nematoda(60%), Harpacticoida(15%), Polychaeta(8.1%), Oligochaeta(5.3%), Bivalvia(4.2%), Tubellaria(3%), Nemertea(1.71%), Naupli larvae(1.15%), Gastropoda larvae(0.66%), Crustacean larvae(0.30%), Amphipoda(0.22%), Halacarida(0.16%), Kinoryncha(0.12%).

Conclusion:

The present analysis of distribution and abundance of meiobenthic community revealed that, due to the changes in pH and TSM (mg/L) the meiofaunal community also shows the variations. Our observation supports the reduced pH and TSM may have effect on meiofaunal abundance found to be decreased in peripheral region as compared to central region of the river. As suggested by Raffaelli and Mason (1981), the ratio of Nematoda Copepoda is <100 indicate impact of degrading the quality of the water. Through our analysis, we observed that in the central region of the river the ratio Nematoda- Copepoda was higher except station CH4A and CH11A (Table 4.8). While at the periphery region the Nematoda- Copepoda ratio lower values at station CH5C, CH13C, CH14B except station CH4A.



Table 4.5: Total meiofaunal abundance (ind/10 cm²) of Chapora Estuary (Central transect).

Taxa	CH1A	CH2A	CH3A	CH4A	CH5A	CH6A	CH7A	CH8A	CH9A	CH10A	CH11A	CH12A	Total	%
Nematoda	43	38	93	47	78	55	29	31	5	28	1	3	450	36.7
Polychaeta	13	10	1	10	3	1	0	4	1	3	3	0	48	3.9
Naupli larvae	0	0	0	0	9	1	0	0	0	1	0	0	11	0.9
Harpacticoida	13	5	289	0	104	50	5	5	4	14	3	1	495	40.3
Amphipoda	0	0	0	0	0	6	0	0	0	0	0	0	6	0.5
Bivalvia	1	0	4	4	0	0	15	9	0	3	0	0	35	2.9
Gastropoda larvae	1	0	0	4	0	5	4	0	1	1	1	0	16	1.3
Oligochaeta	1	0	5	5	1	26	1	5	5	4	6	13	74	6.0
Nemertea	24	13	8	4	0	0	0	0	1	2	0	0	51	4.2
Turbellaria	5	1	4	4	6	0	11	1	0	8	0	0	41	3.3
Total	101	67	404	77	201	146	65	55	16	64	13	16	1227	100.0

* Stations number CH13A, CH14A, CH15A was not collected due to hard substratum.



Table 4.6: Total meiofaunal abundance (ind/10 cm²) of Chapora Estuary (Peripheral transect).

Taxa	CH1B	CH1C	CH2B	CH2C	CH3B	CH3C	CH4B	CH4C	CH5B	CH5C	CH6B	CH6C	CH7B	CH7C	CH8B	CH8C	CH9B
Nematoda	97	826	31	131	84	210	122	167	4	35	23	13	11	4	0	15	6
Polychaeta	25	55	3	1	0	3	0	13	0	0	8	1	0	1	0	72	1
Naupli larvae	0	3	0	0	1	1	0	0	11	0	0	0	0	0	0	1	0
Harpacticoida	5	166	6	6	15	30	13	42	21	1	3	1	1	4	0	9	3
Amphipoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Halacarida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crustacean larvae	1	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Kinoryncha	0	0	1	0	0	3	0	0	0	0	0	0	0	1	0	0	0
Bivalvia	0	3	3	1	3	4	0	0	0	0	0	0	0	9	0	0	0
Gastropoda larvae	1	0	1	3	1	4	0	1	0	0	1	0	0	4	0	0	0
Oligochaeta	20	18	5	1	4	8	0	4	1	5	9	0	1	4	0	16	2
Nemertea	0	6	0	14	3	11	6	6	0	3	3	1	0	0	0	0	0
Turbellaria	5	9	0	5	20	29	4	0	0	1	0	1	0	1	0	1	0
Total	155	1086	49	162	135	302	145	233	38	45	45	17	14	26	0	115	11



Taxa	CH9B	CH9C	CH10B	CH10C	CH11B	CH11C	CH12B	CH12C	CH13B	CH13C	CH14B	Total	%
Nematoda	6	4	26	18	5	5	1	16	3	20	0	1878	60.0
Polychaeta	1	3	34	0	0	4	23	6	1	0	1	254	8.1
Naupli larvae	0	1	4	0	0	0	10	4	0	0	0	36	1.1
Harpacticoida	3	15	29	4	3	49	29	11	1	0	3	469	15.0
Amphipoda	0	0	5	0	0	2	0	0	0	0	0	7	0.2
Halacarida	0	0	0	0	0	5	0	0	0	0	0	5	0.2
Crustacean larvae	0	0	1	0	0	0	3	0	0	0	0	9	0.3
Kinoryncha	0	0	0	0	0	0	0	0	0	0	0	4	0.1
Bivalvia	0	10	20	0	0	8	5	63	1	5	0	133	4.2
Gastropoda larvae	0	1	1	1	0	2	0	0	0	0	0	21	0.7
Oligochaeta	2	9	8	3	20	2	20	0	1	4	1	165	5.3
Nemertea	0	0	0	0	0	0	0	1	0	0	0	53	1.7
Turbellaria	0	0	5	1	0	1	3	1	1	0	6	94	3.0
Total	11	42	133	26	28	77	93	103	8	29	11	3128	100.0

* Stations number CH14C, CH15B, CH15C was not collected due to hard substratum.



Taxa	CH1A	CH2A	CH3A	CH4A	CH5A	CH6A	CH7A	CH8A	CH9A	CH10A	CH11A	CH12A
Nematoda	68	60	148	74	124	88	46	50	8	44	1	4
Harpacticoida	20	8	460	0	166	80	8	8	6	23	5	2
Nematoda/copepoda ratio	3	8	0	0	1	1	6	6	1	2	0	2

Taxa	CH1B	CH1C	CH2B	CH2C	CH3B	CH3C	CH4B	CH4C	CH5B	CH5C	CH6B	CH6C	CH7B	CH7C	CH8B	CH8C
Nematoda	154	1312	50	208	134	334	194	266	6	56	36	20	18	6	0	24
Harpacticoida	8	264	10	10	24	48	20	66	34	2	4	2	2	6	0	14
Nematoda: copepoda ratio	19.3	5.0	5.0	20.8	5.6	7.0	9.7	4.0	0.2	28.0	9.0	10.0	9.0	1.0	0.0	1.7

Taxa	CH9B	CH9C	CH10B	CH10C	CH11B	CH11C	CH12B	CH12C	CH13B	CH13C	CH14B
Nematoda	10	6	42	28	8	8	2	26	4	32	0
Harpacticoida	4	24	46	6	4	78	46	18	2	0	4
Nematoda: copepoda ratio	2.5	0.3	0.9	4.7	2.0	0.1	0.0	1.4	2.0	0.0	0.0

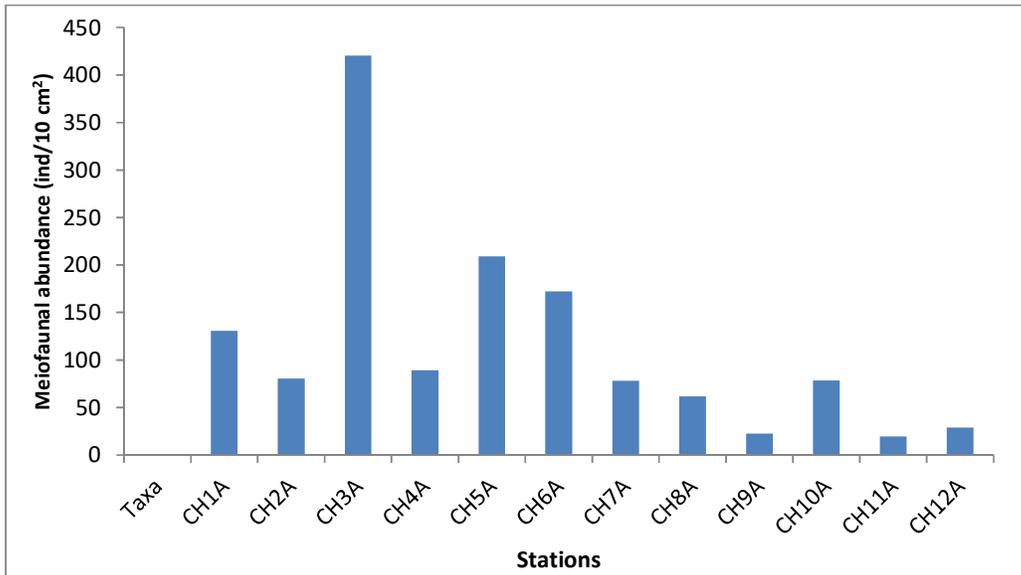


Figure 4.11: Station-wise meiofaunal abundance (ind/10 cm²) from River Chapora (Central transect).

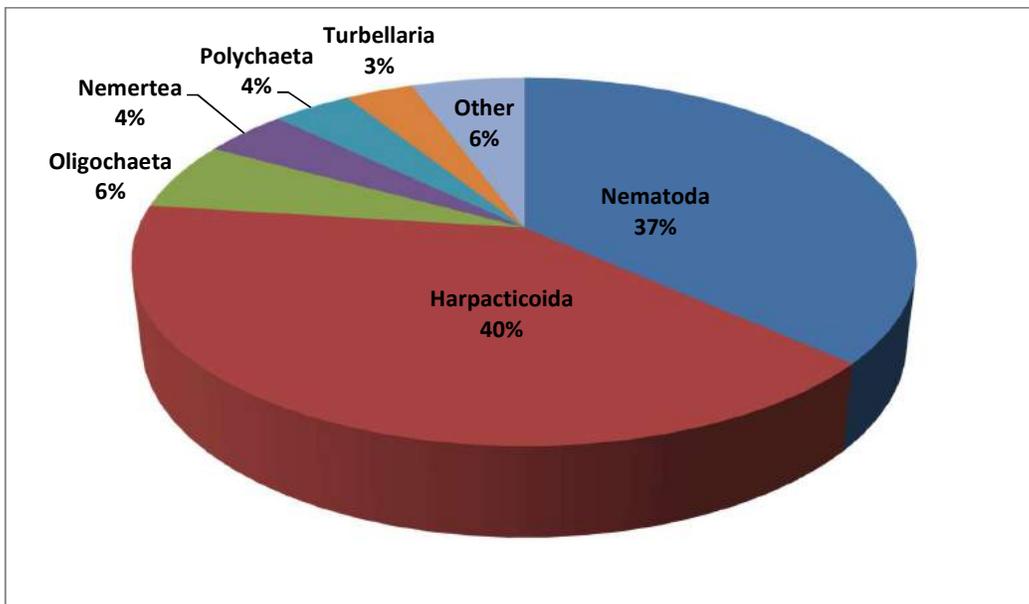


Figure 4.12: Percent composition of meiofaunal taxa from River Chapora (Central transect).

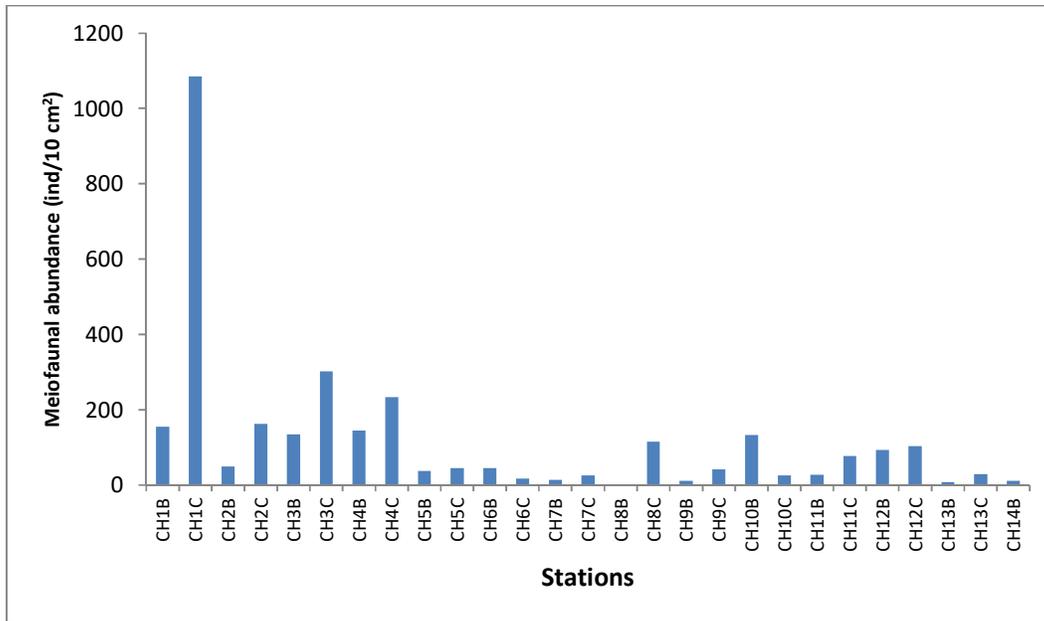


Figure 4.13: Station-wise meiofaunal abundance (ind/10 cm²) from River Chapora (Peripheral transect).

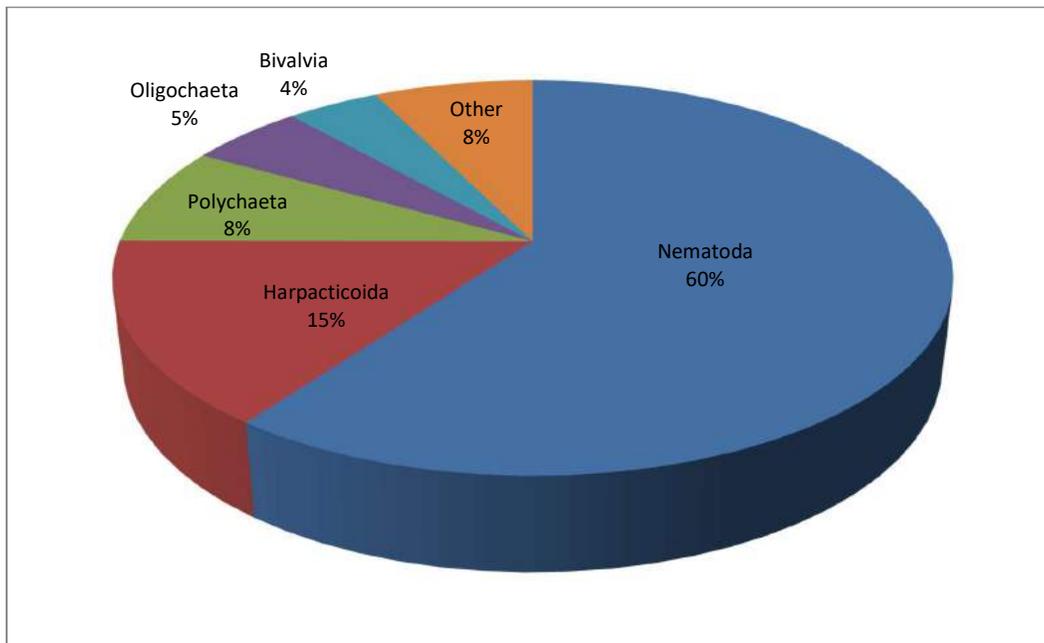


Figure 4.14: Percent composition of meiofaunal taxa from River Chapora (Peripheral transect).

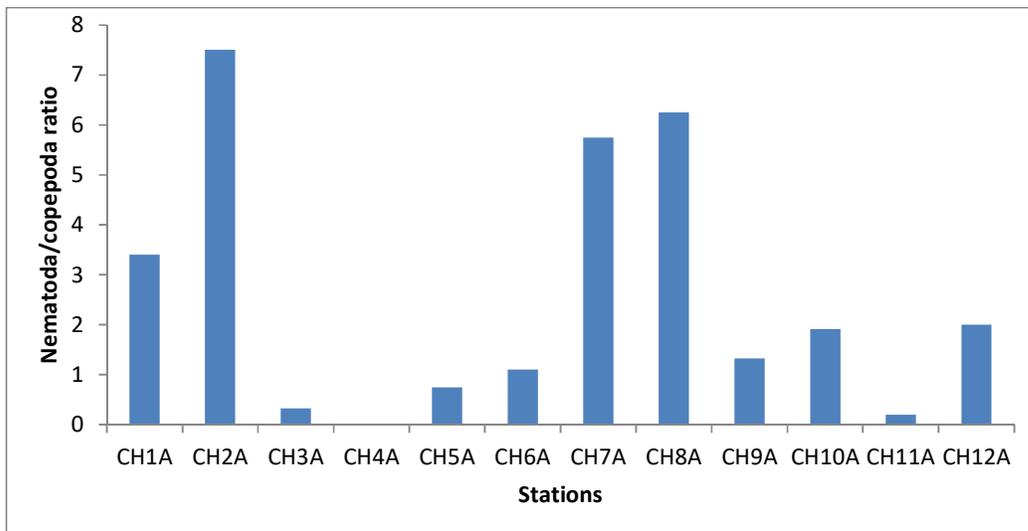


Figure 4.15: Station-wise Nematoda:Copepoda ratio from River Chapora (Central transect).

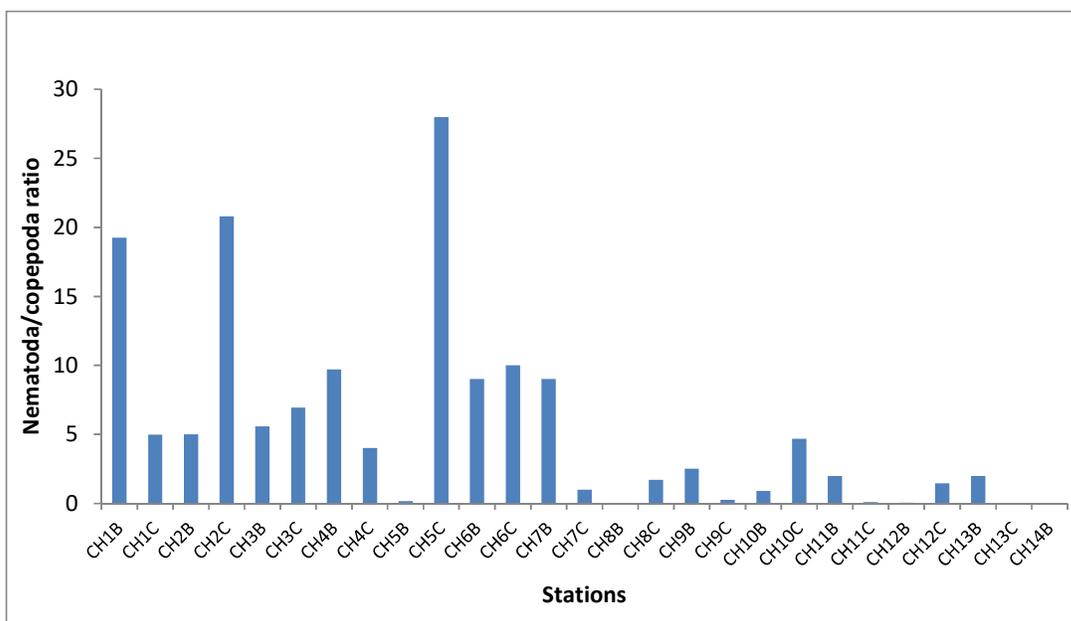


Figure 4.16 :Station-wise Nematoda:Copepoda ratio from River Chapora (Peripheral transect).

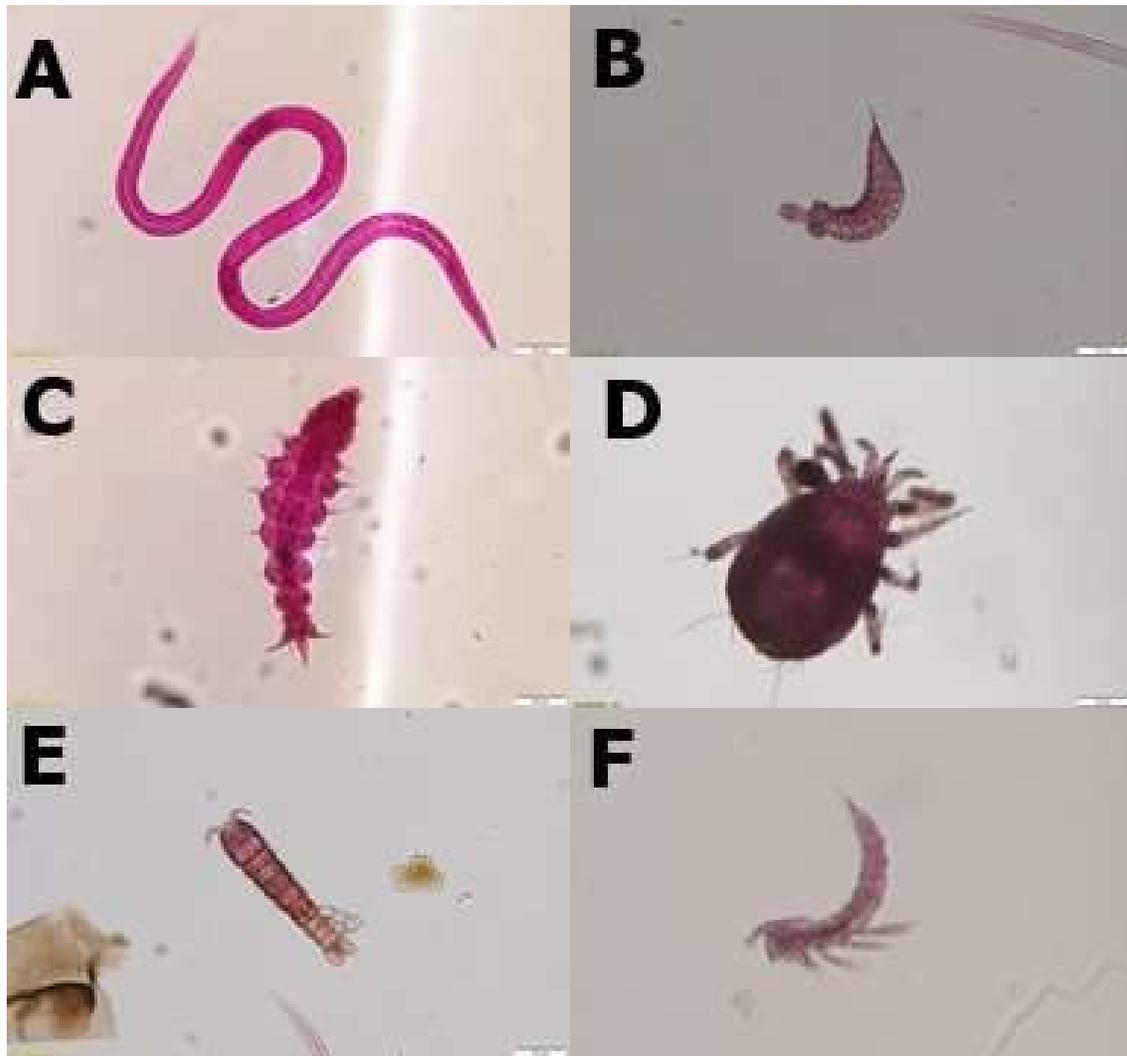


Plate 2: A=Nematoda, B=Kinoryncha, C=Polychaeta, D=Halacarida, E and F=Harpacticoida

4.5.4 Foraminifera

Living benthic foraminifera are rare in the middle of the river bed, whereas a substantial population is observed on the margin of the river. Living benthic foraminiferal population is very low in all the samples collected at station Ch1, at the confluence of the Chapora Estuary with the Arabian Sea. As benthic foraminifera have high sensitivity for low salinity thus their survival in the upper stretches of the river is rare.

The dead foraminiferal population is an order of magnitude higher than the living population. However, the dead foraminifera are also rare in the middle of the river bed, probably due to high flow velocities and hydrodynamic conditions.

The rare benthic foraminiferal presence in the middle of the river bed is attributed to the very coarse texture of the sediments. Such sediments are almost completely devoid of organic matter, the food for foraminifera. The sediments at the river margin have fine texture facilitating a better preservation of the organic matter. Benthic foraminifera thrive in such organic matter rich fine sediments. Analysis of foraminifera data is still in process as it is time consuming work.

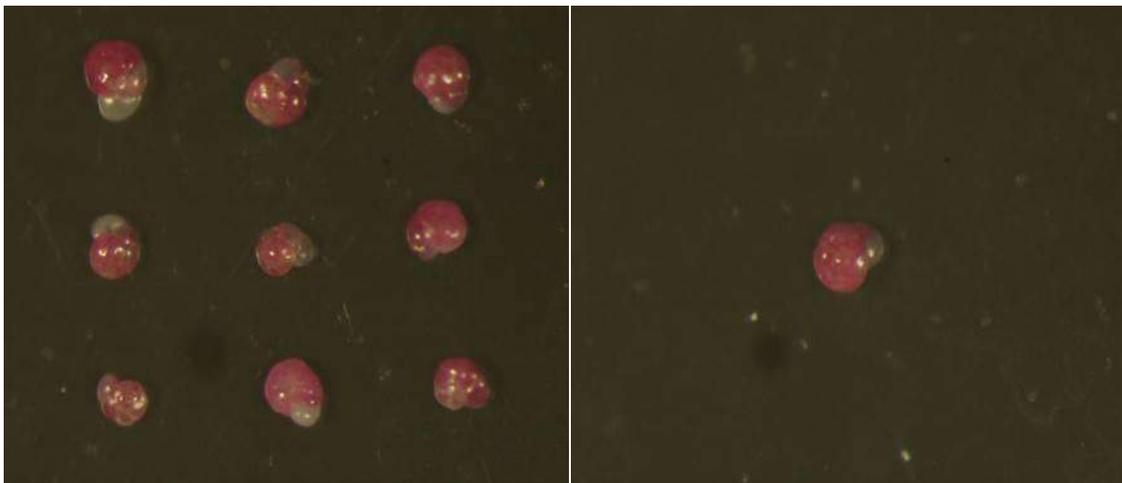


Plate 3: Foraminifera species found in Chapora Estuary.

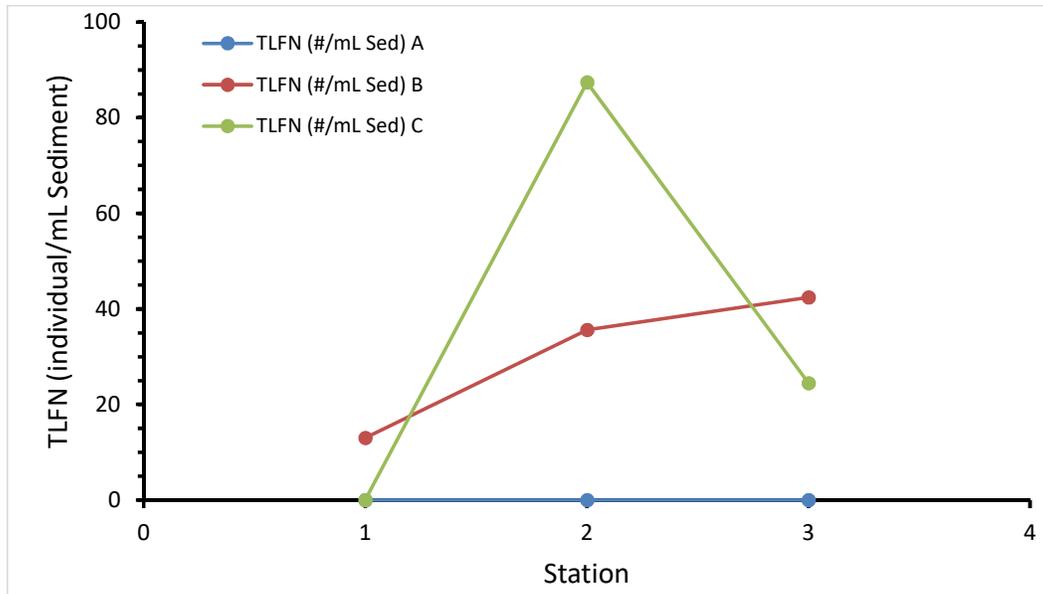


Figure 4.17: Total Living Foraminifera Number in Chapora Estuary

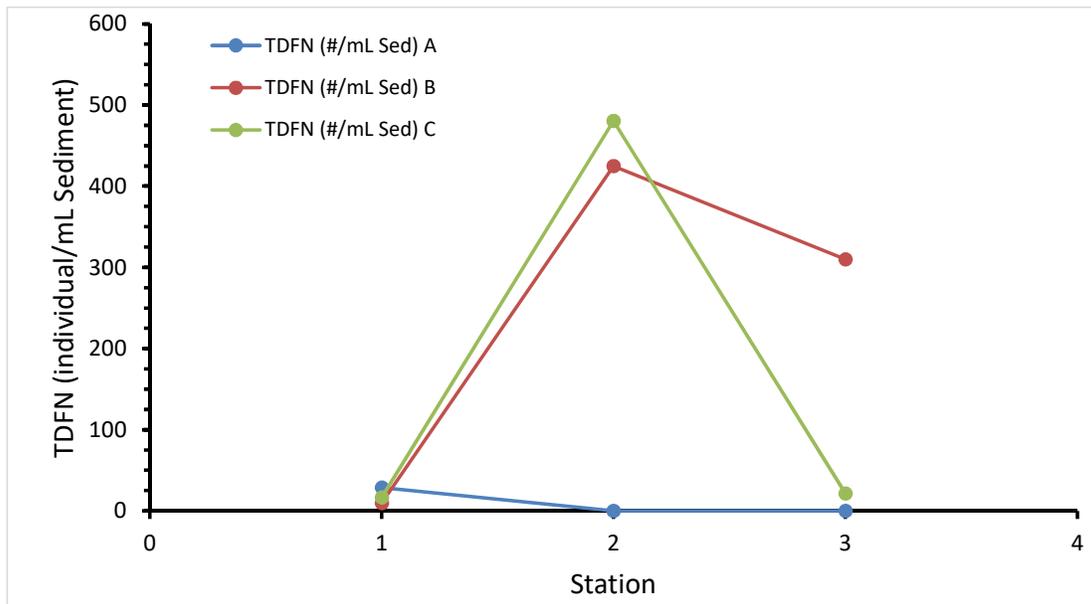


Figure 4.18: Total Dead Foraminifera Number in Chapora Estuary



4.5.5 Macrobenthos:

Central transect:

A total of 28 macro invertebrate taxa belonging to 10 phyla were identified from the central region of the river sample (CHA). Among all these groups, Polychaeta was the most dominant. Higher abundance of Polychaeta was found at station CH12A (3584no/m²) followed by CH8A (2556 no/m²). However, lower abundance found in CH 1A (24no/m²), (Table 4.9). In Polychaeta, *Prionospio pinnata* was the highly abundant species at station CH12A (3345no/m²), and lower abundance at station CH8A (1696 no/m²) and was absent at CH1A and CH1B stations. *Glycera alba* was the second dominant species with highest at CH8A (382no/m²) and lowest abundance found at CH1A, CH2A and CH12A with 24 no/m². Bivalvia were the second dominant taxa present at CH6A, CH7A, Ch8A, CH9A and CH12A. Other taxa like Nematoda, Sipunula, Crustacea, Gastropoda, Ophuroidea, Platyhelminthes, Trematoda, Oligochaeta and Phoronida were found less in abundance at all the stations (Table 4.9). The stations at the centre of mouth of river showed less in abundance due to continuous dredging may results loss of faunal abundance (Figure 4.19). Elias et.al, (2005) reported *Prionospio* spp. are the indicator species for organic enrichment, in areas sampled during summer.

The macrofaunal composition showed polychaetes was the highly abundant (86%) followed by Crustacea (4%) and Bivalvia (4%). The remaining 6% of the fauna was comprised by Nematoda, Sipuncula, Crustacea, Gastropoda, Ophuroidea, Platyhelminthes, Trematoda, Oligochaeta and Phoronida (Figure 4.20). Among Polychaeta, *Prionospio pinnata* showed high composition with 79%, followed by *Glycera alba* (10%), *Poecilochaetus* sp. (4%) and the remaining 7% represented by other Polychaeta which were found less in abundance at the central region of the River (Figure 4.21). Polychaetes are the most dominant group in the benthic communities and may provide the details of effect of pollutants on life history characteristics (Harlan Dean, 2008).

Peripheral transect: A total of 41 macro invertebrate taxa belonging to 13 phyla were identified from the sample from periphery region of the river (CHB & CHC). The macrofaunal abundance was high at CH11C (17120 no/m²) followed by CH10B (11328 no/m²) and CH 2B (11200 no/m²) whereas low abundance was observed at CH8B (48no/m²) station, respectively (Table 4.10)(Figure 4.22). From all these taxa, Polychaeta showed high abundance followed by Crustacea, Chironomidae larvae, Oligochaeta and Bivalvia. Among the Polychaetea, *Nereis*



sp. was found to be the most abundant polychaete with 30896no/m² from all the sampling stations. High abundance of *Nereis* sp. was found in CH11C (6928 no/m²) and CH12C (6384 no/m²) and less at station CH1B, CH3B, CH3C and CH8C. *Prionospio pinnata* was the second abundant species with 29136no/m² from all the samples. Station CH11C showed high abundance (7360 no/m²) followed by CH10B (3968 no/m²) and CH13C (3872 no/m²) and found less in abundance at CH1B (16 no/m²), respectively. The second dominant taxa was Crustacea, among which Amphipoda was the abundant group with 9376 no/m² from all the stations, herein at CH13C and CH10B Amphipoda abundance was found to be 3120 no/m², 2912 no/m². Chironomidae larvae (3824 no/m²) were also found upstream region of the river at the station CH10B to CH14B. Bivalvia (1344 no/m²) and Oligochaeta (3072no/m²) were also found along the periphery area of the river (Table 4.10). The upstream peripheral area of Chapora Estuary showed high diversity as compared to the downstream peripheral region.

The macrofaunal percent composition showed that Polychaeta (78%) were the most dominant taxa with followed by Crustacea (11%) and other groups represented by 11% (Figure 4.23). In Polychaetes, *Nereis* sp. (42%) was the most dominant species from all the stations followed by *Prionospio pinnata* (40%), *Heteromastus* sp. (13%) and the remaining 5% with the other Polychaetes which were found less in abundance (Figure 4.24). The periphery region of Chapora Estuary showed high macrofaunal diversity; this may be due to presence of mangroves area which is known to be rich in faunal diversity.

Biomass:

At the central region of the river, the macrofaunal biomass (wet weight) ranged from 0.02 to 66.53 g/m² with lowest values at station CH1A and CH4A. The highest values were recorded at station CH4A, which was contributed by Polychaeta species due to their larger size and abundance (Figure 4.25). The diversity was very less at the central region of the river may be because the sediment texture as it was mostly sandy in nature. Along the periphery of the river, the diversity was high at station CH2B with 26.83 g/m² and low at CH3C, CH5B and CH8B with 0.02g/m² at each station. The biomass was found to be higher at the upstream region of Chapora Estuary as well as the macrofaunal diversity (Figure 4.26).

Conclusion:



Based on the present data set, macrofaunal abundance was found to be higher at upstream of the Chapora Estuary as compared to downstream. The present analysis also found that the peripheral region of upstream was rich in macrofaunal diversity, which decreased gradually towards the downstream. The observed benthic polychaetes and crustacean which constitute a major food source for fishes and avifauna.



Table 4.9: Abundance (no/m2) of macrofauna from Chapora Estuary(Central transect)

Taxa	CH 1A	CH 2A	CH 4A	CH 5A	CH 6A	CH7A	CH8A	CH9A	CH10A	CH11A	CH12A	Sum	%
Nematoda	0	0	0	0	0	0	24	0	0	0	0	24	0.19
<i>Nereissp.</i>	0	0	24	0	0	0	24	0	0	24	0	72	0.59
<i>Heteromastussp.</i>	0	0	0	24	0	0	24	0	0	24	0	72	0.58
<i>Prionospio pinnata</i>	0	0	119	24	96	72	1696	1003	549	1505	3345	8409	68.48
<i>Polydoraciliata</i>	0	0	72	0	0	0	0	0	0	0	0	72	0.58
<i>Glycera alba</i>	24	24	119	143	119	72	382	119	0	0	24	1027	8.27
<i>Ancistrosyllis sp.</i>	0	0	24	0	0	0	0	0	0	0	0	24	0.19
<i>Lumbrineris sp.</i>	0	0	0	0	0	0	72	0	0	0	0	72	0.58
<i>Amphictene sp</i>	0	24	0	0	0	72	0	0	0	0	0	96	0.78
<i>Sabellaria sp.</i>	0	0	0	0	0	0	0	0	0	0	0	0	0.00
<i>Poecilochaetus sp.</i>	0	406	0	0	0	0	0	0	0	0	0	406	3.31
<i>Inemophytys inermis</i>	0	0	48	0	0	24	0	0	0	0	0	72	0.58
<i>Aphrodite sp.</i>	0	0	24	0	0	0	0	0	0	0	0	24	0.19
<i>Orbinia sp.</i>	0	0	24	0	215	0	0	0	0	0	0	239	1.95
Echuiria	0	0	191	0	0	0	0	0	0	0	0	191	1.56
Amphipoda	0	0	48	0	48	0	96	0	0	0	24	215	1.75
Harpacticoida	0	0	0	0	24	0	0	0	0	0	0	24	0.19
Lucifera	0	0	0	24	0	0	0	0	0	0	0	24	0.19
Cumacea	0	0	0	0	215	0	24	0	0	0	0	239	1.95
Shrimp	0	0	0	24	0	0	0	0	24	0	0	48	0.39
Bivalvia	0	0	0	0	24	143	72	48	0	0	191	478	3.89
Naticidae	0	0	24	0	0	0	0	0	0	0	0	24	0.19
Trochidae	0	24	0	0	0	0	0	0	0	0	0	24	0.19
Ophuroidea	0	0	24	0	0	0	0	0	0	0	0	24	0.19
Platyheminthes	0	0	0	0	24	0	0	0	0	0	0	24	0.19
Trematoda	0	0	72	0	0	0	0	0	0	0	0	72	0.58



Oligochaeta	0	24	0	0	0	24	0	24	72	0	0	143	1.17
Phoronida	0	0	0	0	0	0	143	0	0	0	0	143	1.17
Abundance (No/m²)	24	502	812	239	764	406	2556	1195	645	1553	3584	12279	100

*CH3A, CH13A, CH14A & CH15A station sample could not retrieve due to hard substratum.

Table 4.10: Abundance (no/m²) of macrofauna from Chapora Estuary (Peripheral transect)

Taxa	CH 1B	CH 1C	CH 2B	CH 2C	CH 3B	CH 3C	CH 4B	CH 4C	CH 5B	CH 6B	CH6C	CH7B	CH7C
Hydrozoa	16	0	0	0	0	0	0	0	0	0	0	0	0
Nematoda	0	0	0	0	0	0	0	0	352	0	0	16	0
<i>Nereis</i> sp.	16	0	1568	0	16	16	32	0	0	224	0	32	320
<i>Mediomastus</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Heteromastus</i> sp.	0	0	4512	336	416	16	32	128	0	3264	32	48	112
<i>Prionospio pinnata</i>	16	64	2144	32	0	0	416	48	0	208	112	32	544
<i>Polydora</i> sp.	0	0	0	0	0	0	0	0	0	0	0	16	0
<i>Glycera alba</i>	32	32	224	0	0	0	32	0	0	0	0	0	0
<i>Ancistrosyllis</i> sp.	0	0	864	16	0	0	224	0	0	16	0	0	0
<i>Lumbrineris</i> sp.	0	0	32	0	0	0	0	0	0	32	0	0	0
<i>Amphictene</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sabellaria</i> sp.	0	0	0	0	0	0	0	0	0	16	0	0	0
<i>Poecilochaetus</i> sp.	0	0	64	0	0	0	0	0	32	0	0	0	0
<i>Paraonis</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Hydroides</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Inemophytis inermis</i>	0	32	112	0	0	0	0	0	0	0	0	0	0
<i>Hesione</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Chaetopterus</i> sp.	0	0	32	0	0	0	0	0	0	0	0	0	0
<i>Aphrodite</i> sp.	0	0	16	0	0	0	32	0	0	0	0	0	0

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<i>Orbinia</i> sp.	272	16	0	0	0	0	320	0	0	0	0	0	0
<i>Maldanellasp.</i>	32	0	0	0	0	0	16	0	0	0	0	0	0
<i>Ophelia</i> sp.	80	0	0	0	0	0	48	0	0	0	0	0	0
Echuirea	0	0	0	0	0	0	32	0	0	0	0	0	0
Amphipoda	0	0	16	0	0	0	16	0	0	16	0	48	432
Isopoda	32	0	992	32	0	112	0	0	0	0	0	0	16
Harpacticoida	0	0	0	0	0	0	16	0	16	0	0	0	0
Lucifera	0	0	0	0	0	0	48	0	16	0	0	0	0
Cumacea	0	0	0	0	0	0	0	0	48	0	0	0	0
Tanaidacea	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp	0	32	0	0	0	0	0	0	0	0	0	0	0
Brachyura	0	0	0	0	0	0	0	0	0	0	0	0	32
Decapoda	0	0	0	16	0	0	0	0	0	0	0	0	0
Bivalvia	16	0	368	16	16	16	64	32	32	0	0	16	0
Platyheminthes	0	0	48	0	0	16	0	48	0	0	0	16	0
Planaria	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemertea	80	16	176	32	0	0	32	0	0	0	0	16	32
Chironomidae larvae	96	0	0	0	0	0	0	0	0	0	0	0	0
Fish (Juveniles)	0	0	0	0	0	0	0	0	0	0	0	0	0
Lingulidae	0	0	32	32	0	0	0	0	0	0	0	0	0
Oligochaeta	0	0	0	0	0	48	80	1600	0	0	0	1136	0
Chaetognatha	0	0	0	0	0	0	16	0	0	0	0	0	0
Abundance (No/m ²)	688	192	11200	512	448	224	1456	1856	496	3776	144	1376	1488

*CH5C station had no fauna & CH15 A, CH15B and CH15C samplenot collected due to hard bottom.



(Contd.....): Abundance (no/m ²) of macrofauna from Chapora Estuary (Peripheral transect).																
Taxa	CH8B	CH8C	CH9B	CH9C	CH10B	CH10C	CH11B	CH11C	CH12B	CH12C	CH13B	CH13C	CH14B	CH 14C	Sum	%
Hydrozoa	0	0	0	0	0	0	0	0	0	0	0	32	0	0	48	0.05
Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	368	0.39
<i>Nereis</i> sp.	0	16	0	0	3808	1200	4000	6928	864	6384	48	3056	1456	912	30896	32.65
<i>Mediomastus</i> sp.	0	0	0	0	16	0	0	0	0	0	0	0	0	0	16	0.02
<i>Heteromastus</i> sp.	0	0	16	48	0	0	0	0	0	0	0	0	0	1008	9968	10.53
<i>Prionospio pinnata</i>	0	480	800	672	3968	4112	288	7360	2512	704	448	3872	112	192	29136	30.79
<i>Polydoraciliata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.02
<i>Glycera alba</i>	16	160	32	96	16	16	0	0	0	0	0	32	0	16	704	0.74
<i>Ancistrosyllis</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1120	1.18
<i>Lumbrineris</i> sp.	0	0	0	0	128	0	0	0	0	0	0	16	0	0	208	0.22
<i>Amphictene</i> sp.	0	96	0	64	0	0	0	0	0	0	0	0	0	0	160	0.17
<i>Sabellaria</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.02
<i>Poecilochaetus</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	0.10
<i>Paraonis</i> sp.	0	0	0	0	0	0	0	16	0	0	0	0	0	0	16	0.02
<i>Hydroides</i> sp.	0	0	0	0	0	0	0	0	0	0	48	0	0	0	48	0.05
<i>Inemophytys inermis</i>	0	0	0	48	0	0	0	0	0	0	0	0	0	0	192	0.20
<i>Hesione</i> sp.	0	0	0	0	16	0	0	0	0	0	0	0	0	0	16	0.02
<i>Chaetopterus</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0.03
<i>Aphrodite</i> sp.	0	0	0	0	0	0	0	0	0	0	16	0	0	0	64	0.07
<i>Orbinia</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	608	0.64
<i>Maldanella</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0.05
<i>Ophelia</i> sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128	0.14
Echuiria	0	0	0	0	0	0	0	0	0	0	16	0	0	48	96	0.10
Amphipoda	0	0	16	0	2912	16	16	1328	96	464	48	3120	720	112	9376	9.91
Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	32	1216	1.28



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Harpacticoida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0.03
Lucifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0.07
Cumacea	0	0	16	0	0	0	0	0	0	0	0	0	0	0	64	0.07
Tanaidacea	0	0	0	0	0	0	0	0	0	0	0	0	48	0	48	0.05
Shrimp	0	0	0	0	0	0	0	16	0	0	32	0	0	0	80	0.08
Brachyura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0.03
Decapoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.02
Bivalvia	32	80	0	192	64	0	16	176	0	64	64	48	0	32	1344	1.42
Platyhelminthes	0	0	0	0	0	0	0	0	0	0	0	0	32	16	176	0.19
Planaria	0	0	0	16	0	16	0	0	0	0	0	0	0	0	32	0.03
Nemertea	0	0	0	0	0	32	48	224	208	112	64	32	32	0	1136	1.20
Chironomidae larvae	0	0	0	0	400	0	192	1072	48	1184	16	736	80	0	3824	4.04
Fish (Juvniles)	0	0	0	16	0	0	0	0	0	0	0	32	0	0	48	0.05
Lingulidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0.07
Oligochaeta	0	0	96	0	0	0	48	0	16	16	0	32	0	0	3072	3.25
Chaetognatha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.02
Abundance (No/m ²)	48	832	976	1152	11328	5392	4608	17120	3744	8928	800	11008	2480	2368	94640	100.00

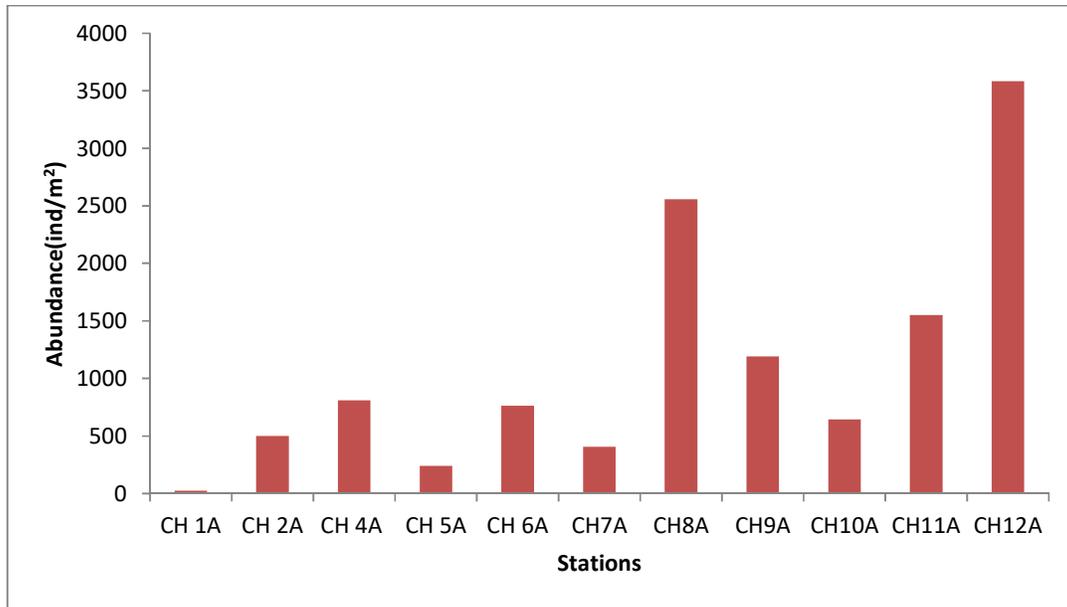


Figure 4.19: Station-wise macrofaunal abundance (no/m2) of the Chapora Estuary (Central transect).

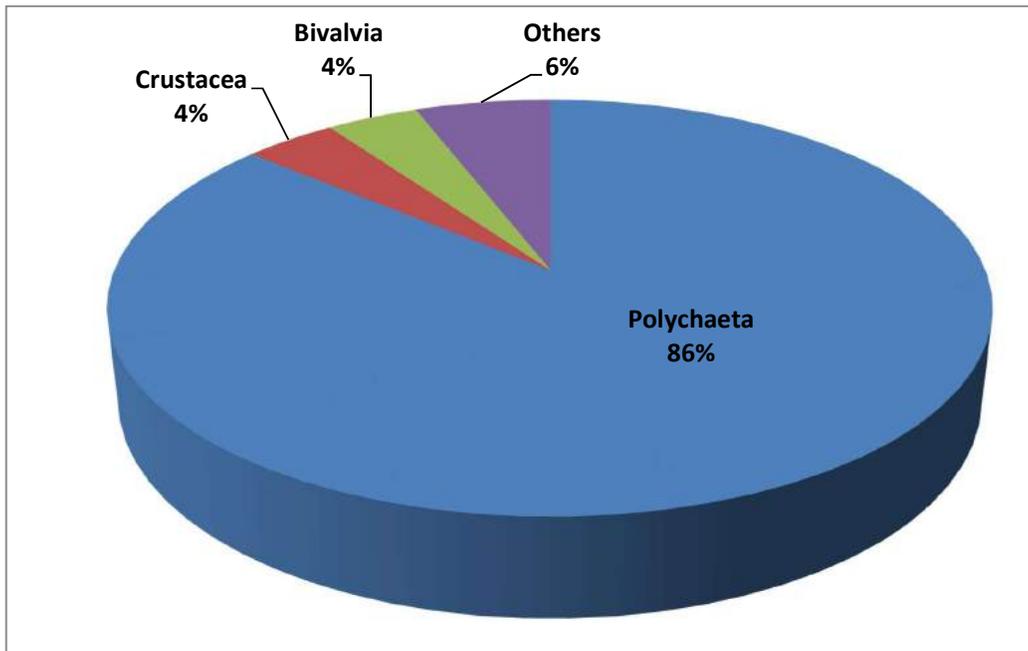


Figure 4.20: Percent (%) composition of macrofaunal abundance of the Chapora Estuary (Central transect).

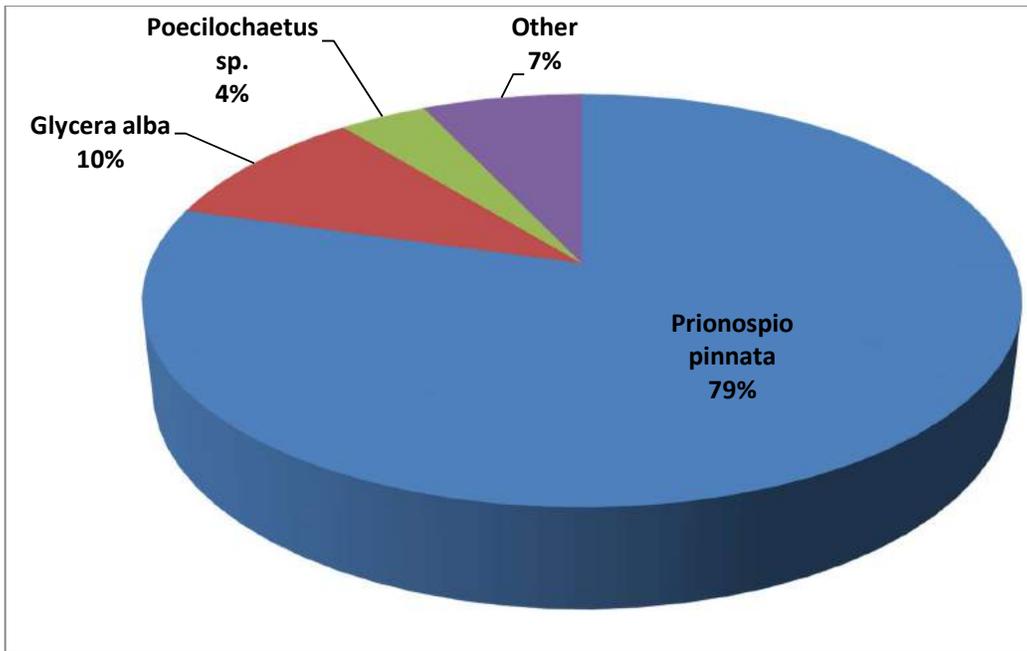


Figure 4.21: Percent (%) composition of Polychaeta of the Chapora Estuary (Central transect).

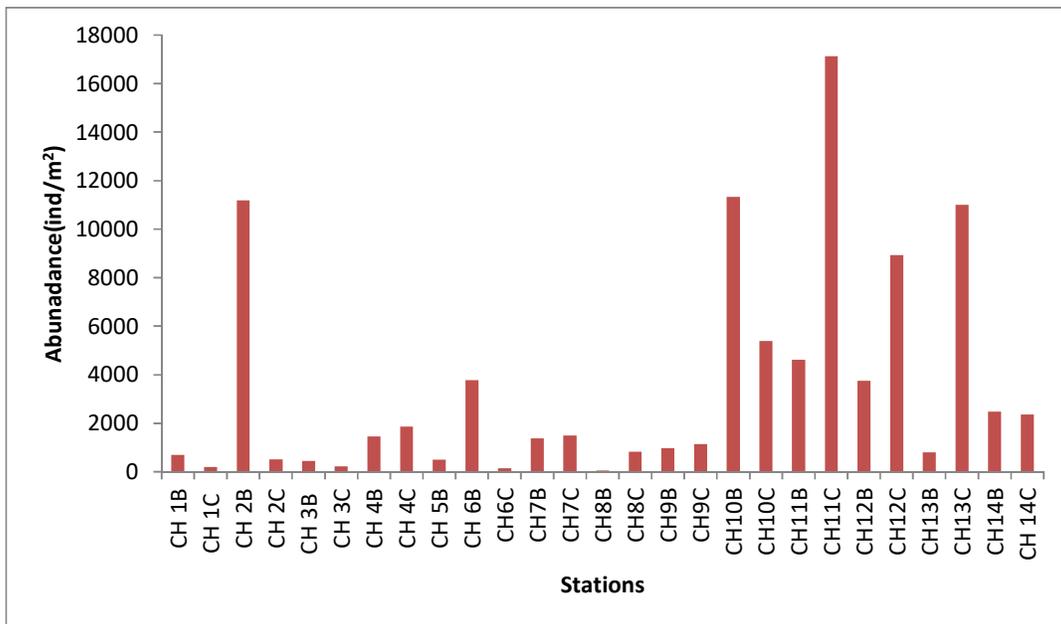


Figure 4.22: Station-wise macrofaunal abundance (no/m²) of the Chapora Estuary (Peripheral transect)..

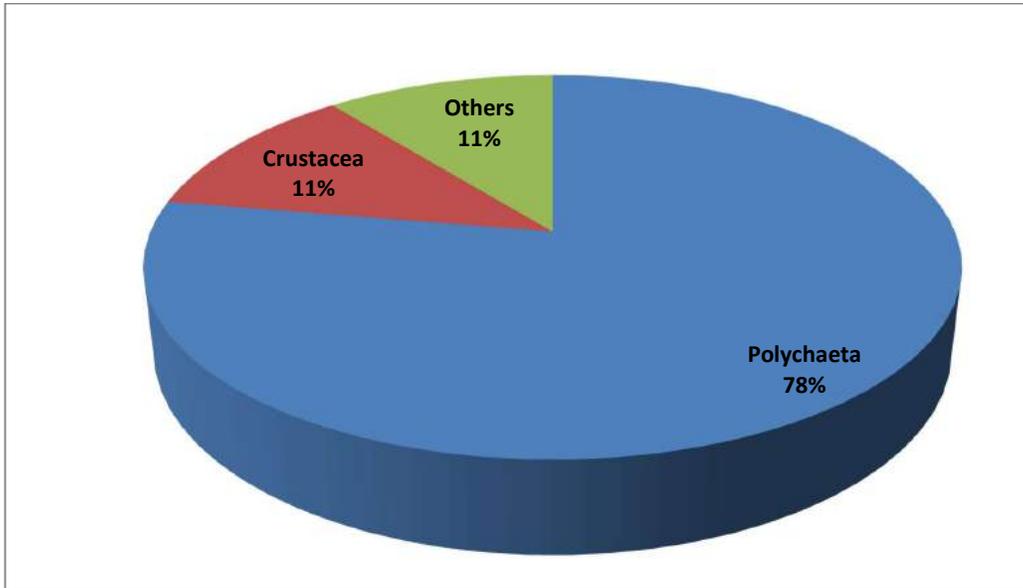


Figure 4.23: Percent (%) composition of macrofaunal abundance of the Chapora Estuary (Peripheral transect).

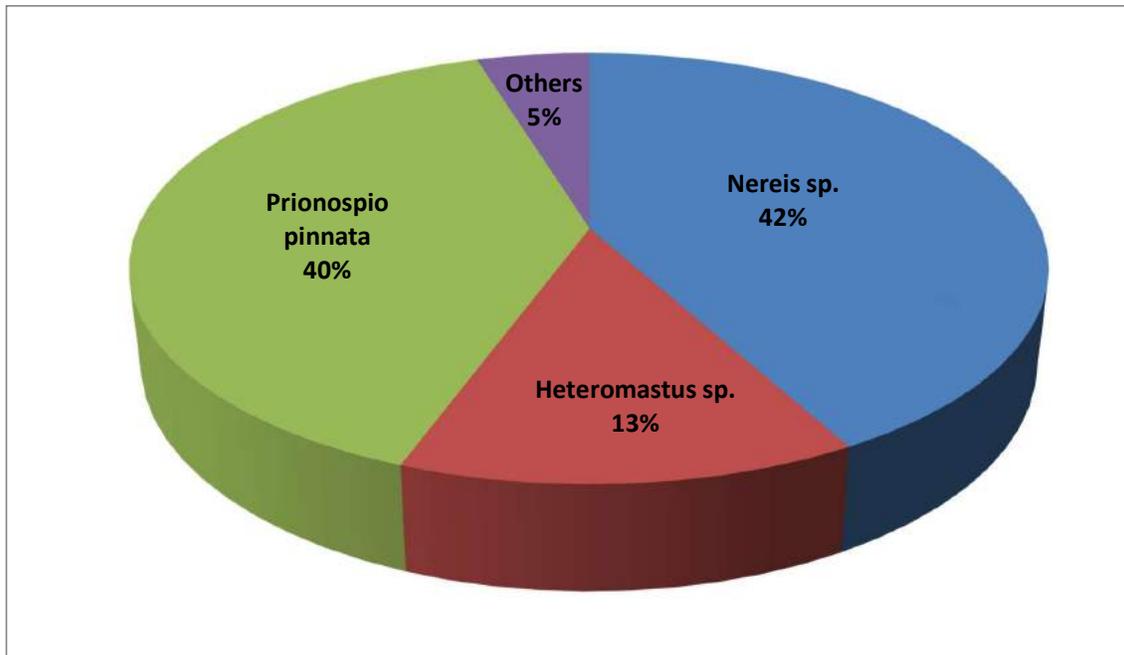


Figure 4.24: Percent (%) composition of Polychaeta of the Chapora Estuary (Peripheral transect).

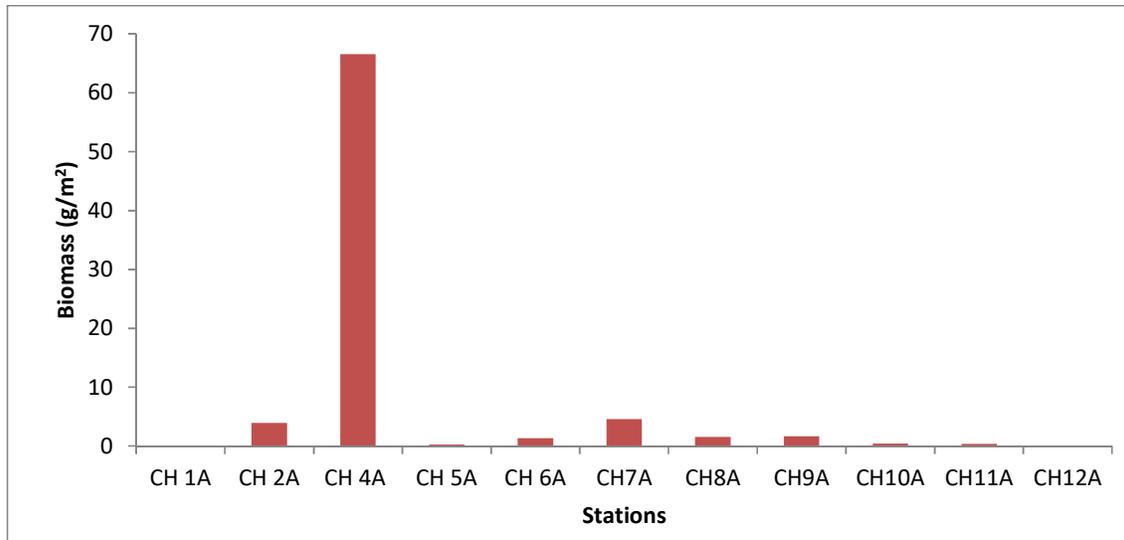


Figure 4.25: Station-wise Biomass (g/m²) of the centre of the Chapora Estuary.

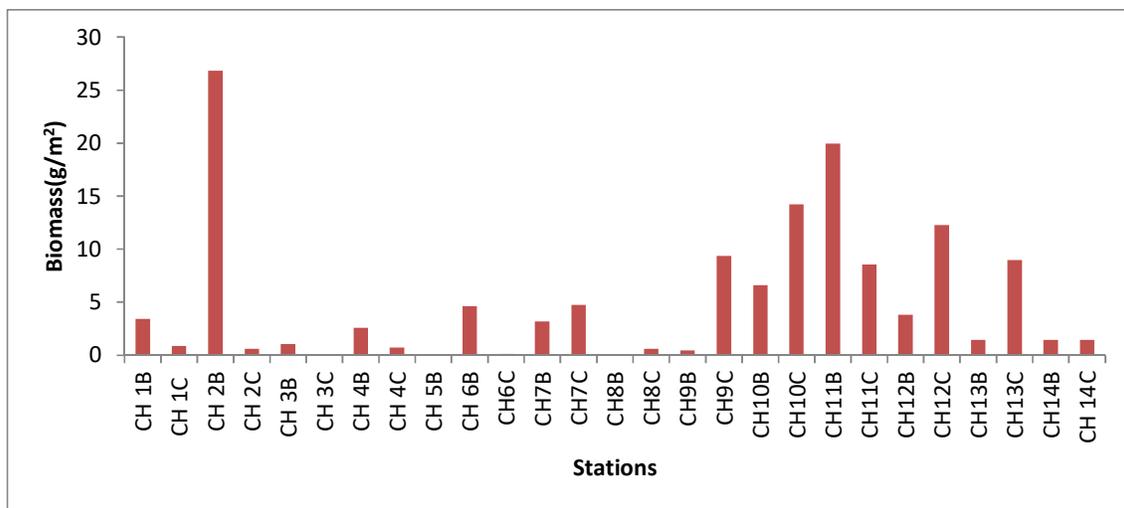


Figure 4.26: Station-wise Biomass (g/m²) of the Chapora Estuary (Peripheral transect).



Plate 4: Macrofauna of Chapora Estuary A-*Prionospio pinnata*; B-*Heteromastus* sp.; C-*Glycera alba*; D- *Inemoptys inermis*; D-; E-Nemertea; F- Bivalvia



4.5.6 Diversity indices

Diversity indices are the mathematical expression of the species diversity of a given community or area, which includes due allowance for the relative abundance of different species present.

Shannon-Wiener index of diversity:

Shannon-Wiener index of diversity (information index), a measure derived from information theories developed by Shannon & Wiener (1949), which is used by ecologists when a system contains too many individuals for each to be identified and examined. A small sample is used; the index is the ratio of the number of species to their importance values (e.g. biomass or productivity) within a trophic level or community. This normalizes the Shannon diversity index to a value between 0 and 1. The lower values indicate more diversity while higher values indicate less diversity. Specifically, an index value of 1 means all groups has the same frequency.

Simpson's Diversity Index:

Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so diversity increases. The value of Simpson's Diversity Index (D) ranges between 0 and 1, the greater the sample diversity.

The macrofaunal diversity was explained in terms of number of individuals or specimens (N), number of species (S), total abundance (A), Margalef species richness (d), Pielou's evenness (J') and Shannon index (H') and Simpson index (1-lambda') using square root scale at each CHA stations (Clarke & Gorley, 2001). The number of species were maximum at station CH8A (119) and minimum at station CH1A (5). The species richness (d) was highest at CH4A (d= 2.6) and lowest at CH1A (d= 0). Evenness was recorded highest at CH4A, CH6A & CH7A (J'=1) and lowest at CH1A (J'=0). The Shannon index was highest at CH4A (H'=2.5) and lowest at CH1A (H'=0) adjacent mangrove area could be the reason for high diversity at CH4A whereas CH1A depicted low diversity as it is located at the mouth channel which explains the lower value as maintenance dredging takes place for swift movement of vessels (Figure 4.26). The number of species were found to be maximum at station CH11 (202) and minimum at station CH03 (31). The species richness (d) was highest at CH02 (d= 2.2) and lowest at CH06 (d= 0.8).

Evenness was recorded highest at CH01 ($J'=1$) and lowest at CH10 ($J'=0.7$). The Shannon index was highest at CH02 ($H'=2.2$) and lowest at CH06 ($H'=1$) (Figure 4.27). CH02 is situated near the mouth with healthy mangrove forest adjacent to it, which explains high diversity. While CH06 lies where sand mining used to be carried out earlier which is why it is found to be low in diversity.

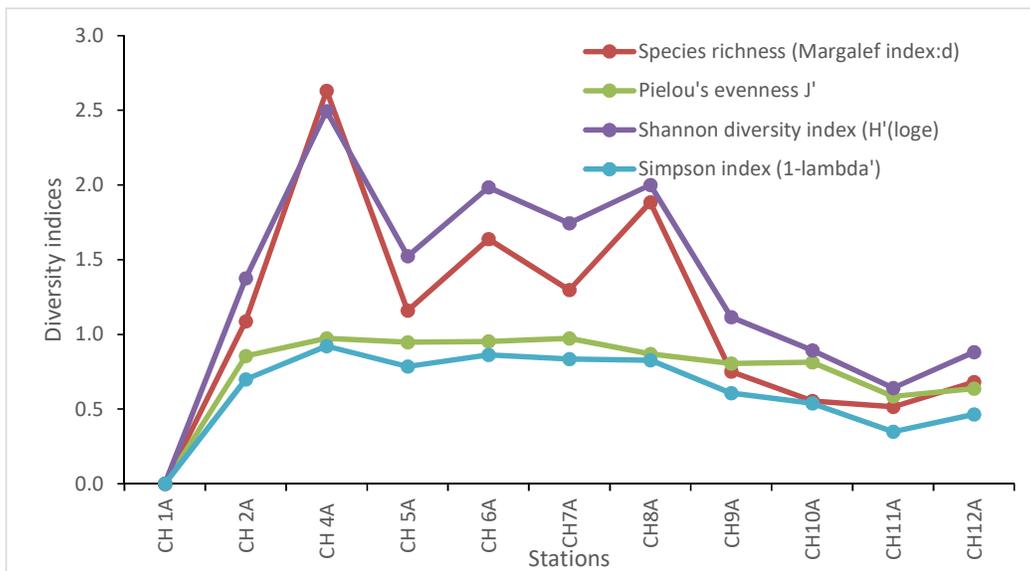


Figure 4.27: Station-wise diversity indices of Chapora Estuary (Central transect).

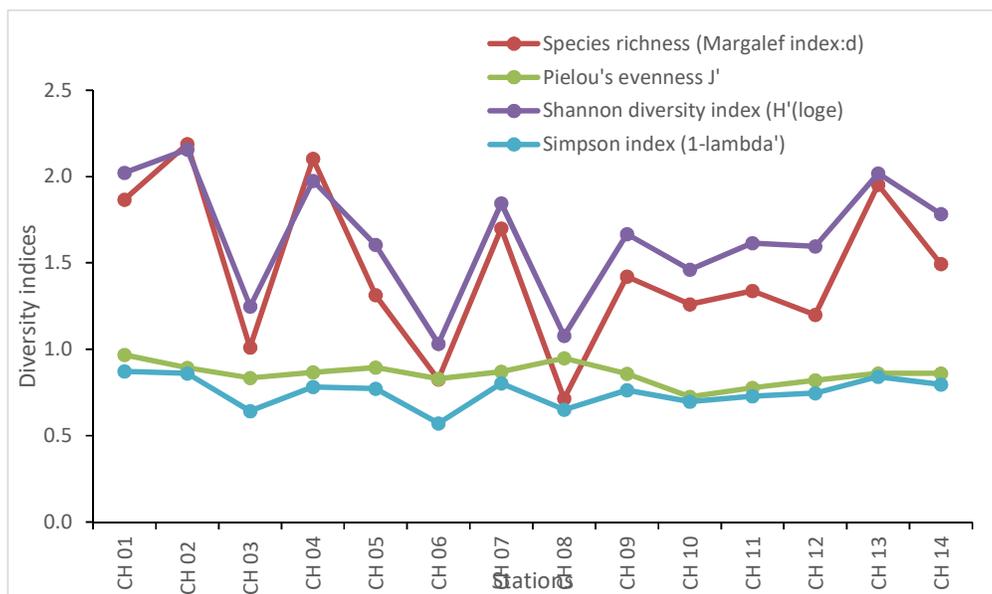


Figure 4.28: Station-wise diversity indices of Chapora Estuary (Peripheral transect).

Benthic Polychaeta: Amphipoda (BPA) Ratio:

To study the pollution status of the marine environment and to access the ecological quality status of the area, biotic indices like Benthic Polychaetes Amphipods Index (BPA) was done. This index was based on the ratio of sensitive amphipods to other fauna like annelids (polychaetes). The Benthic Polychaetes Amphipods Index (BPA) was determined by the lack of sensitive species among polychaetes from the study area. Amphipods are abundant fauna of the estuarine and marine soft-bottoms and they are sensitive to polluted sediments, they mainly disappear from benthic communities which is impacted by pollution and will reappear when the environmental condition recover (Ré *et al.*, 2009; de-la-Ossa-Carretero *et al.*, 2012).

The Benthic Polychaetes Amphipods ratio (BPA) index is given as:

$$BPA = \log_{10} [fp/(fa+ 1)+ 1]$$

Where fp was the polychaete frequency and fa is the amphipod frequency and +1 used to prevent a total absence of amphipods and the other +1 used to prevent a total absence of opportunistic polychaetes. This index corresponded to the total number of polychaetes (or annelids) and total number of amphipods divided by the overall abundance accounted in a station sample. Thresholds for establishing the Ecological Quality status by each index, the values ranged as 0.025-0.130 (Good status), 0.130-0.199 (moderate status), 0.199-0.255 (poor status).

At the centre region of Chapora Estuary, the BPA ratio ranged from 0.307 to 0.47. At station CH4A, CH5A, CH6A and CH7A, the BPA ratio ranged from 0.30-0.0.39 (Table 4.11). The stations CH1, CH2A, CH3A, and CH8 to CH12A showed high values of the polychaete/amphipod ratio where there was absence or low abundance of amphipods and high abundance of polychaetes. *P.pinnata* of the family Spionidae dominated in the centre area, which is an opportunistic polychaete species. At the periphery region, the BPA ratio ranged from 0.02 to 0.30 at Station CH5B and CH6C (Table 4.12). *Heteromastus* sp. and *P. Pinnata* of the family Capitellidae and Spionidae dominated which are the opportunistic polychaetes.

Stations	Polychaeta/Amphipoda ratio
CH 1A	0.477
CH 2A	0.449
CH 4A	0.307
CH 5A	0.398
CH 6A	0.314



CH 7A	0.338
CH 8A	0.422
CH 9A	0.459
CH 10A	0.432
CH 11A	0.473
CH 12A	0.458

Table 4.12: Benthic Polychaete Amphipode (BPA) ratio of Chapora Estuary (Peripheral transect)

Stations	Polychaeta/Amphipoda ratio
CH 1B	0.218
CH 1C	0.243
CH 2B	0.268
CH 2C	0.243
CH 3B	0.293
CH 3C	0.058
CH 4B	0.255
CH 4C	0.039
CH 5B	0.027
CH 6B	0.299
CH 6C	0.301
CH 7B	0.037
CH 7C	0.178
CH 8B	0.125
CH 8C	0.280
CH 9B	0.268
CH 9C	0.257
CH 10B	0.193
CH 10C	0.298
CH 11B	0.285
CH 11C	0.249
CH 12B	0.274
CH 12C	0.244
CH 13B	0.224
CH 13C	0.174
CH 14B	0.173
CH 14C	0.273



Biotic indices

Ecological quality status assessment carried out by AMBI analysis based on the benthic polychaete diversity and abundance. This index assigned the most of the sampling sites as slightly disturbed to moderately disturbed. Only sites CH1B, CH2A, and CH5B were found to be undisturbed based on the AMBI results. According to M-AMBI, most of the sampled sites were assigned to poor ecological quality status. Sites CH1B, CH1C, CH2B, CH7A were in good status. Sites CH2A, CH5A, CH6A-6B, CH7B, CH8C, CH9C, CH10B and CH14C were showed moderate status.

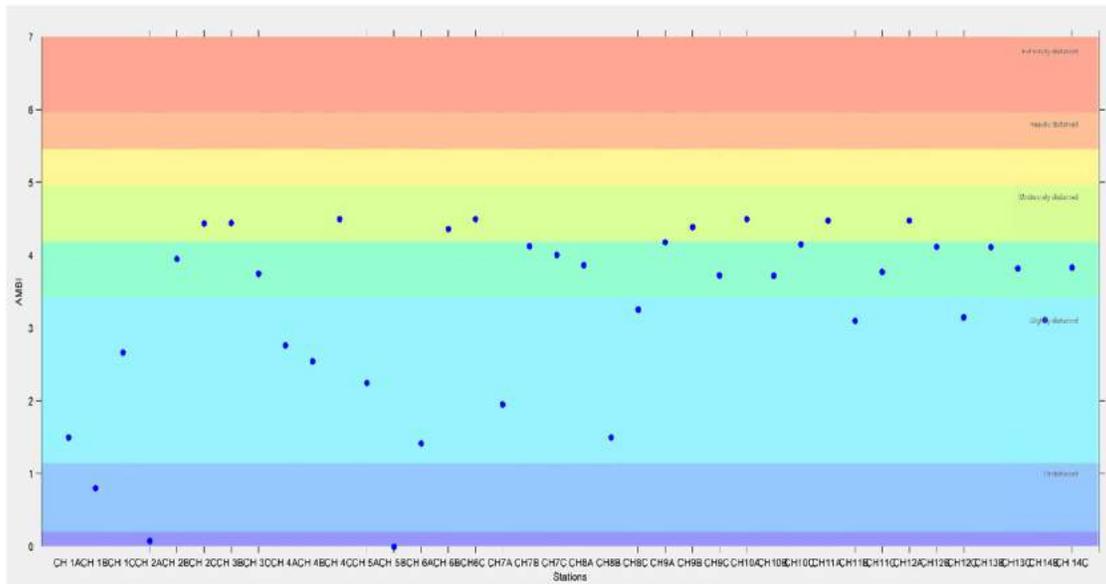


Figure 4.29: Ecological quality status assessment through AMBI index along the sampling sites.

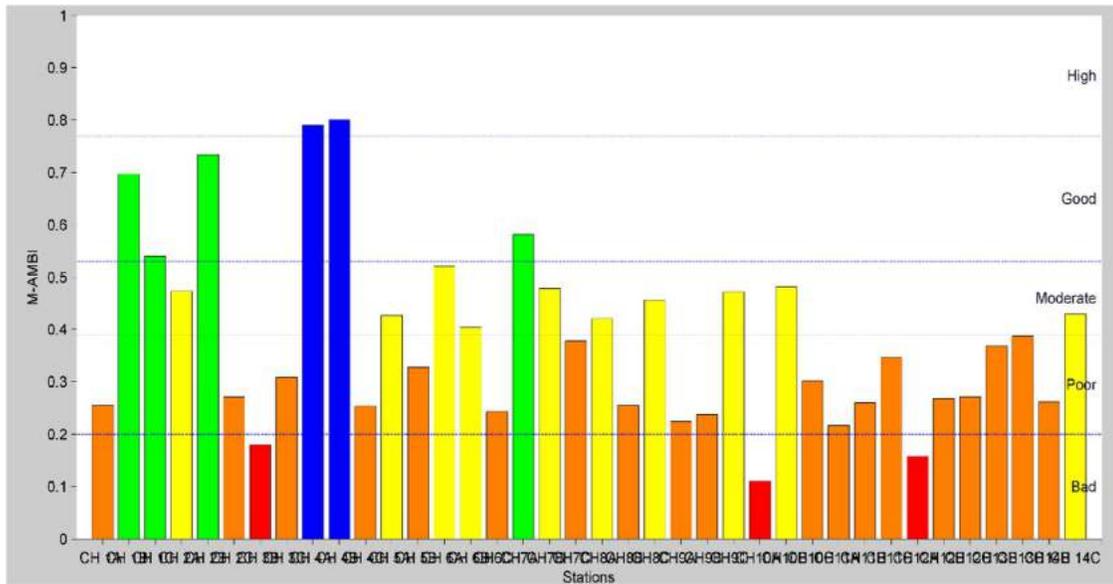


Figure 4.30: Ecological quality status assessment through M-AMBI index along the sampling sites.

BENTIX produced a poor status in most of the sites in the upper stretch of the Chapora Estuary, except the site CH14C, which displayed good ecological quality status. Sites in the lower stretch (Ch1-CH7) of the Chapora Estuary showed high to good ecological quality status due high diversity and abundance in benthic fauna. Site CH8 A and CH8C found as moderate ecological quality. Additionally, sampled sites in the lower stretch of the river were found to harbour more ecological sensitive benthic organisms, whereas the upper stretch was mostly dominated by the stress tolerant benthic organisms.

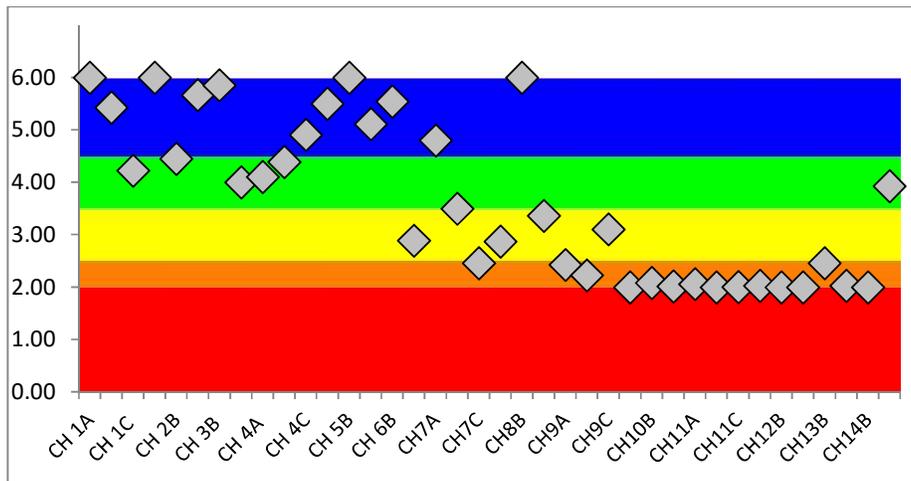


Figure 4.31: Ecological quality status assessment through BENTIX index along the sampling sites.

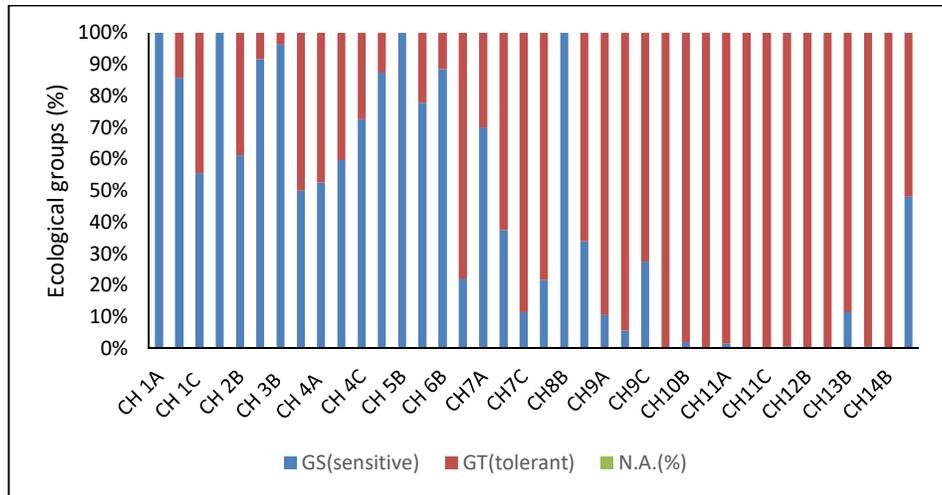


Figure 4.32: Distribution of macrobenthic- Polychaetes based on the ecological sensitivity group assessed through BENTIX index along the sampling sites.

4.5.7 Fishery:

Chapora is a fishing village which falls under the Village Panchayat of Anjuna-Assagao in Bardez taluka in North Goa district, Goa. The Chapora village is about 11 km from taluka headquarters at Mapusa and about 24 km from Panaji, the state capital. Coastal marine waters off Chapora and Chapora estuary is endowed with rich fishery resources and famous for fishing activities which are carried out through fibre reinforced plastic (FRP) outboard engines boats, trawlers and small size traditional dugout canoes. The secondary data for the fishes were collected from the locals and fishermen community around. Therefore, the secondary data reveals that commercially important fish varieties such as mackerels, sardines, catfish, sharks, seerfish, pomfrets, cuttlefish and prawns were found during trawling operations. The fishes found in this area represent marine, estuarine and backwater species. Fishing is mainly carried out with the help of mechanized and non-mechanized or traditional crafts in various parts of Goa. The methods of fishing in Chapora Estuary are of mainly by cast-nets, gill nets, stake nets, hook and line, shore seine (Rampani), purse seine, trawler, and free diving for the collection of clams, oysters and green mussels. Skate fishing is a common traditional fishing method used in the river creeks. It is pursued throughout the year, except the time of high tides during the monsoons. This type of fishing mainly depends upon the ebb and flow of tides and current of water, which differs from day to day. Secondary data of fishes is listed in the table. The shell fishery is common fishing practice used by the local people. Bivalve clams, *Meritrix casta* and *Paphia malbarica* were commonly found in the river. These clams were found throughout the year with variable quantities depending on season. Local

fishermen use to depend on these clams for their livelihood. These clams are collected and harvested by hand picking and hand operated scoop net or with the help of a small hand held digging sick. Locals use canoe to collect these clams from deeper waters. Other species found in this area are *Perna viridis*, *Polymesoda erosa* and *Villorita cyprinoides*. Oyster collection is one of the fishing practices carried out in the river by the local people. List of clams, oysters and mussels is given in table 4.13. Most common fish species found in estuarine and brackish water are *Etroplussuratensis*, *Mugilcephalus*, *Chanoschanos*, *Latescalcarifer* along with species of Red snapper, mud skippers and common shrimps found in this estuary include *Penaeusindicus*, *P. merguensis*, *P. monodon* etc (Source:, NIO 2017; Table 4.13). In the recent times, the clam fishery has almost collapsed in the estuary and according to local sources the overall fishery yield has reduced drastically.

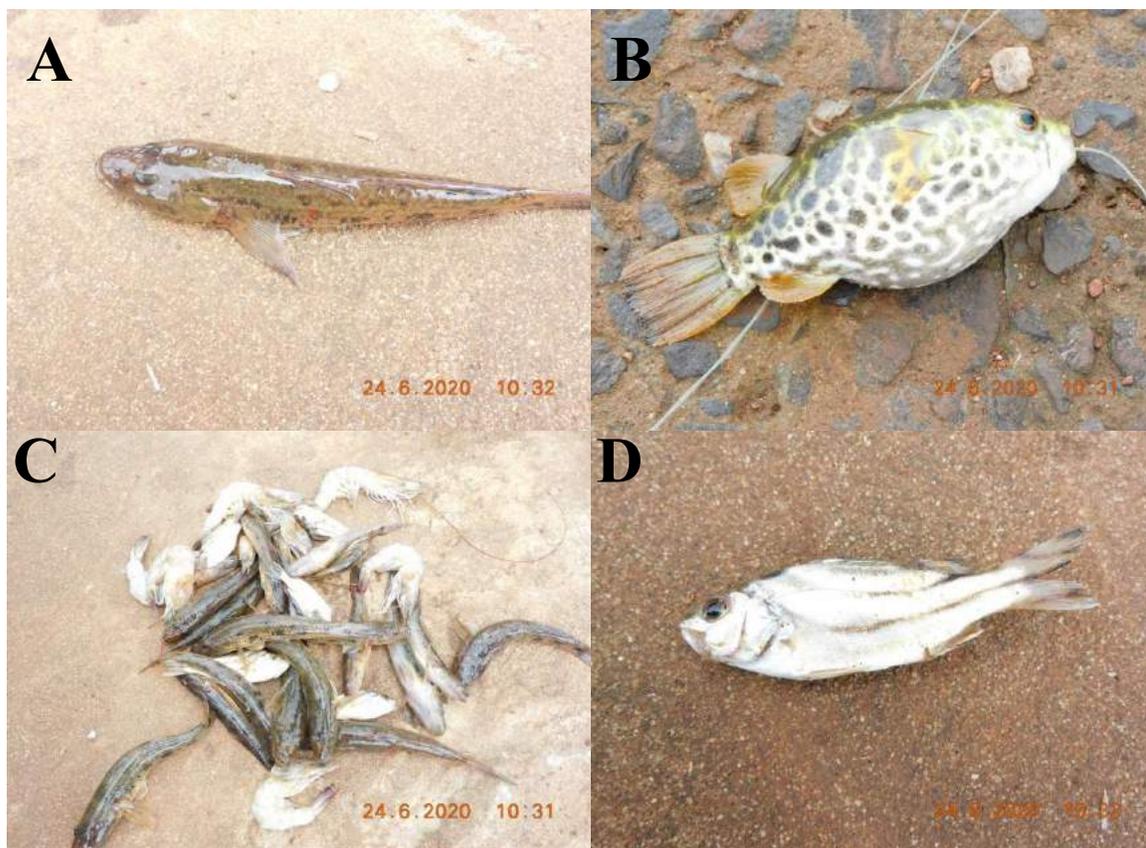


Plate 5: Fish species observed in Chapora estuary [A. Platycephalidae sp.; B.Tetraodontidae; C. Total catch; D. Terapontidae]

Families	Species	Common name	Vernacular name	Habitat class
Congridae	<i>Bathycongrusnasicus</i>	Eel	Vam	Demersal
Chirocentridae	<i>Chirocentrusdorab</i>	Wolf herring	Karli	Pelagic
Engraulidae	<i>Stolophorusindicus</i>	Indian anchovy	Dindvus	Pelagic
	<i>Thryssamalabarica</i>	Malabar thryssa	Khavali	Pelagic
Pristigasteridae	<i>Opisthopterustardoore</i>	Tardoore	Kateri	Pelagic
Ariidae	<i>Ariusjella</i>	Blackfin Sea catfish	Sangot	Demersal
Clupeidae	<i>Sardinellafimbriata</i>	Fringscale sardine	Pedi	Pelagic
Synodontidae	<i>Sauridatumbil</i>	Lizard fish	Bokalav	Demersal
Platycephalidae	<i>Eurycephaluscarbunculus</i>	Papilose flathead	-	Demersal
		Flat headed fish		Demersal
Ambassidae	<i>Ambassisgymnocephalus</i>	Bald glassy	Burato	Pelagic
Nemipteridae	<i>Nemipterusjaponicas</i>	Japanese threadfin bream	Rano	Demersal
Lutjanidae	<i>Lutjanuscampechanus</i>	Red snapper	Tamoshi	Pelagic
Mugilidae	<i>Mugilsp</i>	Mullet	Shevto	Pelagic
Serranidae		Grouper	Palu	Pelagic
Cichlidae	<i>Etroplussuratensis</i>	Pearl spot	Kalunder	Benthopelagic
Terapontidae	<i>Teraponjarbua</i>	Tiger perch		Pelagic
Tetraodontidae		Puffer fish		Pelagic
Gerridae	<i>Gerresfilamentosus</i>	Silver biddy	Shetuk	Demersal
Latidae	<i>Latescalcarifer</i>	Giant sea perch	Chonak	Demersal
Sillaginidae	<i>Sillagosihama</i>	Silver whiting	Muddoshi	Demersal
Sciaenidae	<i>Johniuscarouna</i>	Caroun croaker	Dhodiya	Demersal
Leiognathidae	<i>Otolithesruber</i>	Tiger toothed croaker	Dhodiya	Demersal



	<i>Secutorinsidiator</i>	Pugnose pony fish	Kapi	Demersal
Carangidae	<i>Secutorruconius</i>	Deep pugnose pony fish	Kapi	Demersal
	<i>Alepeskleinii</i>	Razorbellyscad	-	Pelagic
Polynemidae	<i>Caranxsp</i>		-	Pelagic
	<i>Polydactylusplebeius</i>	Stripped threadfin	Ravas	Pelagic
Trichiuridae	<i>Trichiuruslepturus</i>	Ribbon fish	Baye	Pelagic
Stromatidae	<i>Rastrelligerkanagurata</i>	Indian mackerel	Bangdo	Pelagic
	<i>Pampuschinensis</i>	Chinese pomfret	Surungati	BenthoPelagic
Lactariidae	<i>Lactariuslactarius</i>	White fish	Saudale	Pelagic
Solidae	<i>Synapturaalbomaculata</i>	Kaup's sole fish	Lepo	Demersal
Cynoglossidae		Flounder	lepo	Demersal
	<i>Cynoglossusarel</i>	Sole fish	Lepo	Demersal
Penaeidae	<i>C. macrostomus</i>	Malabar tongue sole	Lepo	Demersal
	<i>Penaeusmonodon</i>	Tiger shrimp	Vaghi	Demersal
Portunidae	<i>Fenneropenaeusmerguensis</i>	Banana prawn	Safedsungata	Demersal
	<i>Metapenaeusaffinis</i>	Jinga shrimp	Sungat	Demersal
	<i>Metapenaeusdobsonii</i>	Kadal shrimp	Sungat	Demersal
	<i>Meapeaneusmonoceros</i>	Speckled shrimp	Sungat	Demersal
	<i>Scylla serrata</i>	Mud crab	Kurlo	Demersal
Calappidae	<i>Portunussanguinolentus</i>	Three spot swimming crab	Tin doyanchikurli	Demersal
	<i>Portunuspelagicus</i>	Blue swimming crab	Padyachikurli	Demersal
	<i>Charybdis feriatus</i>	Crucifix crab	Khrusachikurli	Demersal
	<i>Matutalunaris</i>	Moon crab	Bhamburte	Demersal
Squillidae	<i>Calappalophos</i>	Box crab	-	
	<i>Oratosquillaquinquedentata</i>	Mantis shrimp	Luchi	Demersal

Diogenidae	<i>Pagurus sp.</i>	Hermit crab	-	Demersal
Ocupodidae		Fiddler crab		Demersal
Loliginidae	<i>Loligoduvauceli (Juv.)</i>	Indian squid	Manki	Demersal
Sepiidae	<i>Sepia sp. (Juv.)</i>	Cuttle fish	Bebo	Demersal
Naticidae	<i>Naticatigrina</i>	Tiger moon shell	Congo	Demersal
Cyrenidae	<i>Villoritacyprinoides</i>	Black clams	Khube	Benthic
Veneridae	<i>Polymesoda erosa</i>	Mud clam	Khube	Benthic
	<i>Meretrix meretrix</i>	Asiatic hard clam	Tissryo	Benthic
Ostreidae	<i>Meretrix casta</i>	Backwater hard clam	Tissryo	Benthic
	<i>Paphia malabarica</i>	Venus clams	Khube	Benthic
	<i>Paphia textilis</i>	Venus clams	Khube	Benthic
	<i>Crassostrea madrasensis</i>	Oyster	Kalva	Benthic
Mytilidae	<i>Crassostrea gigas</i>	Oyster	Kalva	Benthic
	<i>Saccostrea</i>	Oyster	Kalva	Benthic
	<i>Perna viridis</i>	Asian green mussel	Shenanyo	Benthic
Melongenidae	<i>Hemifusus pugilinus</i>	Sea snail	-	Demersal
Turritellidae	<i>Turritella acutangula</i>	Screw shell	Congali	Demersal
Rostellariidae	<i>Tibia curta</i>	Indian tibia	Congali	Demersal
Bursidae	<i>Bufo nariarana</i>	Frog shell	-	Demersal
Muricidae	<i>Murex aduncospinosus</i>	Spine murex	-	Demersal
Babyloniidae	<i>Babylonia spirata</i>	Whelks	-	Demersal
Conidae	<i>Conus sp.</i>	Cone shell	-	Demersal
Astropectinidae	<i>Astropecten indicus</i>	Star fish	-	Demersal
Rhizostomatidae	<i>Rhopilema spp.</i>	Jelly fish	Zar	Pelagic

4.5.8 Reptiles & Mammals:

Reptiles, such as estuarine crocodiles *Crocodylus palustris*, snakes, monitor lizards, turtles are found in Chapora Estuary. Morjim beach on the north of Chapora Bay is a protected site for Turtle nesting mainly the Olive Ridley sea turtles (*Lepidochelys olivacea*). Every year number of turtles visits this beach for breeding during October and hatchling emerges in March-April every year. Morjim was the first site in Goa where sea turtle conservation was started by the Forest Department in 1997. Mammals are mainly represented by Otters, jackals, flying fox,



wild cats and wild boar. These mammals visit mangroves for shelter, breeding or feeding on molluscs, crabs, fishes and other crustaceans (Table 4.14).

Sr. no.	Common name	Scientific name	IUCN status	Wildlife Protection Act (1972)
1	Smooth-coated otter	<i>Lutrogale perspicillata</i>	Vulnerable	Schedule II
2	Mugger crocodile	<i>Crocodylus palustris</i>	Vulnerable	Schedule I
3	Indian grey mongoose	<i>Herpestes edwardsi</i>	Least concern	Schedule II
4	Indian flapshell turtle	<i>Lissemys punctate punctata</i>	Least concern	Schedule I
5	Flying fox	<i>Pteropus medius</i>	Least concern	Schedule IV
6	Indian rock python	<i>Python molurus</i>	Near threatened	Schedule I
7	Golden jackal	<i>Canis aureus</i>	Least concern	Schedule II
8	Wild boar	<i>Sus scrofa</i>	Least concern	Schedule III

4.5.8 Avifauna:

Birds are the prominent part of the mangrove ecosystem and they are often present in large numbers. Many bird species make extensive use of mangroves for roosting, feeding and breeding. The mud flats, marshes provide abundant food to these birds in the form of small molluscs, crustaceans, worms, insects etc. Bird species such as kingfishers, Plovers, large Herons, Storks, Egret etc. were found feeding in the mangrove mudflats. It is common site for birds perched on mangroves for roosting or some waiting for an opportunity to catch a fish when they surface in the water. Besides mangroves many shore birds like Gulls were observed on sand bars at the mouth of the river for feeding purposes. Chapora Estuary also hosts a variety of migratory birds such as Painted stork, Heuglins gull, Caspian gull during the winter months. Large numbers of birds were seen during low tides. Eroded vertical banks of the upper stretches of the banks have burrow nests mostly by kingfishers and bee-eaters. List of birds found in Chapora estuary are given in table 4.15. (Ref: NIO Report, 2017 & <http://www.realbirder.com/Goa%20-%20Morjim%20Beach.htm>).



Table 4.15: List of Bird species spotted from Chapora Estuary

Sr.No.	Common name	Scientific name	IUCN status	Wildlife Protection Act 1972
1	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	Least Concern	Schedule IV
2	Lesser Cormorant	<i>Microcarbo niger</i>	Least Concern	Schedule IV
3	Red-wattled lapwing	<i>Vanellus indicus</i>	Least Concern	Schedule IV
4	black headed oriole	<i>Oriolus larvatus</i>	Least Concern	Schedule IV
5	Stock billed kingfisher	<i>Pelargopsis capensis</i>	Least Concern	Schedule IV
6	White breasted kingfisher	<i>Halcyon smyrnensis</i>	Least Concern	Schedule IV
7	Common kingfisher	<i>Alcedo atthis</i>	Least Concern	Schedule IV
8	Small green bee eater	<i>Merops orientalis</i>	Least Concern	Schedule IV
9	Painted stork	<i>Mycteria leucocephala</i>	Near Threatened	Schedule IV
10	White ibis	<i>Threskiornis melanocephalus</i>	Near Threatened	Schedule IV
11	Glossy ibis	<i>Plegadis falcinellus</i>	Least Concern	Schedule IV
12	Intermediate Egret	<i>Ardea intermedia</i>	Least Concern	Schedule IV
13	White breasted waterhen	<i>Amaurornis phoenicurus</i>	Least Concern	Schedule IV
14	Brahminy kite	<i>Haliastur indicus</i>	Least Concern	Schedule IV
15	White browed wagtail	<i>Motacilla maderaspatensis</i>	Least Concern	Schedule IV
16	House crow	<i>Corvus splendens</i>	Least Concern	Schedule V
17	Sand Plover	<i>Charadrius sp.</i>	Least Concern	Schedule IV
18	Bay-backed Shrike	<i>Lanius vittatus</i>	Least Concern	Schedule IV
19	Common Quail	<i>Coturnix coturnix</i>	Least Concern	Schedule IV
20	Ruddy Turnstone	<i>Arenaria interpres</i>	Least Concern	Schedule IV
21	Asian Koel	<i>Eudynamys scolopaceus</i>	Least Concern	Schedule IV
22	Common Sandpipers	<i>Actitis hypoleucos</i>	Least Concern	Schedule IV
23	Caspian Gull	<i>Larus cachinnas</i>	Least Concern	Schedule IV
24	Heuglin's Gull	<i>Larus heuglini</i>	Least Concern	Schedule IV
25	Steppe Gull	<i>Larus (heuglini) barabensis</i>	Least Concern	Schedule IV
26	Pallas's Gull	<i>Ichthyaeetus ichthyaeetus</i>	Least Concern	Schedule IV
27	Brown headed Gull	<i>Chroicocephalus brunnicephalus</i>	Least Concern	Schedule IV
28	Black headed Gull	<i>Chroicocephalus ridibundus</i>	Least Concern	Schedule IV
29	Gull-billed tern	<i>Gelochelidon nilotica</i>	Least Concern	Schedule IV
30	Greater Crested Tern	<i>Thalasseus bergii</i>	Least Concern	Schedule IV



31	White bellied Sea Eagle	<i>Haliaeetus leucogaster</i>	Least Concern	Schedule I
32	Osprey	<i>Pandion haliaetus</i>	Least Concern	Schedule I
33	Lesser whistling duck	<i>Dendrocygna javanica</i>	Least Concern	Schedule IV
34	Plain prinia	<i>Prinia inornata</i>	Least Concern	Schedule IV
35	Snipe	<i>Scolopacidae</i>	Least Concern	Schedule IV
36	Terek sandpiper	<i>Xenus cinereus</i>	Least Concern	Schedule IV
37	Little Egret	<i>Egretta garzetta</i>	Least Concern	Schedule IV
38	Western Reef-egret	<i>Egretta gularis</i>	Least Concern	Schedule IV
39	Great Egret	<i>Ardea alba</i>	Least Concern	Schedule IV
40	Eastern Cattle Egret	<i>Bubulcus ibis coromandus</i>	Least Concern	Schedule IV
41	Indian Pond-heron	<i>Ardeola grayii</i>	Least Concern	Schedule IV
42	Black-crowned Night-heron	<i>Nycticorax nycticorax</i>	Least Concern	Schedule IV
43	Black-shouldered kite	<i>Elanus caeruleus</i>	Least Concern	Schedule IV
44	Black kite	<i>Milvus migrans</i>	Least Concern	Schedule IV
45	Common Kestrel	<i>Falco tinnunculus</i>	Least Concern	Schedule IV
46	Kentish plover	<i>Charadrius alexandrinus</i>	Least Concern	Schedule IV
47	Lesser Sand Plover	<i>Charadrius mongolus</i>	Least Concern	Schedule IV
48	Greater Sand Plover	<i>Charadrius leschenaultii</i>	Least Concern	Schedule IV
49	Caspian Sand Plover	<i>Charadrius asiaticus</i>	Least Concern	Schedule IV
50	Common Redshank	<i>Tringa totanus</i>	Least Concern	Schedule IV
51	Common Greenshank	<i>Tringa nebularia</i>	Least Concern	Schedule IV
52	Common Sandpiper	<i>Actitis hypoleucos</i>	Least Concern	Schedule IV
53	Ruddy Turnstone	<i>Arenaria interpres</i>	Least Concern	Schedule IV
54	Slender-billed Gull	<i>Larus genei</i>	Least Concern	Schedule IV
55	Gull-billed Tern	<i>Sterna nilotica</i>	Least Concern	Schedule IV
56	Lesser Crested Tern	<i>Thalasseus bengalensis</i>	Least Concern	Schedule IV
57	Sandwich Tern	<i>Thalasseus sandvicensis</i>	Least Concern	Schedule IV
58	Plum-headed Parakeet	<i>Psittacula cyanocephala</i>	Least Concern	Schedule IV
59	Southern (Greater) Coucal	<i>Centropus sinensis parroti</i>	Least Concern	Schedule IV
60	Spotted Owlet	<i>Athene brama</i>	Least Concern	Schedule IV
61	Black-capped Kingfisher	<i>Halcyon pileata</i>	Least Concern	Schedule IV
62	Indian Roller	<i>Coracias benghalensis</i>	Least Concern	Schedule IV
63	Malabar Lark	<i>Galerida malabarica</i>	Least Concern	Schedule IV
64	Eurasian Swallow	<i>Hirundo rustica</i>	Least Concern	Schedule IV



65	Wire-tailed Swallow	<i>Hirundo smithii</i>	Least Concern	Schedule IV
66	Red-rumped Swallow	<i>Hirundo daurica rufula</i>	Least Concern	Schedule IV
67	Richard's Pipit	<i>Anthus richardi</i>	Least Concern	Schedule IV
68	Paddy field Pipit	<i>Anthus rufulus</i>	Least Concern	Schedule IV
69	Common Iora	<i>Aegithina tiphia</i>	Least Concern	Schedule IV
70	Pied Bushchat	<i>Saxicola caprata</i>	Least Concern	Schedule IV
71	Grey-breasted Prinia	<i>Prinia hodgsonii</i>	Least Concern	Schedule IV
72	Clamorous Reed-warbler	<i>Acrocephalus stentoreus</i>	Least Concern	Schedule IV
73	Common Tailorbird	<i>Orthotomus sutorius</i>	Least Concern	Schedule IV
74	Asian Brown Flycatcher	<i>Muscicapa dauurica</i>	Least Concern	Schedule IV
75	Black-lored Tit	<i>Parus xanthogenys</i>	Least Concern	Schedule IV
76	Long-tailed Shrike	<i>Lanius schach</i>	Least Concern	Schedule IV
77	Brahminy Starling	<i>Sturnus pagodarum</i>	Least Concern	Schedule IV
78	Rosy Starling	<i>Sturnus roseus</i>	Least Concern	Schedule IV
79	Common Myna	<i>Acridotheres tristis</i>	Least Concern	Schedule IV

4.5.9 Riparian Vegetation:

A riparian zone is the interface between land and water bodies, including streams, rivers, lakes and estuarine marine shores. Riparian zones can therefore be considered as a transitional belt between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota (National Research Council, U.S, 2002).

A riparian zone is often a habitat for rare species and it is also a breeding ground for aquatic fauna such as fish and invertebrates (Naiman *et al.*, 2005). Loss of riparian vegetation can decrease the amount of suitable habitat for riparian and aquatic fauna such as fish and invertebrates, thereby reducing stream productivity and fish carrying capacity (Karen, M. & Karen, S., 1998). Riparian vegetation has many critical functions; it provides resistance to flowing water as well as to runoff during floods. The vegetation provides protective cover which helps to absorb the forces exerted by flowing water (Watson & Basher, 2006). Riparian plant canopies intercept, store and evaporate a portion of precipitation and have an important role in influencing stream temperature and the health of aquatic species (National Research Council, U.S., 2002).

A considerable change in riparian zone of the river is evident. . Increased urbanisation, especially in the coastal areas and river fronts is visible as well as many areas having increased accessibility by roads. Apart from expansion of villages and increase in urban areas, forest area has reduced and vegetation cover changes are evident as many natural habitats are converted to orchards and plantation. In the upstream half of the river, the vegetation and plantations are unsuccessful in protecting the banks from erosion. In the stretches of the river wherever there are soft muddy and silty banks, erosion has taken away a part of land while taking with it the riparian vegetation as well and leaving behind vertical banks. These vertical banks remain vulnerable to erosion and it is extremely important to protection these banks urgently.

Downstream part of the river has more saline influenced waters with higher salinity compared to upper stretches. Thus most of the areas have been protected by embankments traditionally. These embankments require constant repair and maintenance, as the terrestrial part of it is used for paddy cultivation and building houses. In the downstream areas, many parts of the riparian zone have been intruded by salinity and now converted to saline marsh lands, mudflats or mangroves. This is one of the most significant land use changes noted for this river. The present land use of the riparian zone of the River is shown in Figure 4.33.

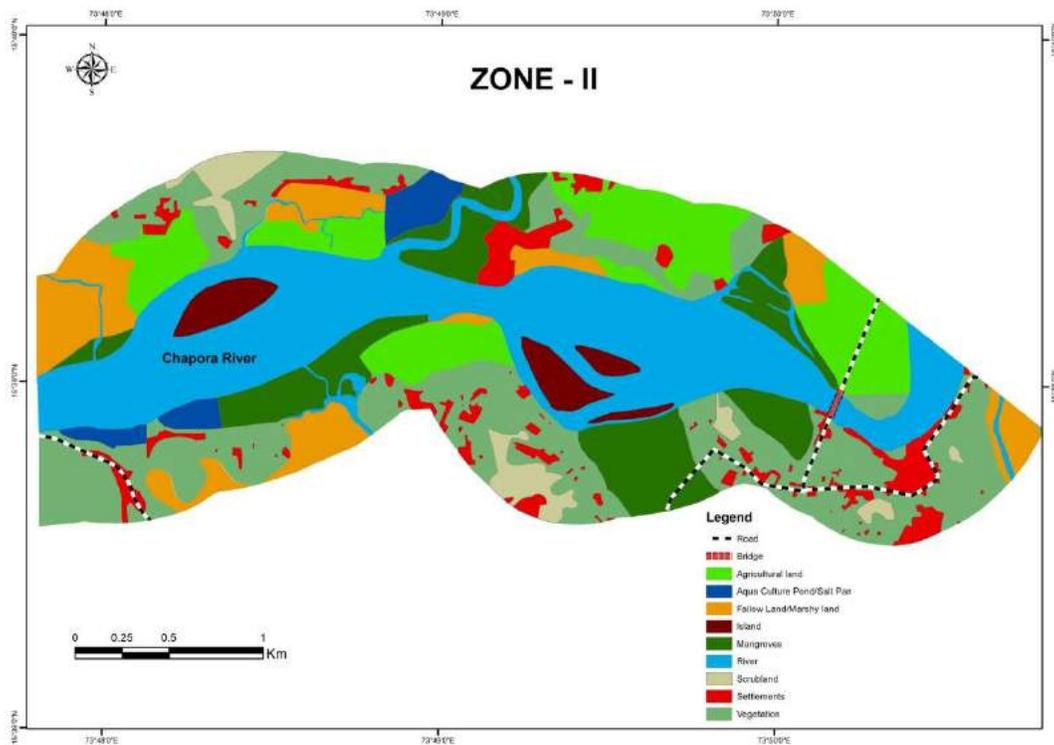
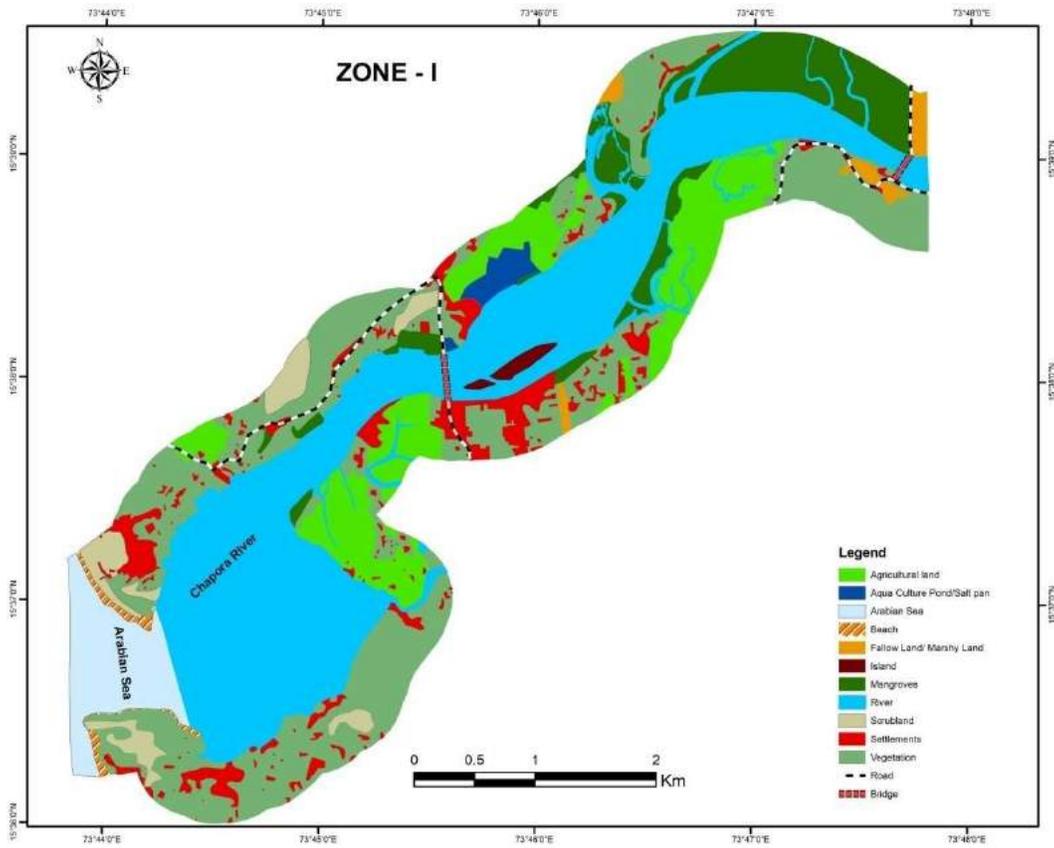
The riparian vegetation along the banks of the river in the upstream stretches consist of typical tropical deciduous species typical to this region and the department of forest categorises this region under open forest (<https://fsi.nic.in/isfr19/vol2/isfr-2019-vol-ii-go.pdf>). The area is predominantly planted with *Cocos nucifera* and mostly represented by species of *Terminalia* spp., *Ficus* spp., *Syzygium cumini*, *Careya arborea*, *Mangifera india*, *Anacardium occidentale*, *Xylia xylocarpa*, *Caesalpinia* spp., *Bauhinia* spp. and *Bombax ceiba* along with several species of bamboos, shrubs, herbs and grasses.

The river bank in the upstream areas (with mostly narrow mudflats) have grasses such as *Cyprus* sp./ *Typha* sp. (Plate 5) which have ability to resist some salinity. Although grasses are known to offer protection from erosion, these grasses may not be able to resist strong current which is visible from the eroded bank stretches in the upstream regions which have also uprooted larger trees (mostly coconut palms).



There are few notable species which have invaded this region and may pose threat to the native vegetation in the long run. Some of the plants were *Chromolaena odorata*, *Cassia tora*, *Ageratina adenophora*, *Triumfetta rhomboidea* and *Acacia farnesiana* (<https://fsi.nic.in/isfr19/vol2/isfr-2019-vol-ii-go.pdf>).

The Chapora estuary has an area of 16.63 square kilometres. Agricultural land makes up 12.9%, Aquaculture Pond/Salt pans are 0.9%, Fallow land 2.89%, Islands 1.3%, Mangroves 6.5%, Scrubland 4.5%, Settlements 6.7%, Vegetation 35.5% and water body 0.01%. (Table 4.16). Mangroves have invaded agricultural land resulting in increase in cover of mangroves and hence have to be managed.



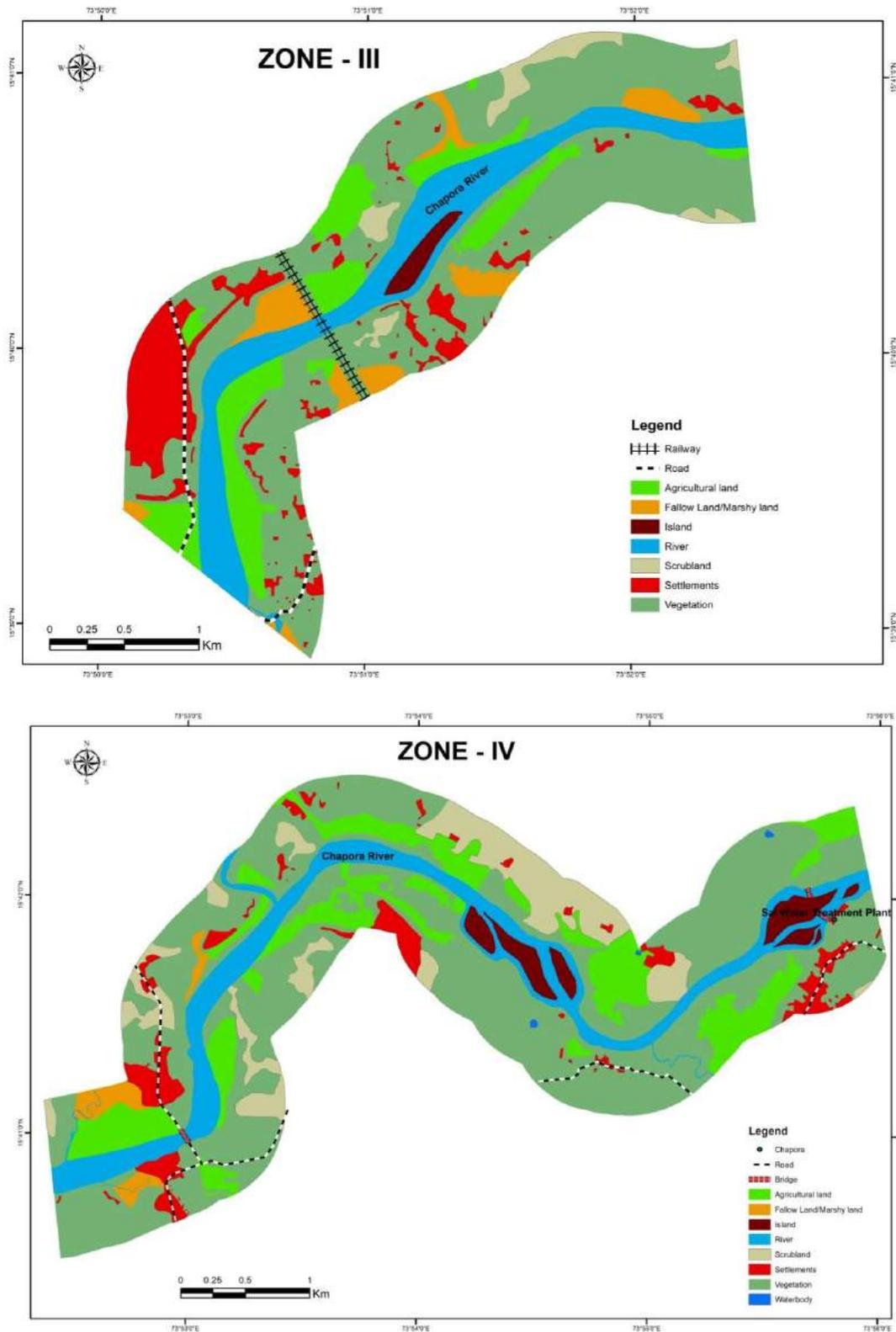


Figure 4.33: LULC Map of Chapora Estuary (Divided in 4 zones, image used LISS-IV, December 2019)



Sl:No:	LULC Class	Area in Square Kilometers	Percentage Area
1	Agricultural land	7.49	12.9
2	Aqua Culture Pond/Salt Pans	0.49	0.9
3	Fallow land	1.67	2.89
4	Island	0.77	1.3
5	Mangroves	3.75	6.5
6	River(Chapora)	16.63	28.8
7	Scrubland	2.55	4.5
8	Settlements	3.85	6.7
9	Vegetation	20.51	35.5
10	Waterbody	0.008	0.01
Total		57.718	100



4.5.10 Seaweeds & Grass (Halo tolerant):

Seaweeds or macroalgae are the marine algae which found either on marine or brackish environments. Depend on their pigments they are classified into three types; Red Algae (Rhodophyta), Brown Algae (Phaeophyta) and Green Algae (Chlorophyta). Most commonly they inhabit the littoral zone preferably rocky shores as they are attached to the substratum. Some species of seaweeds are edible and are commercially important as they are cultivated for food, medicine, fertilizer and are considered as one of the potential source of bioethanol. Some of the examples are: *Ulva* sp., *Sargassum* sp., *Padina* sp., *Caulerpa* sp. Common species of sea weeds was found in the mouth of the estuary, as these species inhabit pools in the littoral zone typically with clayey, silty and sandy sediment. A typical grass was found along the periphery of the river (Table 4.17).

Sl. No.	Seaweeds/Grass (Halo tolerant)
1	<i>Padina</i> sp.
2	<i>Dictyota</i> sp.
3	<i>Cyperus</i> sp



Plate 6: Representative Seaweed and grass sample from Chapora Estuary.

4.5.11 Sand Dune Vegetation:

Sand dunes are a mound, hilly or ridge of sand formed mainly by Aeolian action that lies behind the beach affected by tides. They are formed over many years when windblown sand is trapped by beach grass or other stationary objects. Dune grasses anchor the dunes with their roots, holding them temporarily in place, while their leaves trap sand promoting dune expansion. Without vegetation, wind and waves regularly change the form and location of dunes. Sand dunes provide sand storage and supply for adjacent beaches. They also protect inland areas from storm surges, hurricanes, floodwater, and wind and wave action that can damage property.

Sand dunes arrest blowing sand, deflect wind upwards, assist in the retention of fresh water and protect the hinterland from attack by waves, cyclones and storm surges and thus obstruct the ingress of saline marine water into the hinterland, and thus protecting the inland low lying



areas and terrestrial ecosystem from strong wave actions and tide surges. Dune vegetation helps in dune stability however, is vulnerable to even slightest interference due to its fragility. Moreover, sandy stretches including dune vegetation contain many species of specific flora (and fauna).

Sand dunes, especially if covered by dune vegetation which acts as sand binders, preclude loose sand from advancing inland on the coastal zone, thus menacing coastal populations and structures.

Sand dunes support an array of organisms by providing nesting habitat for coastal bird species including migratory birds. Sand dunes are also habitat for coastal halophilic vegetation. Increased tourism foot traffic, and removal of plant species can cause destruction of dunes and erosion. Sand dunes are of various sizes, shapes and the size depends on two factors, namely, physical and biotic factor. The physical factors are the speed of wind, the prevailing wind directions, wave regime, the amount of sand available, the size of the sand, the sand supply from the beach and offshore bars whereas the biotic factor are plant succession and grazing pressure.

Below the Chapora fort, and especially at Vagator, low sand dunes are common over a limited stretch.

The coastal stretch is thickly vegetated by coconut trees. At Morjim, a long strip which terminates at the mouth of river Chapora is marked by rows of sand dunes with dune vegetation, being more pronounced in the southern part. The Morjim area which has been protected from anthropogenic disturbances is one of beaches used as nesting site by Olive Ridley's Turtle. But in recent times, increase in tourism, beach huts and shacks have occupied many parts of this pristine habitat and has resulted in drastic reduction of dune vegetation. These dunes have very patchy distribution of *Ipomea* sp. and *Vitex* sp. followed by large trees (eg: Coconut) in the hind dune region. Thus it is imperative to conserve sand dunes and development has to be regulated.



4.5.12 Mangrove:

India has 4827 km of mangrove cover out of which only 23% is present on West Coast of India. Altogether, 69 species of mangroves belonging to 25 families and 43 genera have been reported from Indian Coast. On the West Coast, rich mangrove habitat can be observed along Gujarat Coast in Gulf of Kutch and Gulf of Khambat which is approximately 80% of total mangrove cover of West Coast and 23% that of India. Reported 370 km of mangrove cover in Gujarat which is now increased in last two decades due to declaration of Marine National Park in Gulf of Kutch in 1983. Though mangrove cover is more in Gujarat state (1058 km), species diversity is limited to nine species; on the other hand, species diversity is more in Maharashtra, Goa, Karnataka and Kerala state. Mangroves show various specialized root structures for support, oxygen supply and sediment accumulation. Some of the mangroves like *Kandelia candel* adapt buttresses root system which not only helps in balancing but also cover wide area for long distance transport of water, nutrients and metabolites. A total of eleven mangrove species and four mangrove associates have been recorded from the Chapora estuary (Table 4.18).

From the historic images (Google Earth) it can be noted that mangrove vegetation has increased over the years. The mudflats and paddy fields have been established by new grown mangrove forest and many areas are in progression of converting into mangrove habitat. It can be noted that the dominance of mangroves has been a major change in land use in Chapora estuaries' downstream stretch. There can be several reasons for this change of land use viz; non-maintenance of embankments, extreme weather events, tidal surges, flooding, sand mining and dredging activity.

Sr. No.	True mangrove species	Mangrove associate species
1	<i>Avicennia marina</i>	<i>Clerodendrum inerme</i>
2	<i>Avicennia officinalis</i>	<i>Derris heterophylla</i>
3	<i>Rhizophoramucronata</i>	<i>Porterasiacoaretata</i>
4	<i>Kandeliacandel</i>	<i>Calophylluminophyllum</i>
5	<i>Sonneratiacaseolaris</i>	<i>Acrostichum aureum</i>
6	<i>Sonneartia alba</i>	
7	<i>Cerriopstagal</i>	
8	<i>Brugieracylindrica</i>	

9	<i>Aegicerascorniculata</i>	
10	<i>Acanthus ilicifolius</i>	
11	<i>Excoecariaagallocha</i>	

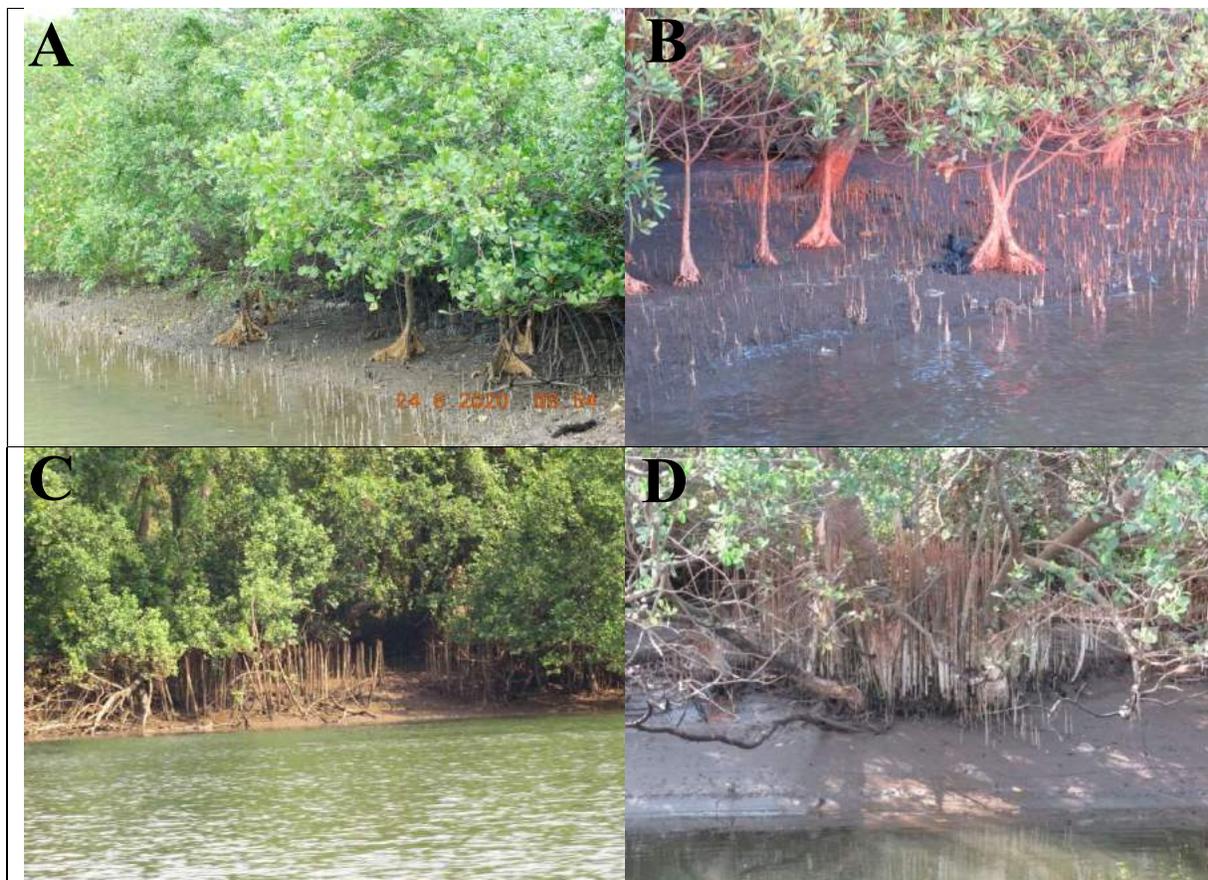


Plate 7: Mangroves from Chapora estuary



CHAPTER- 5 MODELLING- CLIMATOLOGY & METEOROLOGY

The meteorological data is important to understand the meteorological and climatic conditions of the study area for the evaluation of impacts of the proposed project. Historical data on meteorological parameters also plays an important role in identifying the synoptic meteorological regime of the region.

Climate: Climatic conditions in the district are strongly influenced by its geographical conditions. The district falls under the 'Assured and High Rainfall zone'. The climate is generally humid, oppressive weather in the hot months and high humidity throughout the year. The winter season is from December to February, followed by summer from March to May. June to September is the south-west monsoon, while, October and November constitute the post-monsoon season. December is the coldest month with mean daily maximum temperature at 32.7 °C and the mean daily minimum temperature at 18.7 °C. April is the hottest month. The relative humidity during the south-west monsoon is very high (86 to 90%). The relative humidity during winter and summer months is also >57%.

Winds: Winds are very strong and blow from west or south-west during the monsoon season. During October-December, the winds are generally moderate and blow from directions between north-east and south-west. In the three months from January to March the winds continue to be moderate and are predominantly from directions between south-west and northwest. Sometimes associated with cyclonic storms in the Arabian Sea in the post-monsoon months and to a lesser extent in May, the region experiences powerful winds, occasionally reaching gale force with widespread heavy rain.

River Discharge: The data obtained from secondary source shows that during Dry season (October–May), monthly freshwater input was less than 8 m³/s.

Rainfall: Pernem rainfall station data is obtained from IMD. Pernem is located near the Chapora Estuary. The average annual rainfall (2010-2019) over Pernem, North Goa, is about 3546 mm. The maximum precipitation occurs within June- September. The monthly rainfall data at Pernem, North Goa, is presented in Figure 5.1.

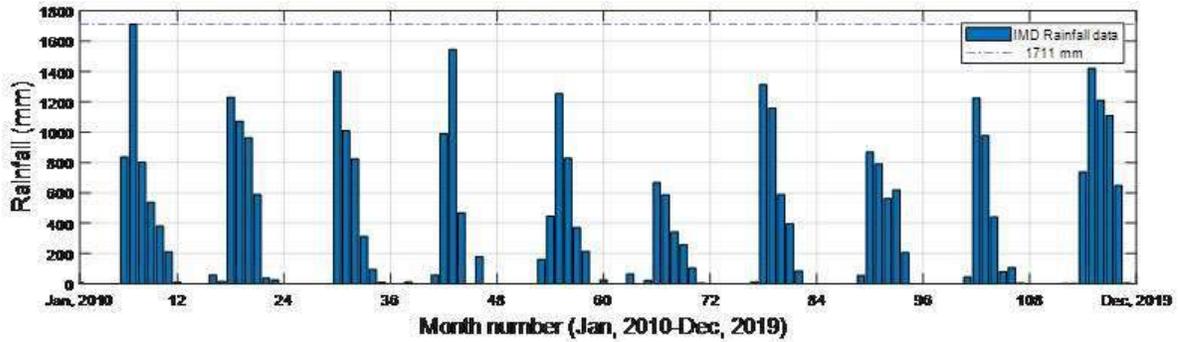


Figure 5.1. The monthly rainfall data at Pernem, North Goa from 2010-2019 (source IMD)

Soil: Soil map has been reclassified using the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) soil classification charts, and a hydrological soil group basis is classified for Chapora basin. Different soil textures were digitized up to boundaries and the polygons representing many soils classes were assigned and different colors for recognition. The hydrologic soil groups (HSG) divided into A, B, C, and D.

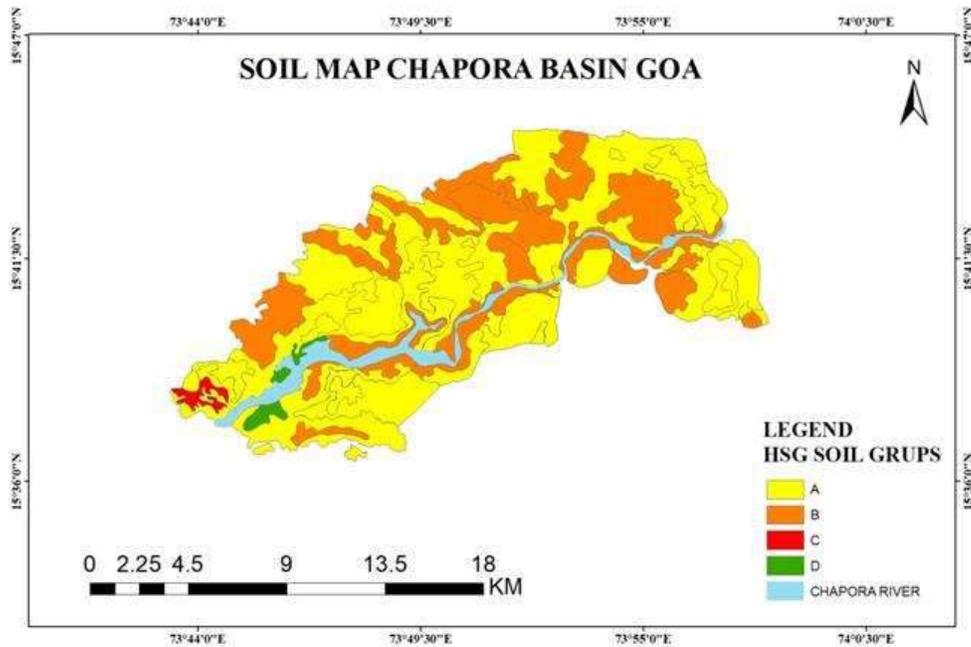


Figure 5.2. Soil map of Chapora basin, Goa (Source: NBSS&LUP)



Table 5.1 Soil classification in Chapora Estuary

Types	Area(sq.km)	Soil Texture
A	120	Sandy, sandy loam
B	63.34	Silt, gravel
C	1.96	Sandy clay loam
D	2.37	Clay loam, silty clay loam, sandy clay.

Table 5.2 Table showing secondary data used in the study

Type of data	Availability	Source
Soil map	YES	ICAR National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)
Rainfall	YES	India Meteorological Department (IMD)
Land use/ Land cover map	YES	LISS IV 5.8m
River discharge Time series data	Secondary source	Department of Water Resources, Government of Goa and Lina et al. (2018)
River bathymetry	YES	Captain of Ports Department, Government of Goa



Physical parameters

This chapter comprises of the physical measurements carried out at Chapora Estuary, Goa, during February-April 2020 and September-October 2020. The current and water level measurements were carried.

Instruments used

The various instruments used for measuring different parameters are presented in Table 5.3.

Table 5.3 Instruments used for measuring different parameters

Parameter	Equipment used
Currents	Aanderaa RCM9
Water level	SBE 26plus Seagauge WTR / Seaguard WLR

Deployed locations and parameters

The deployment locations (Figure 5.3) and duration are as given in Table 5.4

Table 5.4 Table showing instruments used and deployed locations

Location	Location-1 (CR1) Chapora Estuary	Location-2 (CR2) Chapora Estuary	Location-3 (CR3) Chapora Estuary	Dumacem Chapora Estuary
Latitude	15°38'58.3" N	15°38'57"N	15°36'31"N	15°41'22.9"N
Longitude	73°50'05.4" E	73°50'11"E	73°44'19"E	73°54'46.6"E
Duration	04 Feb. 2020 till 05 Mar. 2020 and 12 Sep. 2020 till 11 Oct. 2020	12 Mar. 2020 till 13 April 2020 and 12 Sep. 2020 till 11 Oct. 2020	09 March. 2020 till 16April. 2020	12 Sep. 2020 till 11 Oct. 2020



RCM-9	YES	NO	NO	NO
SBE 26plus Seagauge WTR / Seaguard WLR	YES (20 Feb. 2020 till 05 Mar. 2020 and 12 Sep. 2020 till 11 Oct. 2020)	YES	YES	YES



Figure 5.3. Locations of current and water level measurements in Chapora Estuary

Results

The results of the current and water level measurements carried out in the study region are presented in this section.

Currents

Current measurement was carried out at location CR1 (15°38'58.3" N; 73°50'05.4" E) near Colvale at Chapora Estuary during February-March, 2020 and September-October, 2020. The water depths at measuring point were 8.5m and 9m at the time of pre monsoon and monsoon deployment respectively. The Current meter was placed at mid-water depth. The measured current speed and direction during pre-monsoon and monsoon, are shown in Figure 5.4 and Figure 5.5. From the Figures, it is observed that during pre-monsoon, the maximum current speed was 0.38 m/s, and the current is mainly towards South East (SE)



and North West (NW) at the measuring location. However, during monsoon, maximum current speed was 0.78 m/s.

Table 5.5 Maximum and average value of Current speed at Chapora Location-1 CR1

Current Parameter	Maximum	Average
Current Speed (m/s) (Pre-monsoon)	0.38	0.11
Current Speed (m/s) (Monsoon)	0.78	0.21

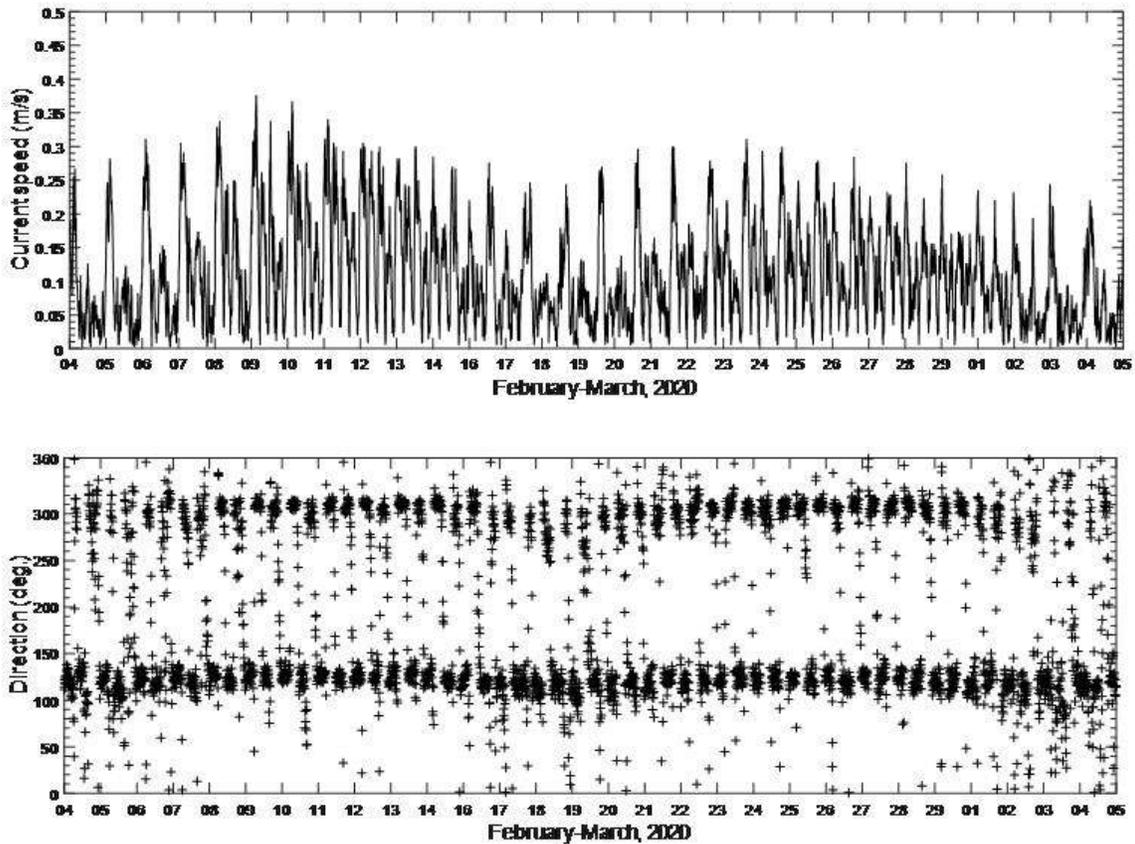


Figure 5.4. Variation of measured current speed and directions at CR1 during pre-monsoon 2020.

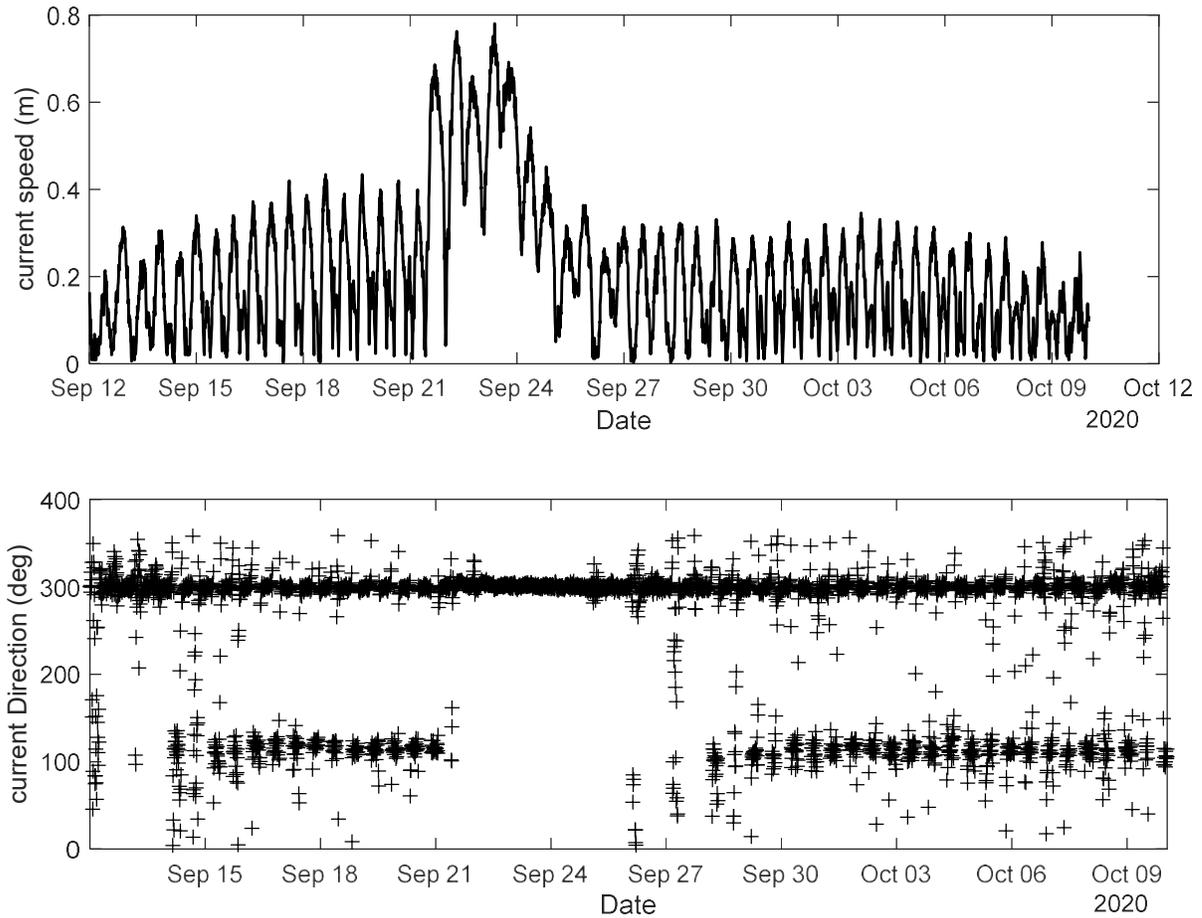


Figure 5.5. Variation of measured current speed and directions at CR1 during monsoon, 2020.

Water level

Water levels were measured at three different locations. Water level was measured near Colvale (15°38'58.3" N; 73°50'05.4" E) (CR1) at Chapora Estuary for 15 days during February-March, 2020. Water levels were measured at Colvale bridge (15°38'57"N; 73°50'11"E) (CR2) and (15°36'31"N; 73°44'19"E) (CR3) Chapora jetty at Chapora Estuary for a month during March-April, 2020. The water level ranges are about 1.84m, 2.32m and 2.45m at CR1, CR2 and CR3 respectively during the pre-monsoon measurement period. The measured water level variations at CR1 during monsoon period, is shown in the next chapter.

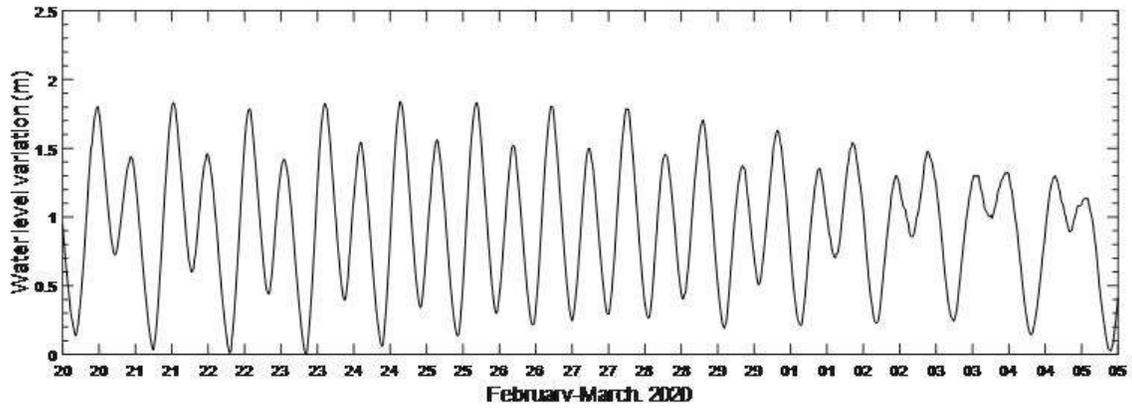


Fig 5.6. Variation of water levels at Location-1 CR1

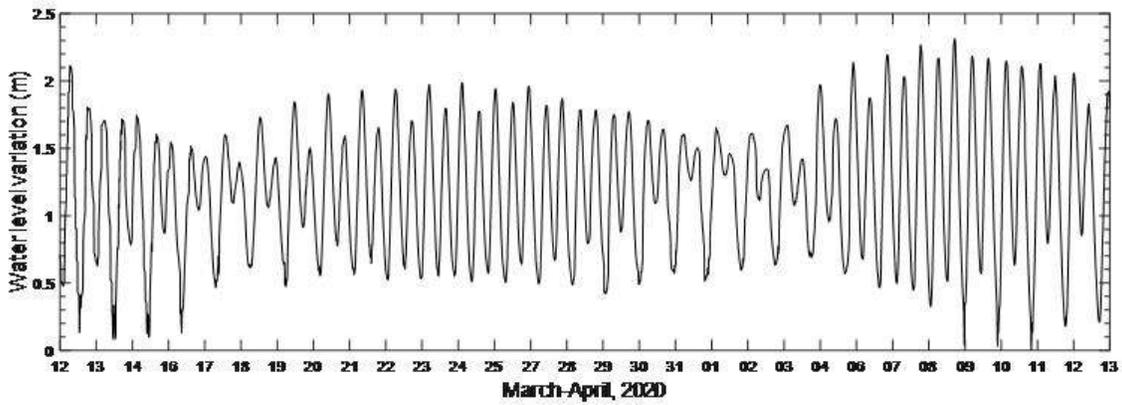


Figure. 3.1.

Fig 5.7. Variation of water levels at Location-2 CR2.

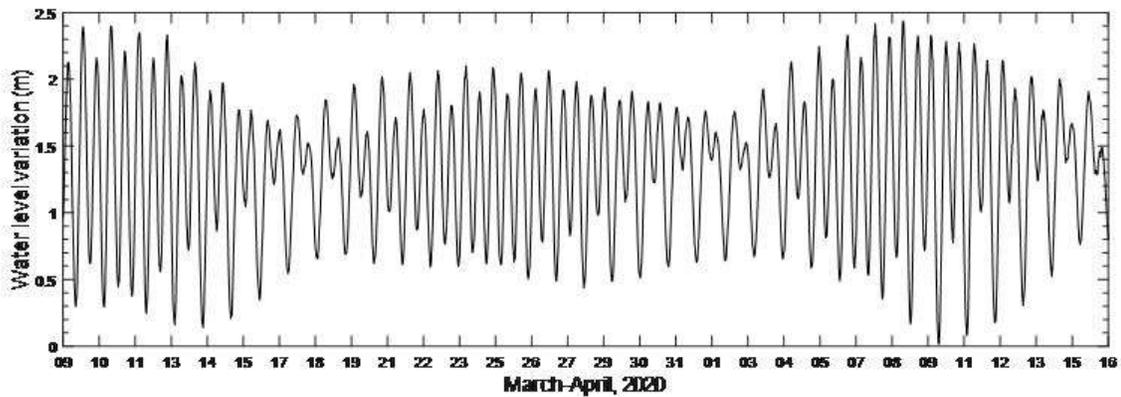


Figure. 3.2.

Fig 5.8. Variation of water levels at Location-3 CR3.



CHAPTER 6: NUMERICAL MODELLING STUDIES

Introduction

In order to simulate the coupled hydrodynamics and morphology in the study region, a state of the art numerical modelling software suite (MIKE by DHI) is used. The flow model FM comprising of flow model, and sediment transport model is used to study the hydrodynamics and morphology impact in the region due to different mining pit scenario. All these models take feedback from each other as well as provide inputs to each other. The sediment transport models also utilise the flow parameters from the hydrodynamics model. In this manner, the coupled model provides output of modified flow, and changes in the bed morphology in the study region.

Coupled model

The MIKE 21 flow model FM is used in this study which dynamically couples the flow and sediment transport calculations. Full feedback of bed level changes on flow calculations is included in this formulation. Wave has negligible effect on the flow dynamics and morphology changes inside the river. Hence, wave is not considered in the present simulations. However, the morphology changes due to wave with the coupled model at Chapora Estuary mouth can be found in NIO report 2017. The flow model FM is mostly used for investigating the morphological evolution of the near shore bathymetry due to the impact of engineering works (coastal structures, mining, dredging works etc.) and also to study the morphological evolution of tidal inlets and rivers. It is most suitable for medium-term morphological investigations (several weeks to months) over a limited study area. The computational effort can become quite large for long-term simulations, or for larger areas. The different models used in the flow model FM are briefly described below.

Hydrodynamic model

The Hydrodynamic Module is the basic computational component of the entire MIKE21 Flow Model FM modelling system. The MIKE 21 Flow Model FM is a modelling system based on a flexible mesh approach providing the hydrodynamic basis for the Sediment transport Module.

The modelling system is based on the numerical solution of the two-dimensional shallow water equations i.e., depth-integrated incompressible Reynolds Averaged Navier-Stokes equations. Thus, the model consists of continuity, momentum, temperature, salinity and density equations. In the horizontal domain both Cartesian and spherical coordinates can be used. The spatial discretization of the basic equations is performed using a cell-centred finite volume method wherein the spatial domain is discretized by subdivision of the continuum into non-overlapping element/cells. An unstructured grid comprising of triangles or quadrilateral element is used in the horizontal plane. An approximate Riemann solver is used for computation of the convective fluxes, which makes it possible for MIKE21 FM model to handle discontinuous solutions. For the time integration an explicit scheme is used. Coriolis term, eddy viscosity using Smagoransky formulation and bed friction are included in the model. For more details of the MIKE 21 FM module and its validation, the scientific manual can be referred.

The model domain used in this study is shown in Figure 6.1. This model domain was further used for all simulations. In this study, a sand mining case scenario is studied by modifying existing bathymetry. The model domain for sand mining case is shown in Figure 6.2.

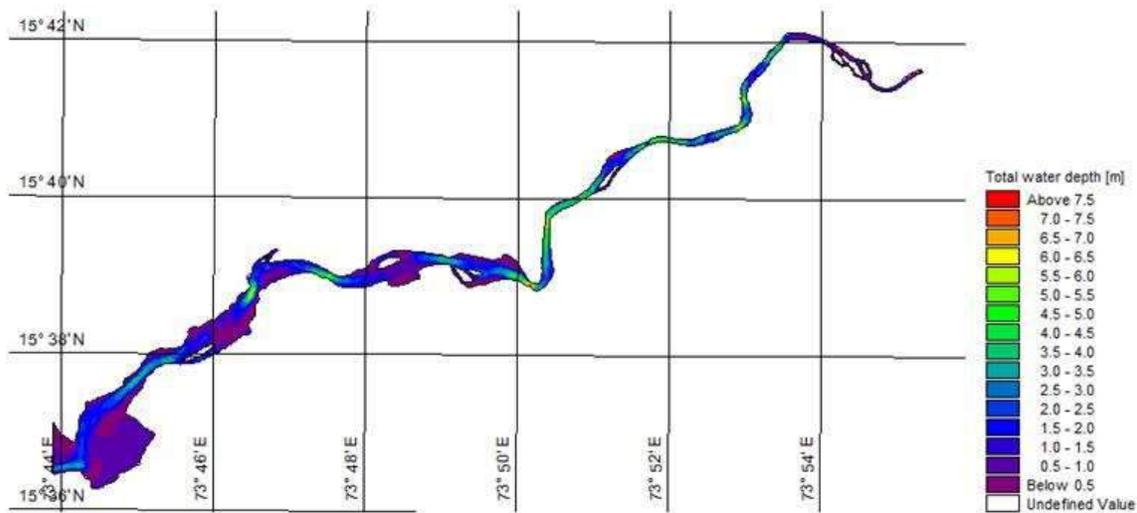


Figure 6.1. Model domain of the Chapora Estuary

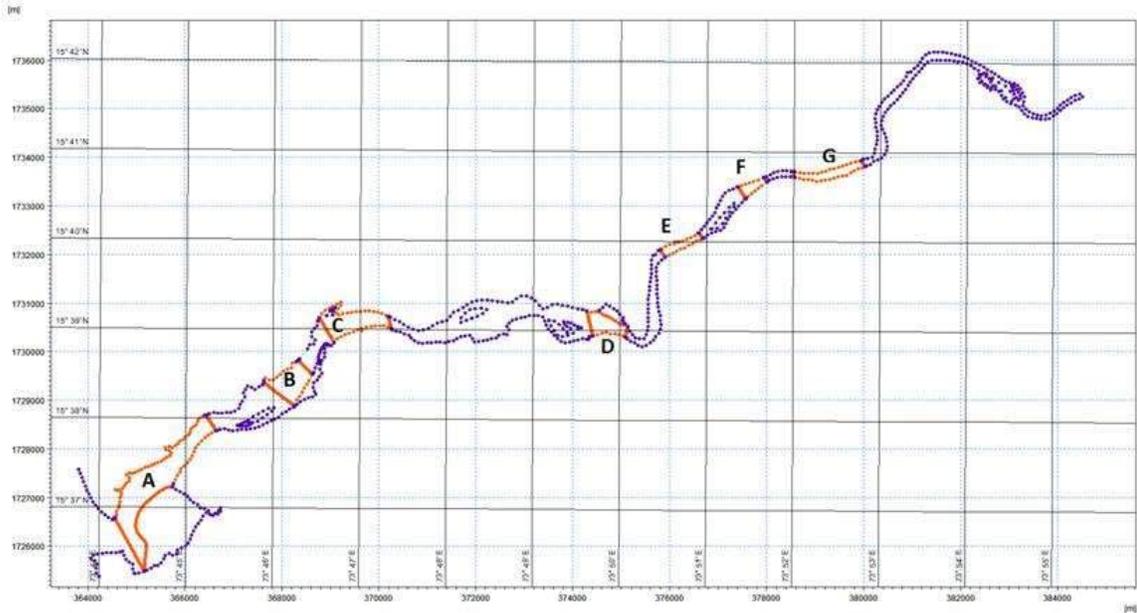


Figure 6.2. Figure showing seven different sections (A-G) in the model domain.

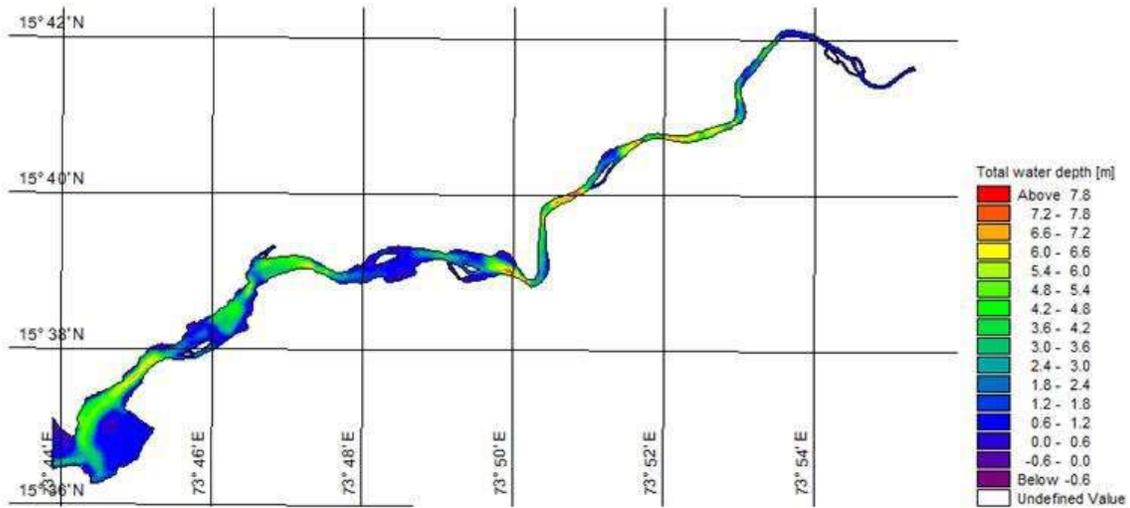


Figure 6.3. Model domain for modified bathymetry increasing depth by 3 m at different sections (A-G)

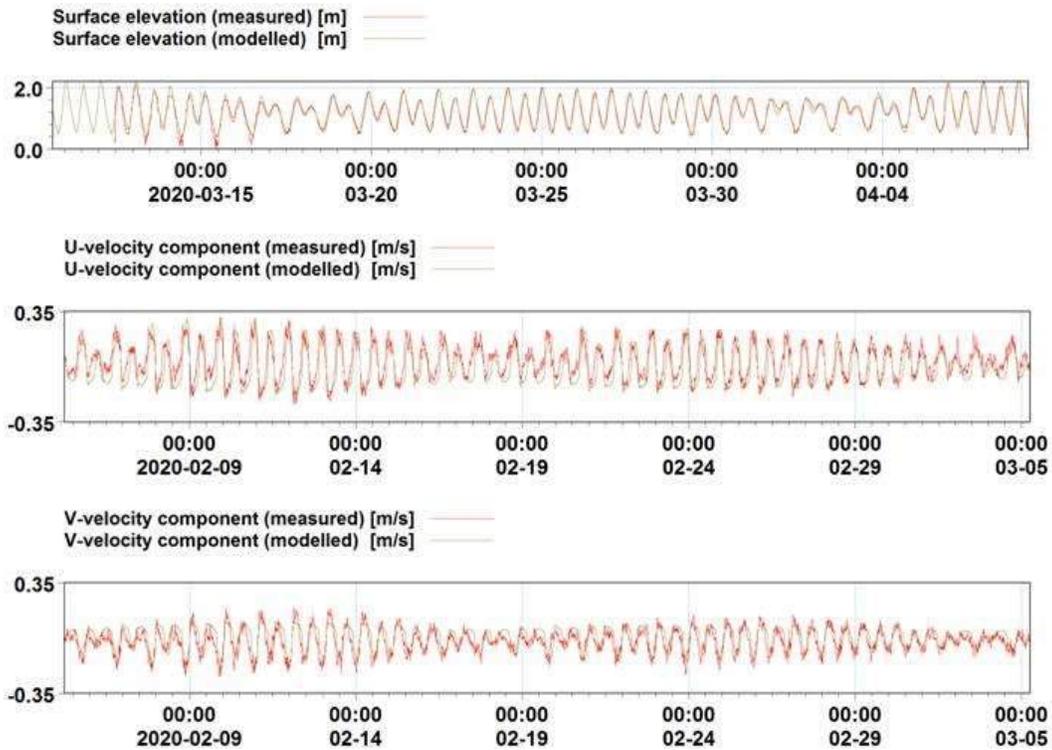
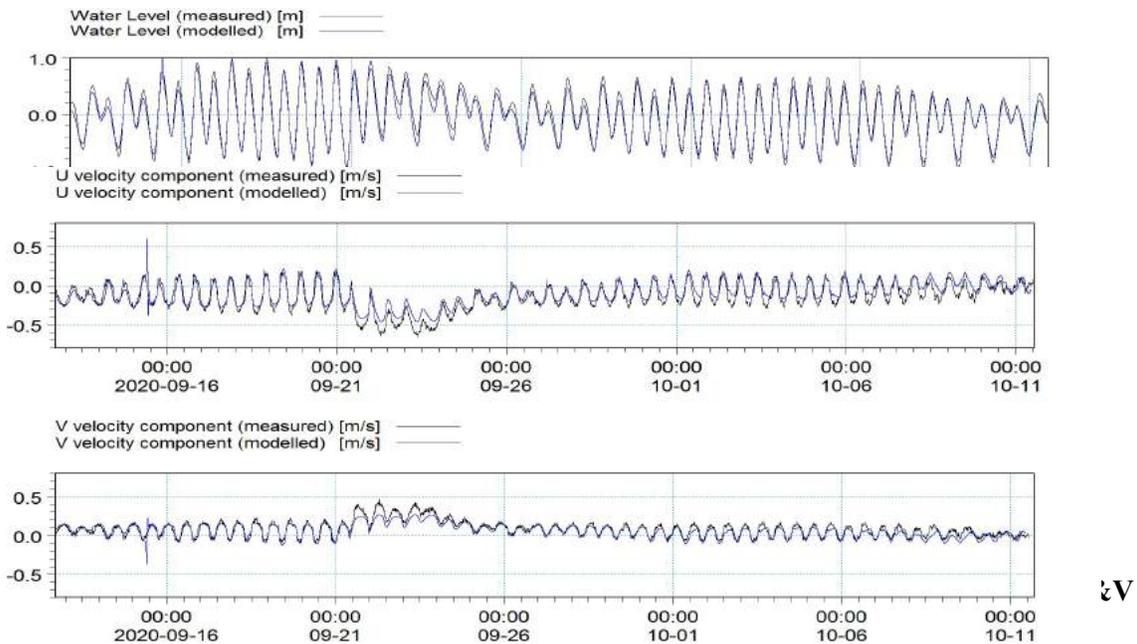


Figure 6.4a. Comparison between measured and modelled surface elevations and U&V component of current during pre-monsoon.



A comparison between the model derived and measured surface elevations, currents have been carried out at location #1 (CR1), and the comparisons are shown in Figure 6.4. It is



observed that the surface elevations and currents are well predicted by the model during both pre-monsoon and monsoon period, 2020.

Sediment transport model

The sediment transport module calculates the resulting transport of non-cohesive materials based on the flow conditions found in the hydrodynamic calculations. The model output consists of bed level changes, amongst other parameters. In this study, the current formulation of sediment transport is considered with the flow model providing the currents.

Methodology

The main inputs considered to the numerical model are river topography, river discharge and water level. The Chapora Estuary's bathymetry chart received from Captain of Ports, Govt. of Goa, is in Everest 1956 datum and has 14 parts. The map was digitized for the numerical modelling purposes keeping the datum unchanged. The base case scenario (Case-1) is with bathymetry provided by Captain of Ports, Govt. of Goa. The second scenario (Case-2) is the modified bathymetry by deepening 3m uniformly at 7 locations (A-G), as in Figure 2.2, of Chapora Estuary.

The numerical model described in the previous sections is setup for various scenarios initially to ascertain the validity of the model for the study region. In order to test the validity of the model, purely tidal forcing is given to the model during non-monsoon. However, during monsoon, measured water level data at the upstream model boundary of Chapora estuary, is given to the model and the hydrodynamic results are compared in Figure 6.4.

In this study, the effects of the deepening of the river at A-G sections on the hydrodynamics and morphology are studied by comparing with the base case scenario. The Case-1 (base case) scenario model therefore provides a basis for comparison with the modified bathymetry model simulations. However, it is important to simulate the model for the full year to understand the dynamics of the sediment transport. In this study, after testing the validity of the model (Figure 6.4), the numerical model is simulated for Jan-Dec 2014 based on availability of fresh water input data (source: Water Resources Department, Goa) of Chapora estuary. The model results of each of these scenarios are presented in following sections.

Assessment of mining



Based on the modelling of the hydrodynamics or flow conditions of the region, possible impacts due to the Case-2 scenario of this work are reported in terms of (i) changes in flow or hydrodynamics impact, and (ii) bed level change or morphological impact. The difference between the base case (Case-1) and modified bathymetry case (Case-2) are studied to ascertain the changes in flow patterns and bed morphology changes. The variations of current speed and bed level changes for each of the scenarios are also compared for each section A-G, in the study region.

Hydrodynamic impact

Any change in existing bathymetry, results in changes in the local hydrodynamics till such time equilibrium is attained. Till then the local hydrodynamics would be in dynamic mode adjusting to the new and changing conditions. The extent of change in the hydrodynamics can be ascertained through comparison of flow conditions between the base case (Case-1) and modified bathymetry case (Case-2). In this study, the hydrodynamic impact assessment is carried out through numerical modelling of flow conditions. This is ascertained by studying the differences between the validated model results for the base case and the modified bathymetry case.

Morphological impact

The activity of sand mining would modify the local bottom topography which in turn changes the local hydrodynamics. The impact of the change in bottom topography is studied through numerical modelling of the bed level changes. Modelling the morphology changes using the sediment transport model provides the bed level changes. The changes in the bed morphology for the base case, as well as the modified bathymetry scenario, are carried out.

Results

The numerical model study results are presented in the following sections. The flow patterns in the study region for the Case 1 and Case 2 are presented in the hydrodynamic model results. The comparisons of the current speed during pre-monsoon, 2020 between Case 1 and Case 2 at each section A-G are presented. However, the comparisons of the bed level changes between Case 1 and Case 2 for the full year 2014, are presented in the morphology model results.



Hydrodynamics modelling

Hydrodynamic model validation is carried out with the measured currents and water levels in the study region. The comparison of water levels, u-component and v-component of currents are presented in Figure 6.4. The model simulated water levels, and the tidal current flow components well for both the east-west and north-south components. The flow vector patterns with surface elevation during the typical ebb and flood tides are shown in Figure 6.5.

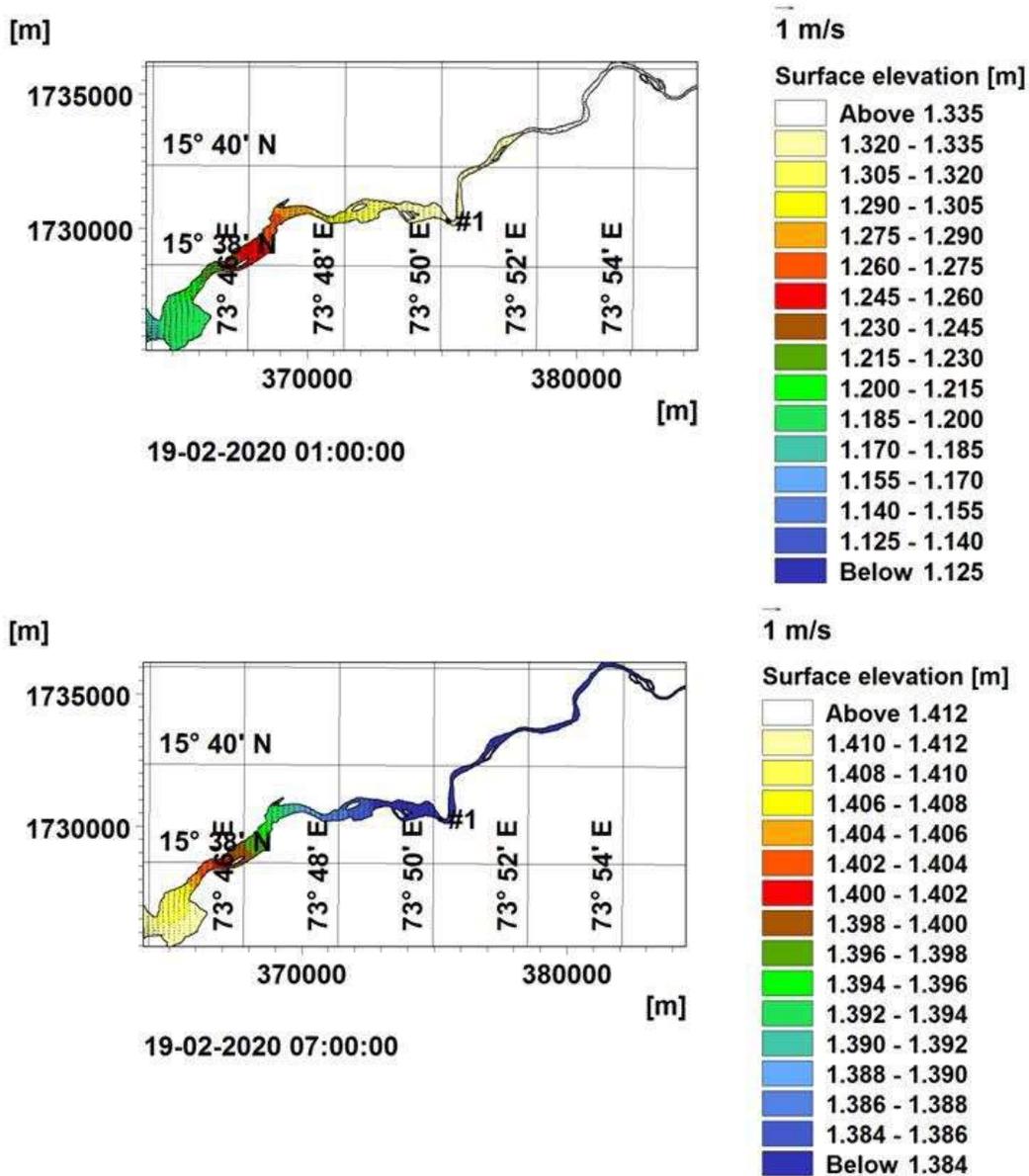
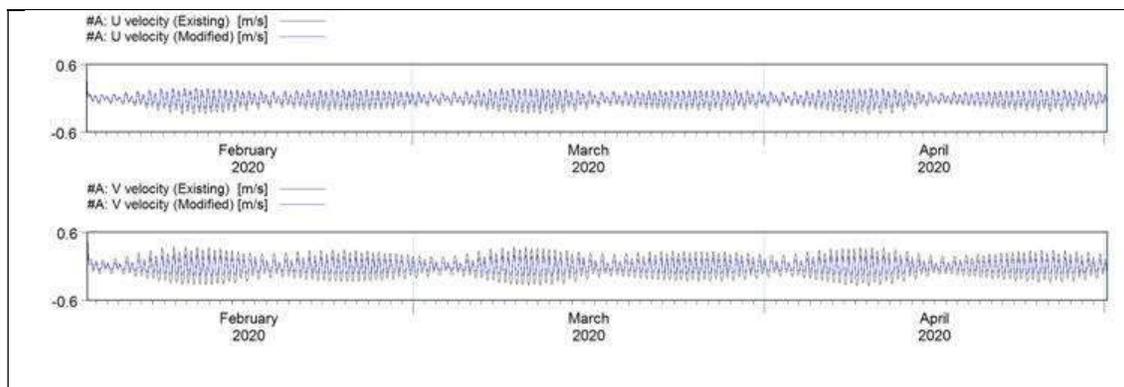
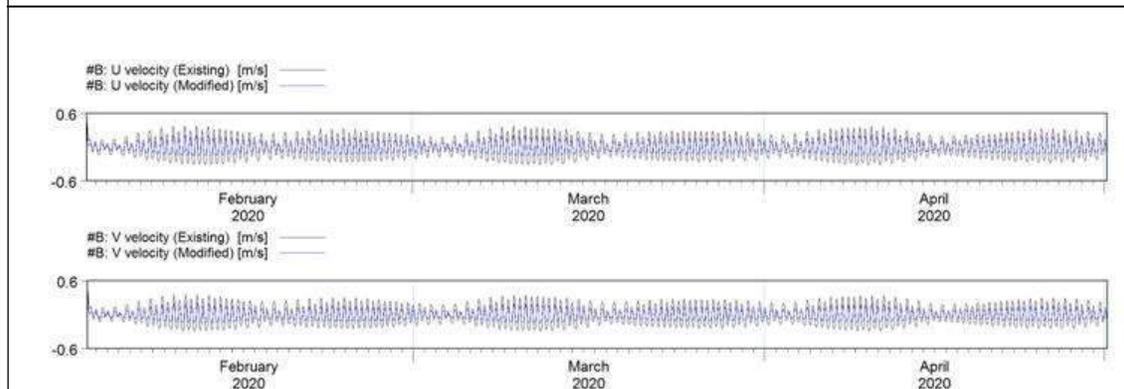


Figure 6.5. Flow patterns and surface elevations during typical ebb and flood tide for Case-1.

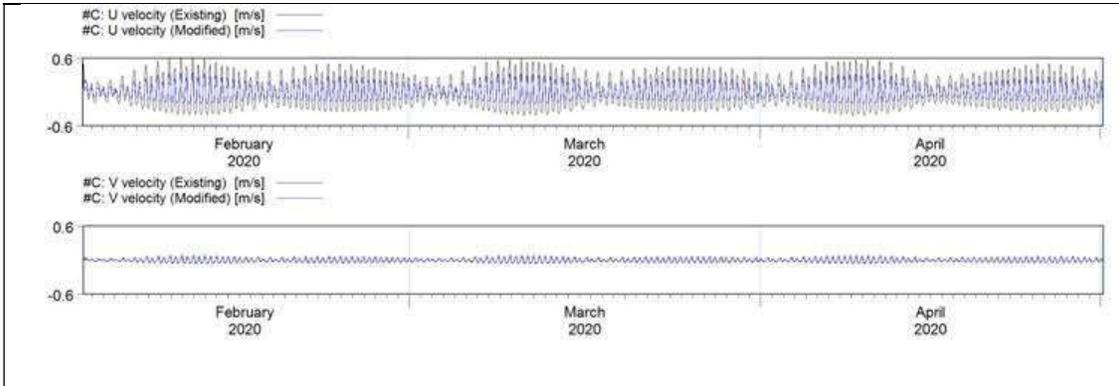
A comparison of current speeds between the Case-1 (base case) and Case-2 (Modified bathymetry case) is carried out. A total of 7 points covering the seven sections A to G as in Figure 6.2 are considered for comparing the currents. The comparison Figures are presented in Figure 6.6. The maximum current speeds observed are in the range of 0.26 to 0.63 m/s for Case-1, while maximum current speeds lie in the range of 0.16 to 0.35 m/s for the Case-2 at the different sections A-G with the flow direction changing with the tide. The reduction in current speeds at these sections is mainly due to the change in the water depths. The maximum and minimum current speed with u and v components for Case-1 and 2 are shown in Table 6.1.



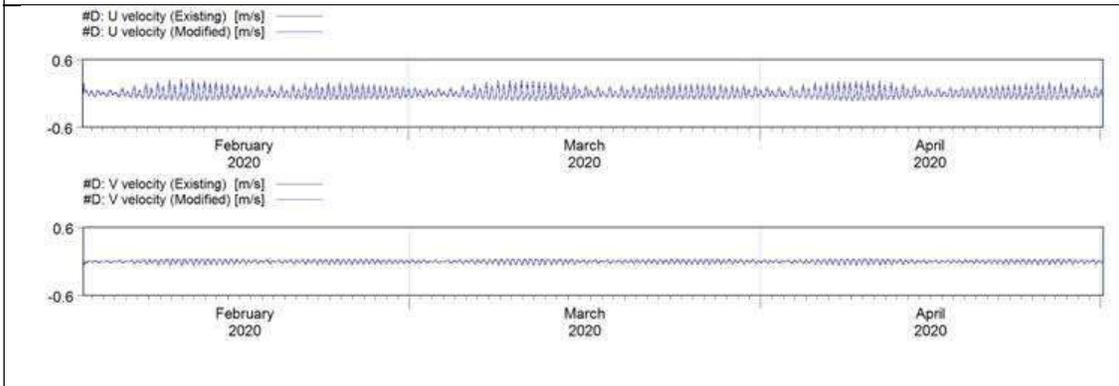
Comparison between existing and modified current U & V component at section A



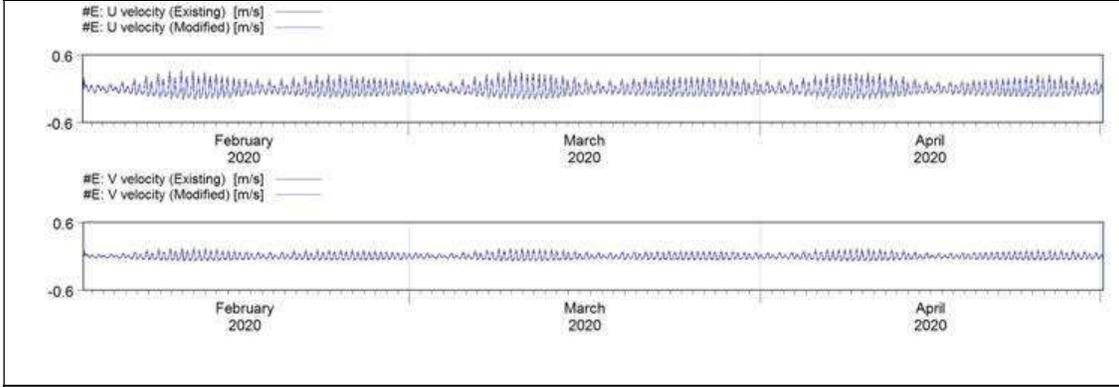
Comparison between existing and modified current U & V component at section B



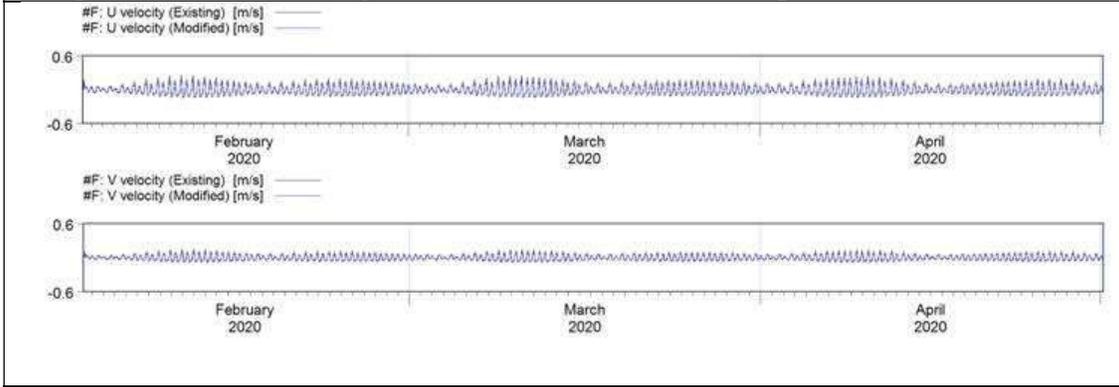
Comparison between existing and modified current U & V component at section C



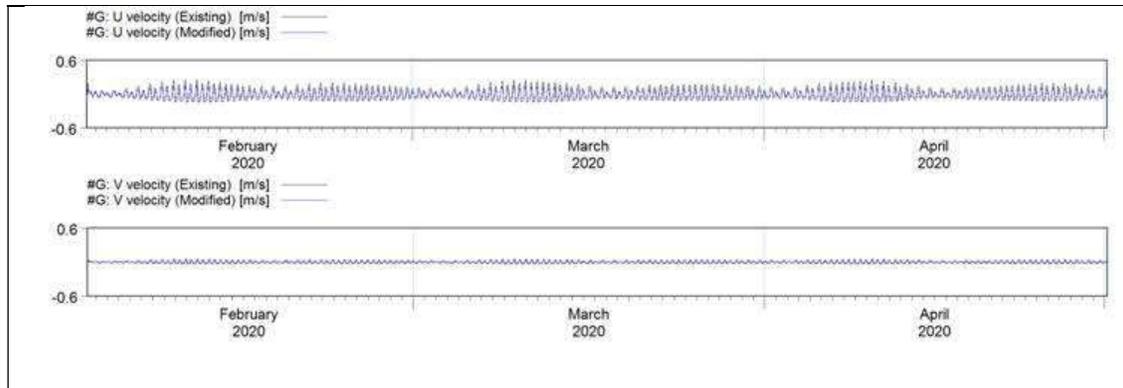
Comparison between existing and modified current U & V component at section D



Comparison between existing and modified current U & V component at section E



Comparison between existing and modified current U & V component at section F



Comparison between existing and modified current U & V component at section G

Figure 6.6 Comparison of U & V velocity at different sections between Case-1 and Case-2.

In Figure 6.7, the comparison of U and V velocity between Case-1 and Case-2 during February-April 2014 at section A are presented. The maximum current speeds observed for Case-1 is higher than Case-2 at section A. The similar phenomenon is observed for Figure 6.6. The reduction in current speed due to uniform deepening of the original bathymetry, is observed irrespective of year.

Table 6.1: Maximum and minimum of current velocity components at different section for Case-1 and Case-2

Section	U-component				V-component				Speed	
	Case-1		Case-2		Case-1		Case-2		Case-1	Case-2
	Min (m/s)	Max (m/s)	Min (m/s)	Max (m/s)	Min (m/s)	Max (m/s)	Min (m/s)	Max (m/s)	Max (m/s)	
A	-0.28	0.30	-0.17	0.24	-0.34	0.44	-0.17	0.23	0.54	0.33
B	-0.32	0.42	-0.16	0.22	-0.29	0.41	-0.14	0.20	0.59	0.29
C	-0.41	0.62	-0.21	0.35	-0.06	0.10	-0.04	0.06	0.63	0.35
D	-0.12	0.25	-0.08	0.17	-0.07	0.04	-0.05	0.03	0.26	0.18
E	-0.19	0.32	-0.13	0.24	-0.09	0.15	-0.06	0.11	0.36	0.26
F	-0.15	0.26	-0.10	0.18	-0.09	0.15	-0.06	0.10	0.30	0.21
G	-0.15	0.25	-0.08	0.15	-0.03	0.06	-0.02	0.04	0.26	0.16

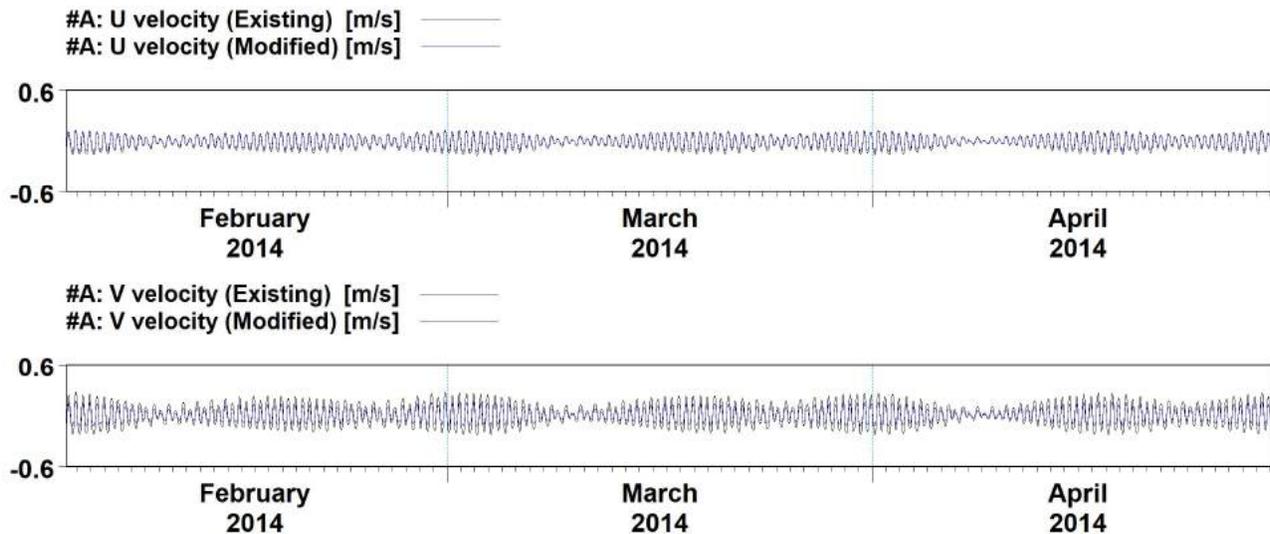


Figure 6.7 Comparison of U & V velocity between Case-1 and Case-2 during February-April 2014 at section A.

Bed level changes

The change in the bed level from the sediment transport model simulations provides accretion/erosion in the study region for the simulation period. This study is carried out assuming that the mined channel is stable and the flow dynamics are stabilized. In Figure 6.8, it is observed that high sediment deposition occurs at the mouth of Chapora estuary. For the sake of clarity, the Chapora Estuary is divided into three different parts based on the locations of sections A-G, and the comparisons of bed level changes between the between the Case-1 and Case-2 models are shown in Figure 6.9-6.11. The changes in bed morphology at different sections of the river are highly dynamic and patchy in nature. In Figure 6.9, it is observed that for Case-2, erosion occurs at the location between sections A and B at Chapora Part I. Figure 6.10 reveals that the accretion happens in section D in Case-2. It is observed that the locations around the northern side of the isolated island between sections C and D is eroded more for Case-2 than Case-1 at Chapora Part II. In Figure 6.11, more sediment accretion is observed at sections F and G than Case-1 at Chapora Part III whilst more intense erosion observed at the island between section E and F for case-2 than Case-1. It is important to note that localized bed level changes may happen due to abrupt change in the bed morphology.

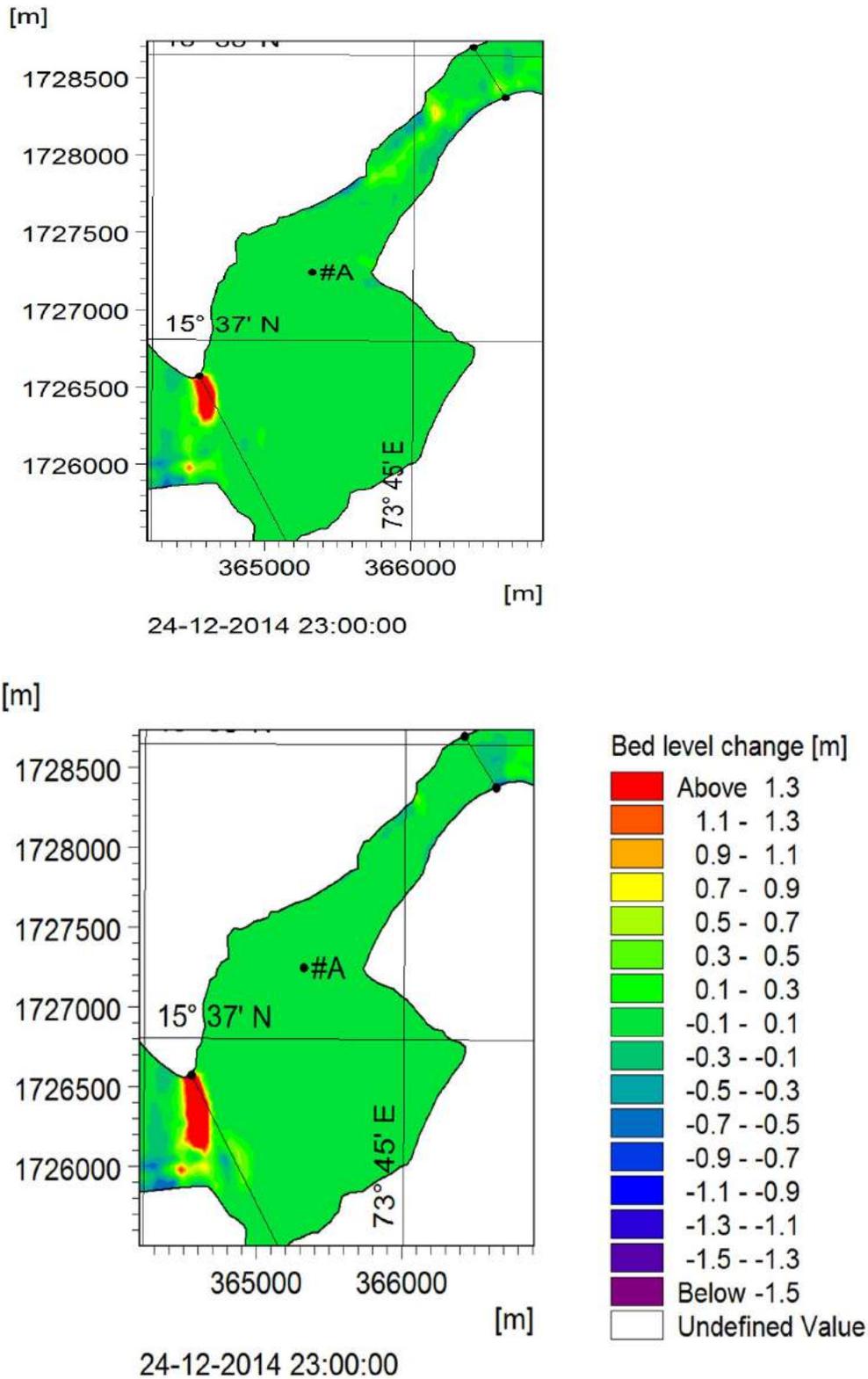
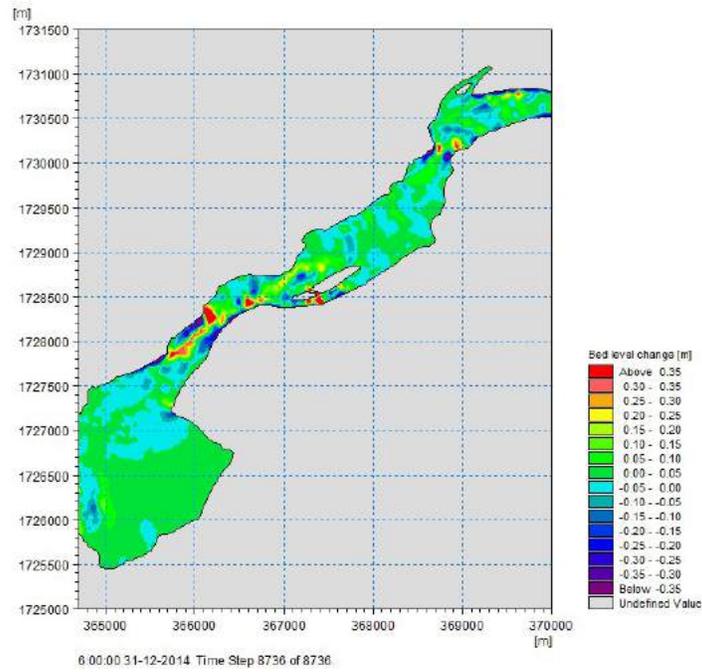


Figure 6.8. showing the deposition/erosion at the Chapora estuary mouth. Top figure is Case-1 and bottom is Case-2



Base Case Scenario (Case-1) for Chapora Part I



Modified Bathymetry Scenario (Case-2) for Chapora Part I

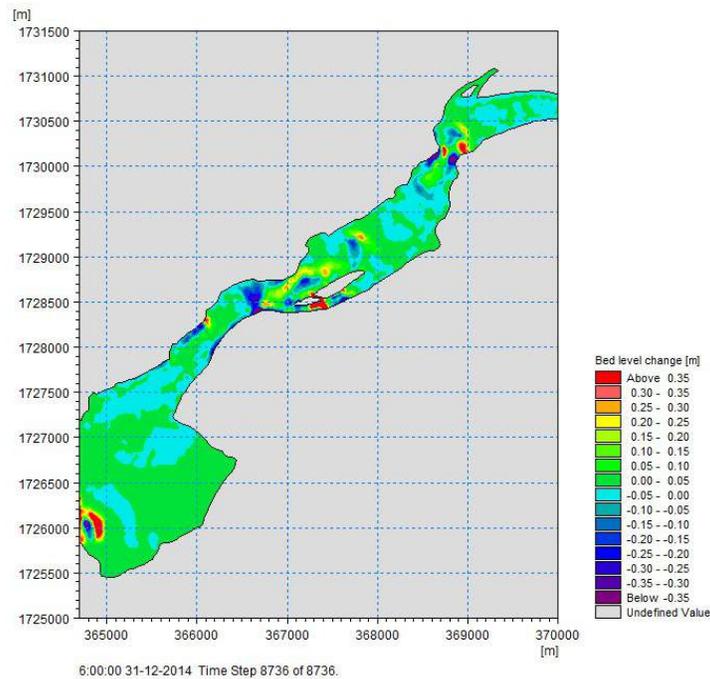
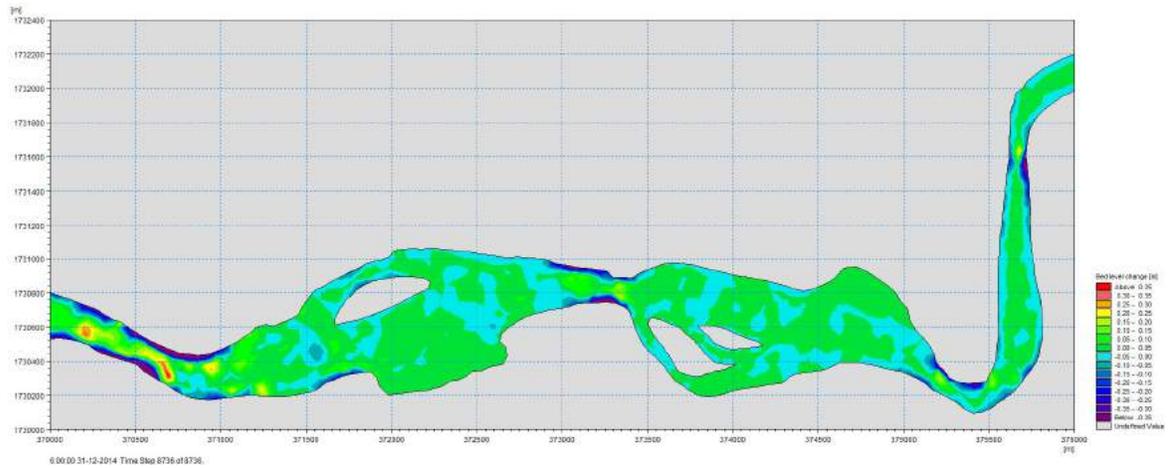


Figure 6.9.showing the deposition/erosion in the Chapora Part I

Base Case Scenario (Case-1) for Chapora Part II



Modified Bathymetry Scenario (Case-2) for Chapora Part II

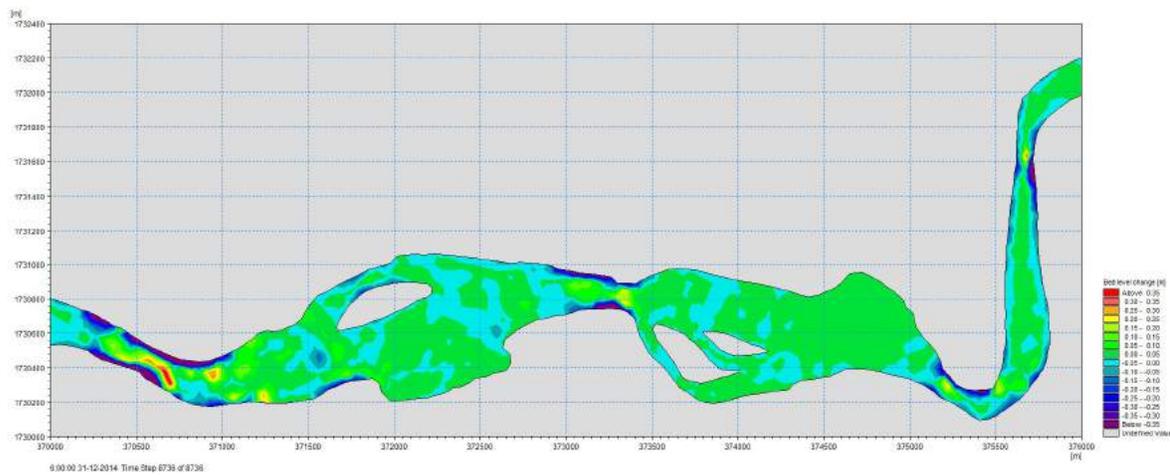
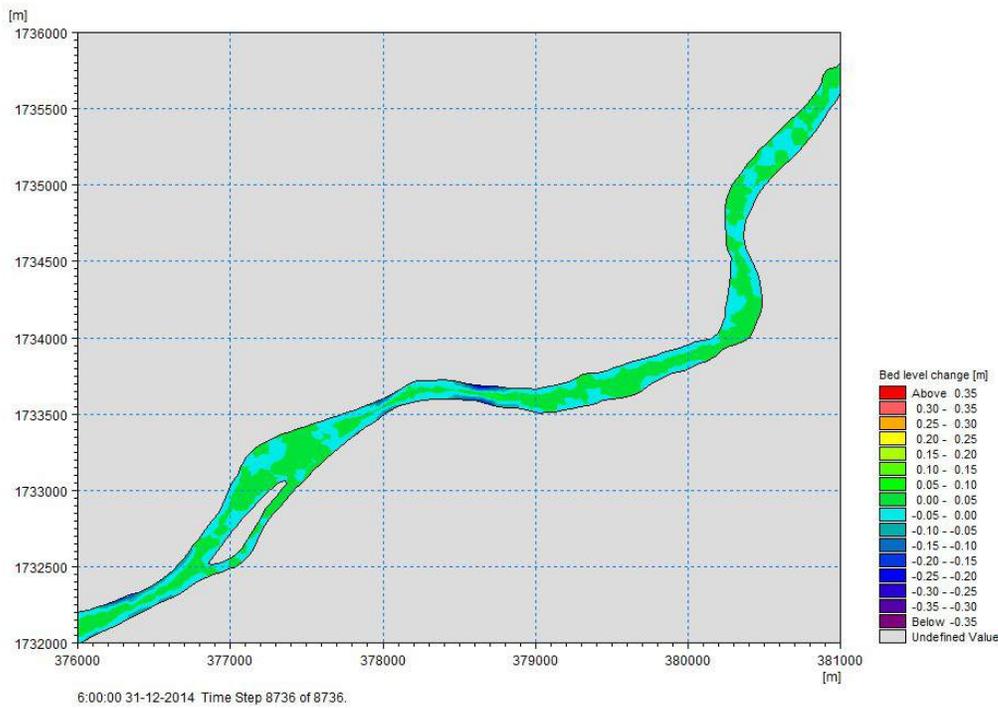


Figure 6.10.showing the deposition/erosion in the Chapora Part II



Base Case Scenario (Case-1) for Chapora Part III



Modified Bathymetry Scenario (Case-2) for Chapora Part III

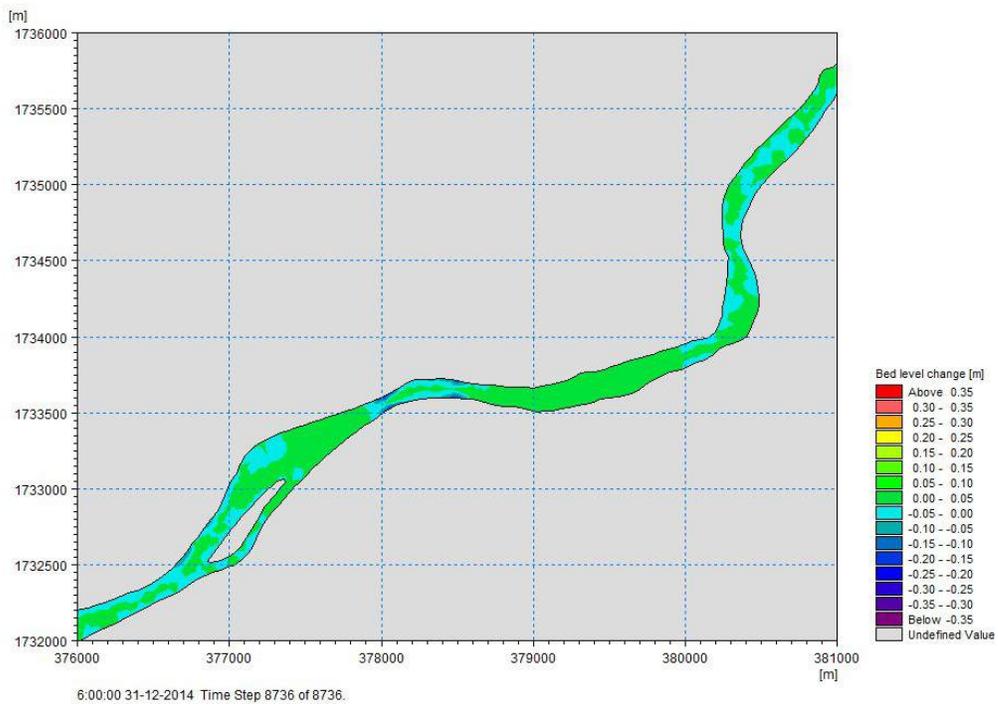


Figure 6.11. showing the deposition/erosion in the Chapora Part III



CHAPTER 7 ANTICIPATED IMPACTS

The primary function of an environmental impact assessment study is to predict and quantify potential impacts, and assess & evaluate the magnitude. Environmental impacts could be positive or negative, direct or indirect, local or regional and also reversible or irreversible. For each identified environmental impact, the associated risk is assessed based on its likelihood and significance.

Sand has become a very important mineral for our society due to its many uses. It can be used for making concrete, filling roads, building sites, brick-making, making glass, sandpapers, reclamations etc. The role of sand is very vital with regards to the protection of the coastal environment. It acts as a buffer against strong tidal waves and storm surges by reducing their impacts as they reach the shoreline. Sand is also a habitat for crustacean species and other related marine organisms. Individuals and private companies are increasingly demanding sand for construction purposes and this has placed immense pressure on sand resources. It is a practice that is becoming an environmental issue as the demand for sand increases in industry and construction.

Environmental Management Plan is a guiding document for environmental impacts associated with the proposed projects. It is a guiding document for management of good environmental condition on the site & surrounding of the proposed sand mine.

A scientific assessment of these impacts those are likely to influence the existing environmental scenario is needed. This could also facilitate in formulating a suitable environmental management plan depicting all mitigation measures. It can help in implementing the project in an eco-friendly manner. The project activities influencing the following environmental attributes have been studied and their impacts on the following attributes have been assessed.

The proposed project is to study impact of sand mining on the health of the Chapora Estuary. The projects seeks to understand the geomorphology, bathymetry, sand budget and flow dynamic of the river and the impact of sand mining on environment and biodiversity of the river. The EIA seeks to ensure that the potential negatives impacts arising from sand mining are mitigated or minimised whilst at the same time maximising on the positive impacts. The potential impacts of the project have been identified through literature review and site-



specific baseline. A variety of technical studies and investigations were also conducted. These include geo-morphological, modelling, physico-chemical and ecological studies.

7.1 Prediction & Assessment of impacts

In the state of Goa, the sand extraction activity is carried out in the estuarine areas of the river as the sand is mostly available in this region due to the topography and river hydrodynamics. In Goa the sand extraction activity has slowly increased over the year and is mostly carried out by traditional manual methods. There are no earlier studies on the estimates of sand available and the quantities and rates of replenishments. There the exact impacts due to long term sand mining are difficult to assess. Therefore the present section deals with impacts that can be anticipated considering the baseline conditions prevailing at present.

Developmental projects such as sand mining have an impact on their surrounding environment. These impacts beneficial or harmful depend on the effect it brings about in the status of air, land, water, natural systems, ecology, socio-cultural, lifestyles and economics.

Depending on the improvement or the deterioration it brings about in the status of air, water, land, ecology, natural systems, socio-cultural life styles and economics of the local population. The impacts are assessed for their importance based on the nature of activities and environmental screening.

Marine organisms are known for their adaptive nature to the environmental changes though they possess certain tolerance capacity. Crossing these tolerance limits could give rise to serious impact on their existence which will ultimately result in ecological damage to the environment. The extent to which the baseline conditions can be altered by sand mining needs to be thoroughly analysed, and adequate mitigation measures need to be adopted so as to minimise the damage, if any to environment. Impacts to biological resources from physical and chemical environmental alterations are associated with sand mining activities. Major classes of alteration include suspended sediments, sedimentation, chemical release, flow patterns, topography. The biological impacts of marine sediments extraction are the disturbance and removal of benthic epifauna and infauna and alteration of the substratum upon which the colonization depends. This in turn affect its stability as a fish or shellfish food habitat where the remnant substrate is identical to the surficial sediment, disturbance is



unlikely to be permanent and the extraction area will be re-colonized, although the time scale will vary depending on the nature and location of the deposit.

Sand mining is the physical activity in the proposed project and it is known and increased sand mining has an adverse impact on the biodiversity by disturbing the biological community structure. Furthermore sand mining activities potentially affect not only the site itself but also the surrounding areas. The major impact of sand mining will be habitat destruction due to dislodging of sediment. The important parameters that influence the impacts are the scale of sand mining, its extent and duration.

Based on the present study and using available information, following anticipated impacts to the environment in the study area of the estuarine system have been identified. This needs to be further examined considering the monsoon flow conditions.

7.1.1 Anticipated impact on Physical environment

- Large-scale extraction for over a long period of time extraction of streambed materials, mining below the existing stream bed and the alteration of channel-bed form and shape may lead to several impacts such as erosion of channel bed and banks, increase in channel slope, and change in channel morphology.
- Undercutting and collapse of river banks
- Loss of adjacent land and/or structures
- Upstream erosion as a result of an increase in channel slope and changes in flow velocity.
- Formation of deep pits in the channel bed produce slower flow velocities and lower flow energies, causing sediments transported from upstream to deposit at deepened area.
- Deficient water (hungry water) can have a very high erosive effect on the river banks.
- Downstream triggering bank erosion and damages to engineering structures.

7.1.2 Anticipated impact on traffic

- Mining contractor will use the same main roads to transport product out of the study area and through road networks. This will result in an increase in the number of trucks utilizing the road.



- Traffic congestion may occur due to narrow width of road and damage to roads due to plying of heavy vehicles further disturbing local well-being and increasing the maintenance cost.

7.1.3 Anticipated impact on Air Environment

- Dust will be generated from loading, screening and transportation operations. This dust becomes air borne and gets carried away to surrounding areas.
- The impact on air is mainly localized in nature as the dust particles are not carried to longer distances due to larger size.
- Combined impact of air borne dust from the mining lease areas will definitely give a relatively larger picture of fugitive dust emission in the area.
- Collection and lifting of minerals will be done manually without any blasting. Therefore the dust generated is insignificant as compared to mining process of other hard minerals like the process of drilling, blasting, mechanized loading etc.

7.1.4 Anticipated impact on Water environment

- Sand mining activities will have an impact on the river's water quality. Impacts include increased short-term turbidity at the mining site due to re-suspension of sediment, and dumping of excess mining materials, oil spills or leakage from transportation vehicles and washing of vehicles in the river.
- Suspended solids may adversely affect water towards downstream and aquatic ecosystems. The impact is particularly significant if water toward downstream of the site are abstracting water for domestic and irrigation purposes etc.
- Excessive mining will reduce the thickness of the natural filter materials (sediments) through which the groundwater is recharged. The pollutants due to mining, such as washing of mining materials, wastes disposal, diesel and vehicular oil lubricants and other human activities may pollute the groundwater.

7.1.5 Plume generation

- At the proposed sites of River Chapora, a turbid plume would eventuate as material is released to the water column during sand mining operations.
- Increased turbidity results in decreased primary productivity in the water column.



- Sand mining activity may change the nutrient regime of the water column and may result in increased pollutant.
- The turbidity plume generated may have localized dispersal due to tidal action and riverine flux, thus the overall anticipated impact shall be localized and not of chronic nature.
- The size of plume will depend on the scale and periodicity of the mining activity.

7.1.6 Anticipated impact on pelagic environment

- The increased turbidity may lead to decrease in dissolved oxygen (DO) in the water column during sand mining operations.
- Increase in suspended sediment loads and turbidity level due to sand mining may have adverse impacts on marine producers and consumers by reducing euphotic zone of water column.
- This increased load not only limits light penetration in water temporarily but may also affect filter feeding organisms such as zooplankton and bivalves.
- Reduced DO can cause the loss of micro-eukaryotic biomass, decrease aerobic bacterial community.
- Loss or reduction of bacteria means remineralisation of matter will be significantly slower affecting the invertebrate grazers, predators and fish community.
- Nutrients such as phosphate released from the bottom churning of the sediments during sand mining may increase surface phytoplankton blooms that may clog membranes of filter feeding zooplankton and larval fish.

7.1.7 Anticipated impact on planktons

- Sand mining causes suspension of sediments in the water column during the extraction. The increase in turbidity would decrease light penetration and reduce photosynthesis, thereby causing changes in phytoplankton community structure and the food web. Many bottom dwelling pinnate phytoplankton and zooplankton groups such as bivalves could be impacted or translocated. The suspended solids would also release excessive material such as nitrates during mining. This could lead to blooms of dinoflagellates. Since the activity does not involve long distance vessel movement, the chances of new/exotic/weed/invasive species to be introduced would be negligible.



- One of the main concerns of sand mining is the suspension of fine sediments into water column, causing short term increase in turbidity. This increased turbidity has short-lived effect on phytoplankton, which are light dependent, these are generally negligible and temporary.

7.1.8 Anticipated impact on Fishery

- Common fish found in Chapora Estuary are *Etroplus suratensis*, *Mugil cephalus*, *Sillagosihama*, *Lates calcarifer* but the overall fishery yield from the river is very low. Thus the sand extraction may have deleterious effects on the already depleted fish population (Based on secondary information from the native stakeholders)
- Disturbance during sand mining activities may limit the ability of such areas to function as a nursery area, and/or feeding ground for aquatic fauna.
- Physiological stress to marine fish and commercially important species by creation of higher sediment loads in the water column.
- Increased bioaccumulation of contaminants in commercially important species.
- Reduction in habitat due to loss of benthic primary producer habitat.
- Change in fish catch may occur due to proposed activity. Based on the secondary information (local stakeholders) the sand extraction activity is ongoing for several years and the fish and shellfish quantities have also reduced over the years. The interdependence of these two activities is difficult to assess as cumulative activities and impacts require historic trend dataset.
- Increased turbidity and organic matter may change the microbial water quality at nearby recreational sites and may also affect the fish fauna. May lead to increase in the population of undesirable species such as viruses and parasites.

7.1.9 Anticipated impact on benthic environment

- During sand mining operations, the removal of material from the seabed also removes organisms living on and in sediments which are collectively termed as 'Benthos'.
- Initial reduction in abundance, species diversity, benthic biomass as well as recovery of the lost biota varies with scale and duration of disturbance, local hydrodynamics,



and associated transport processes and lacks similarity to the habitat that existed prior to sand mining.

- Sand mining results in complete removal of surface biota at mining sites.
- Excessive and unplanned riverbed sand mining results in the destruction of aquatic and terrestrial habitat through large changes in the channel morphology.
- Disturbance of the upper layers of the seabed causes short term re-suspension of sediments, re-mineralization of nutrients and contaminants and re-sorting of sediment particles. Direct removal damages, displaces or kills a portion of benthic flora and fauna. It also causes a short term attraction of carrion consumers. It leads to alteration of habitat structure (e.g. removal of sand, flattening of wave forms, and removal of structures required by some organisms).
- Increased suspended sediment due to sand mining can affect the filter feeding organisms such as shellfishes by clogging and damaging their feeding and breathing physiology.
- Sand mining may lead to patchy distribution of organisms between mined and adjacent non-mined areas.
- Adult fish are likely to move away or avoid areas of sand mining sites, unless food supplies are increased as result of increase in organic matter.
- Fauna was comprised of polychaetes & crustacean which constitute a major food source for benthic feeding fishes; these showed low population in the central regions of the river and thus lowered secondary benthic productivity.

7.1.10 Impact on riparian areas

- Sand-and-gravel mining in stream channels can damage public and private property. Channel incision caused by sand/gravel mining can undermine bridge piers and expose buried pipelines and other infrastructure.
- Excavation of a mining pit in the active channel lowers the stream bed, creating a nick point that locally steepens channel slope and increases flow energy.
- Excessive and unplanned riverbed sand mining results in the destruction of aquatic and terrestrial habitat through large changes in the channel morphology. Impacts include bed degradation, bed coarsening, and channel instability. This in turn can



cause erosion of banks, embankments along fields leading to salt water intrusion and loss of land.

7.1.11 Anticipated impact on mangrove

- Mangroves are crucial habitats as they act as feeding and breeding grounds for many organisms. These are also an important site for crab fisheries. Mangroves could be affected by sustained inundation of pneumatophores and declining water quality which may lead to their death.
- In downstream areas sand mining may lead to damage to embankments which cause saline water intrusion into fields this leads to abandonment of fields which are colonized by mangroves (already damage due to breach of bunds), and bunds hence have to be restored in the traditional method.
- Damage to mangroves can also affect species (eg: *Meretrix* spp., *Polymesoda* spp., oysters and clams) that depend on mangroves for resources.
- However the overall impacts to mangrove in the study area are not of concern as mangrove cover has shown steady increase in-turn showing indications of large scale increasing its expanse in to other land use areas.

7.1.12 Impact on mudflats

- Sand mining can cause increased scour, erosion and increase steepening of slopes thereby removing the mudflat habitat.
- Create a disturbed benthic community and possibly reduce the number and diversity of benthic species and affects larval recruitment negatively.

7.1.13 Anticipated impact on sandflats

- In-stream mining lowers the stream bottom, which may lead to bank erosion. Depletion of sand in the streambed and along coastal areas causing deepening of rivers and estuaries, and the enlargement of river mouths and coastal inlets.
- Epifaunal and large in-faunal organisms will be most affected by sand mining. Crab and lobster spawning areas occur where sand banks meet rocky areas. It can cause extinction of commercially important species dependent on sand flats for eg: *Paphia* spp.



- Cumulative impacts will include undercutting and collapse of river banks, loss of adjacent land and/or structures, upstream erosion and uprooting of as a result of an increase in channel slope and changes in flow velocity. In the downstream region there is channel widening and deepening, undermining of engineering structures, dwindling of riverine habitats, damage to protective structure such as bunds leading to salt water intrusions into paddy field.

7.1.14 Others

- The most likely adverse impact will be of cumulative nature and it will be hard to discern from the singular impact of any new or old activity in the given location and period.
- There are crocodile and smooth coated otters found in the river which are protected under schedule I and II respectively by the Indian Wildlife Protection Act, 1972. Other mammals such as Otters, jackals, flying fox, wild cats, wild boar etc. visit mangroves for shelter, breeding or feeding. Primate species such as macaques and langurs can face increased threats. These animals can face increased threats and can be harmed in man-animal conflicts.
- Olive Ridley's turtle protected under schedule I of Wildlife protection Act, 1972 nesting sites could be affected due to sand extraction around the mouth of the estuary in large scale.
- Chapora Estuary has a good diversity and abundance of avifauna. Birds gather on the sand bars at mouth of River Chapora for feeding. Several migratory birds visit these rivers during winter and use it as an important feeding ground. These are most sensitive to any sort of disturbance such as noise, use of mechanized vessels, change in turbidity, productivity or change in water quality. The disturbance by sand mining may affect foraging behavior of birds, mainly aquatic birds. These birds are likely to move away from such areas.
- Occurrence of unintended events such as vehicle collision, accidents, fire, fuel leaks and other inadvertent events may occur mainly due to lack of coordination, casual approach, un-managed activity and associated activities (e.g.: fishing) and no timely communication within and between stakeholders involved in nearby



areas. These events may also result in environmental disaster if there are no precautions taken.

7.1.15 Positive anticipated impacts

- Sand mining can help the economy directly by generating employment for extraction of sand and income from sale of sand.
- Maintenance of channel for the movement of fishing vessels is carried out by the state authority. Same areas can be excavated which can serve dual purpose and reduce expenses.

7.2 Mining Sensitive Areas:

Estuaries are most dynamic and complex ecosystems known around the globe. They are made up of a wide range of different habitats, which exist in an ever changing mosaic structure. Typical habitats that make up an estuary include sand banks, mudflats, mangroves, salt marshes, sand flats, and at their coastal edge sand dunes, small islands sandy beaches etc. They are prime importance for wildlife especially migrating and breeding birds and major values in terms of their rich natural resources (nursery grounds and commercially important fish). In addition they also offer a wide range of ecosystem services such as shoreline stabilization, nutrient regulation, carbon sequestration, detoxification of polluted water and supply of food and energy resources.

To preserve and protect these habitats areas have been demarcated based on importance and in accordance with Sustainable Sand Mining and Management Guideline 2016. The entire region is divided into four different zones. Zone –I (Figure 7.1 and Legends as per Table 7.1) is located at the mouth region, it ends at Camurlim village jurisdiction. The area consists of sensitive regions *viz*; Turtle nesting site, embankment to protect paddy fields, sand flat, Mangroves, riverside urban areas and bridge. Shallow sand flats provide feeding habitat to a lot of migrating and local birds while Morjim is well known Olive Ridley's turtle nesting site, if sand is excavated from zone-I(Figure 7.1) it is predicted to impact shoreline, change in geomorphology, beach profile and grain size of sandy beach, which will potentially have adverse impact on turtle nesting grounds. Further a bridge is present connecting Siolim and Morjim; mining might damage this structure, stability or strength of the bridge. As per SSMMG, 2016, to avoid structural damage to any bridge, an area upto 500 m on both the sides of bridge is



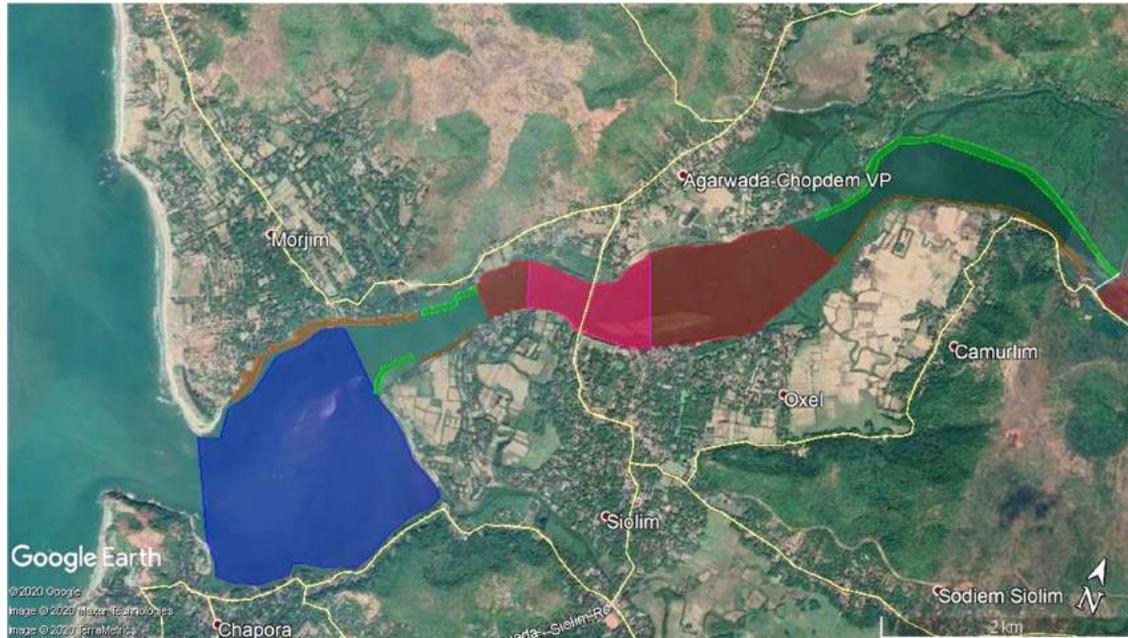
restricted for mining. East to the bridge an Island (North of Oxel village) vegetated with mangroves, and considering the Hon'ble NGT order (28/2015 (WZ)) an area of 1000m (upstream and downstream) has to be restricted for mining. Based on the baseline geomorphology and bathymetry, the profiles reveal deeper excavated areas that may pose threat to the constructed structures.

An embankment exists to protect salt water intrusion as well as to secure paddy field on Siolim side. Opposite to this embankment lies mangrove forest, as per SSMMG (2016), a 50m wide area from ecologically sensitive areas (such as mangroves) and 25m from the embankments are to be avoided for mining.

Next zone is considered from Oxel to Revora which consists of two adjacent islands towards west end, bridge and meandering towards east. Here the order of Hon'able NGT order (28/2015 (WZ)) has been followed for excluding an area of 1000m upstream and downstreams of Juem de Tuem Island is applied to all the islands of this river as all the islands are equally important and vulnerable due to changes in geo-morphology and erosion pertaining to mining activity. Thus 1000m upstream and downstream areas from these islands are to be restricted for sand mining. Meandering bends are to be avoided as these may have major geo-morphological changes such as accretion which may lead to deposition and erosion at the upper/lower reaches pertaining to sand extraction. Mudflats and mangroves are also to be avoided as these serve as habitat, breeding ground and nursery for myriad of marine organisms. A flyover bridge is also present at the meandering point where an area of 500 m on both the sides is restricted for mining. Zone III (Figure 9.1) falls between Revora to Nadora, it consists of an Island and bridge towards north while a meander and National highway running parallel to the river. Therefore 100m from any National Highway is exempted from mining activity (SSMMG 2016). Further east of the National Highway a meander is encountered where 200m area on either sides is restricted. On the eastward side there is an Island and bridge which are restricted as well 1000m and 500m on either side respectively. Last zone has three main features viz Bridge, Meander and islands and thus as per SSMMG (2016), these zones are restricted as well from mining activities Zone IV (Figure 9.1).

The figure 7.2 and 7.3 shows the benthic biodiversity indices overlapped on the proposed areas of sand extraction. The upstream stretches indicate low values of indices for A-Ambi

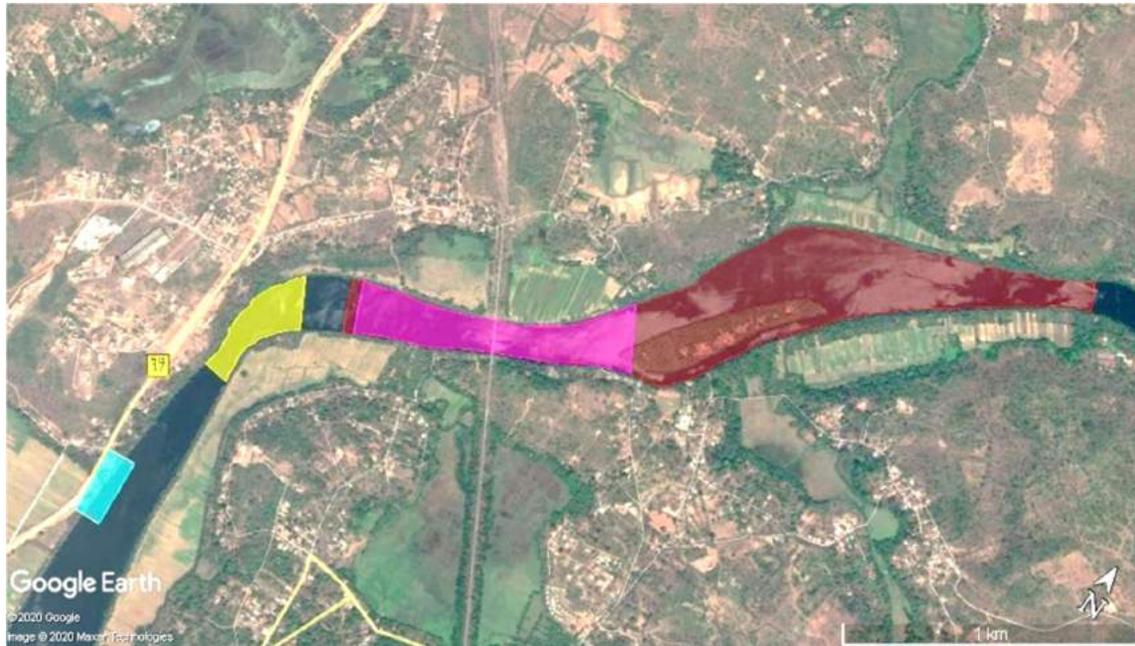
and Benthix therefore the impact of sand extraction will be minimum on the benthic biota but Shannon-Wiener's and Simpson's Index shows high values. While the stretch between Camurlim- Chopdem has higher indices (Figure 7.2) which indicates sand extraction will have higher impacts on the benthic biodiversity.



Zone-I



Zone-II



Zone-III



Zone-IV

Figure 7.1: Depicting Mining Sensitive Zones for Chapora estuary (Zone I to IV).



Table 7.1: Depicting type of sensitivity, colour code, width and guidelines referred.

Colour	Sensitive Areas	Width	Guideline
	Mangrove	50 m	Sustainable Sand Mining Management Guideline 2016
	Embankment (Saline Intrusion)	25 m	Sustainable Sand Mining Management Guideline 2016
	Bridges	500 m up-streams & down-streams	Sustainable Sand Mining Management Guideline 2016
	Islands	1000 m up-streams & down-streams	Sustainable Sand Mining Management Guideline 2016/ National Green Tribunal.
	National Highways	100 m	Sustainable Sand Mining Management Guideline 2016
	Meandering	200 m Up-strems& down-streams	Sustainable Sand Mining Management Guideline 2016
	Ecologically Sensitive	-	Sustainable Sand Mining Management Guideline 2016
	Urban Habitat	50 m	Sustainable Sand Mining Management Guideline 2016

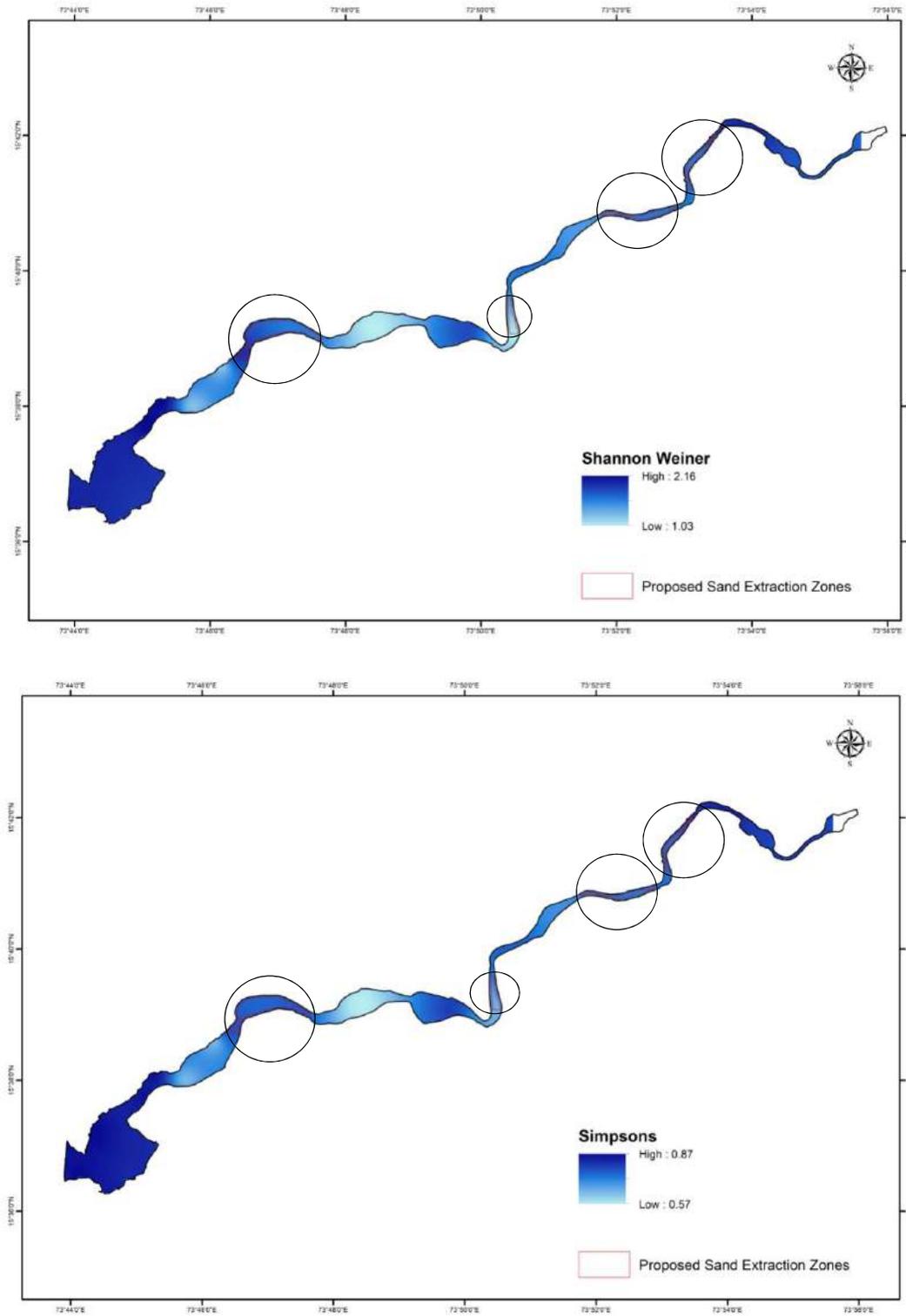


Figure 7.2: Shannon-Wieners and Simpsons Index depicted on the river stretches with encircled proposed sand extraction zones.

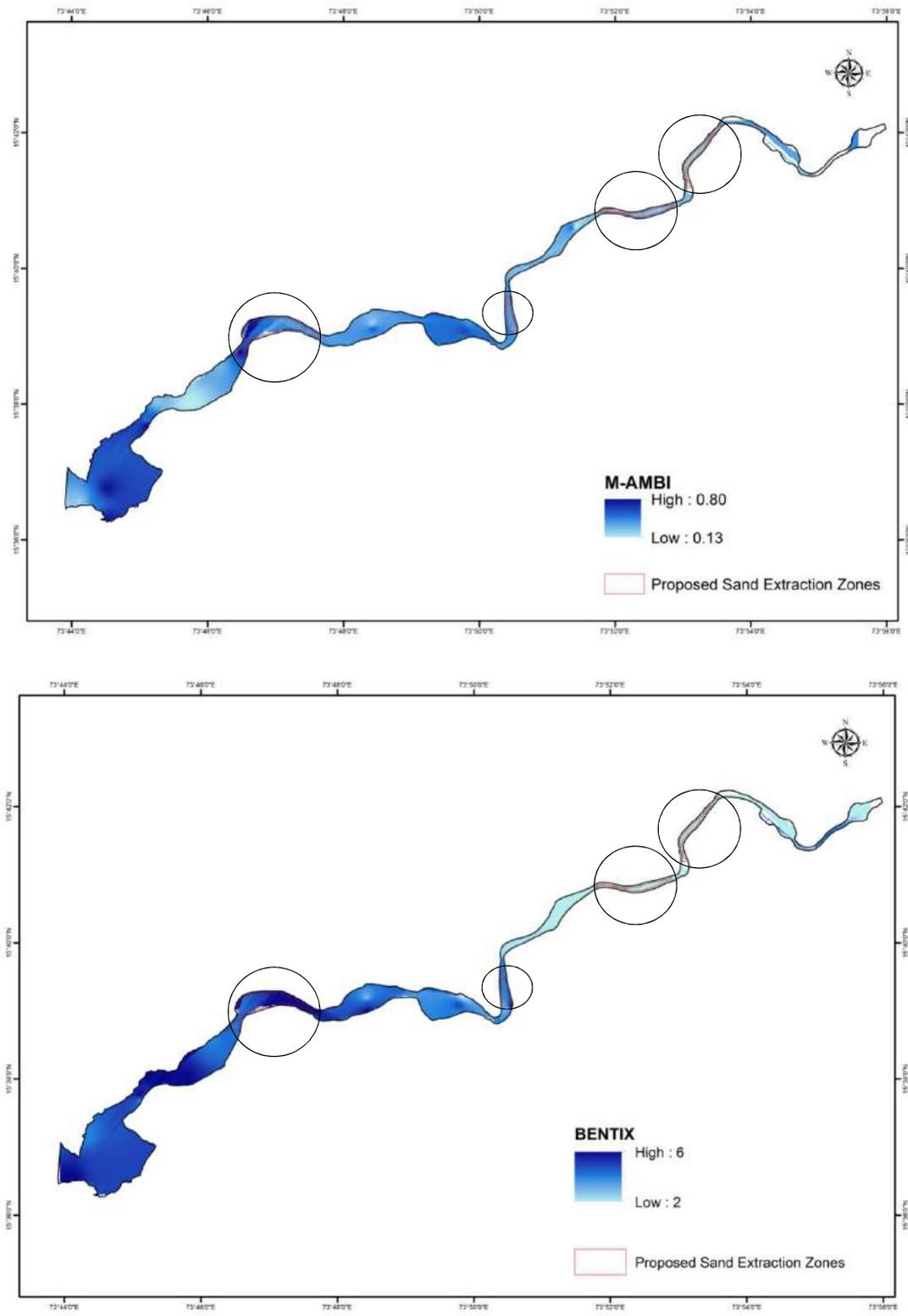


Figure 7.3: M-AMBI and BENTIX indices depicted on the river stretches with encircled proposed sand extraction zones.



7.3 Cumulative Impacts:

In the present study Land Use Land Change cover was observed by mapping the project area by comparing present scenario with year 2003. Several areas were noted and maps were prepared accordingly along the entire stretch of Chapora estuary. Total sixteen regions are identified and depicted based on land use change. For all the regions two maps were created, representing current scenario and other depicting 2003 scenario. These maps have been numbered 1-16.

First region lies near the mouth area of estuary, in the year 2003 the region showed minimal mangrove cover whereas now it shows a significant increase in the mangrove. Similarly in the next region notable increase of mangroves on the island can be seen. Earlier aquaculture ponds/salt pans were in use near the bridge (Siolim-Morjim) area, but now it has been taken over by mangroves. There has been change in Pernem area as well; the land used for agriculture earlier has now become fallow land. This could be the result of salt water intrusion due and simultaneous increase in mangrove cover, as clearly visible in the sporadic distribution of mangrove has grown into a thicket now which depicts a possible shift of mangrove region landward side. In the mid region of estuary, significance increase in saline areas is clearly visible. The areas once utilised for paddy cultivation, now have turned barren and fallow due to a single saline water surge or recurrent high tide water brining in salinity. This intrusion of saline water could be due to lack of maintenance of already existing embankments, breach in embankments, eroding mudflats or shift in mangrove area to landward side as well as excavation of sand. In the upper reaches of the estuary cumulative impacts on the banks is visible wherein banks have been eroded taking away the riparian vegetation (Fig: 7.4). It is to be noted that in spite of good vegetation cover like tall grasses, shrubs and large trees (mostly coconut palm) the chunk of land is eroded, leaving a cross sectional vertical wall of the soft sandy silty bank sediment (Figure 7.6).

From the comparison of historic land use it is clearly visible that land once used for paddy cultivation has been converted into waste/marshy land due to saline intrusion (Figure 7.5). Apart from the major areas depicted in the Figure 7.51A-B to 16A-B there are several small land parcels that have been either intruded by saline water or are eroded due to strong monsoon currents.

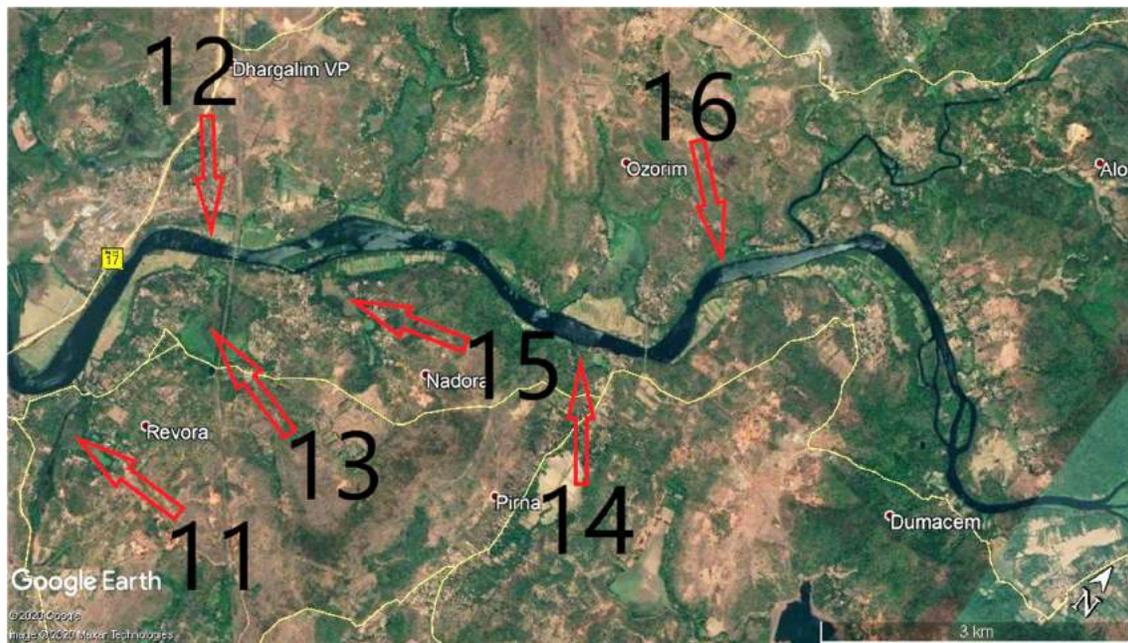
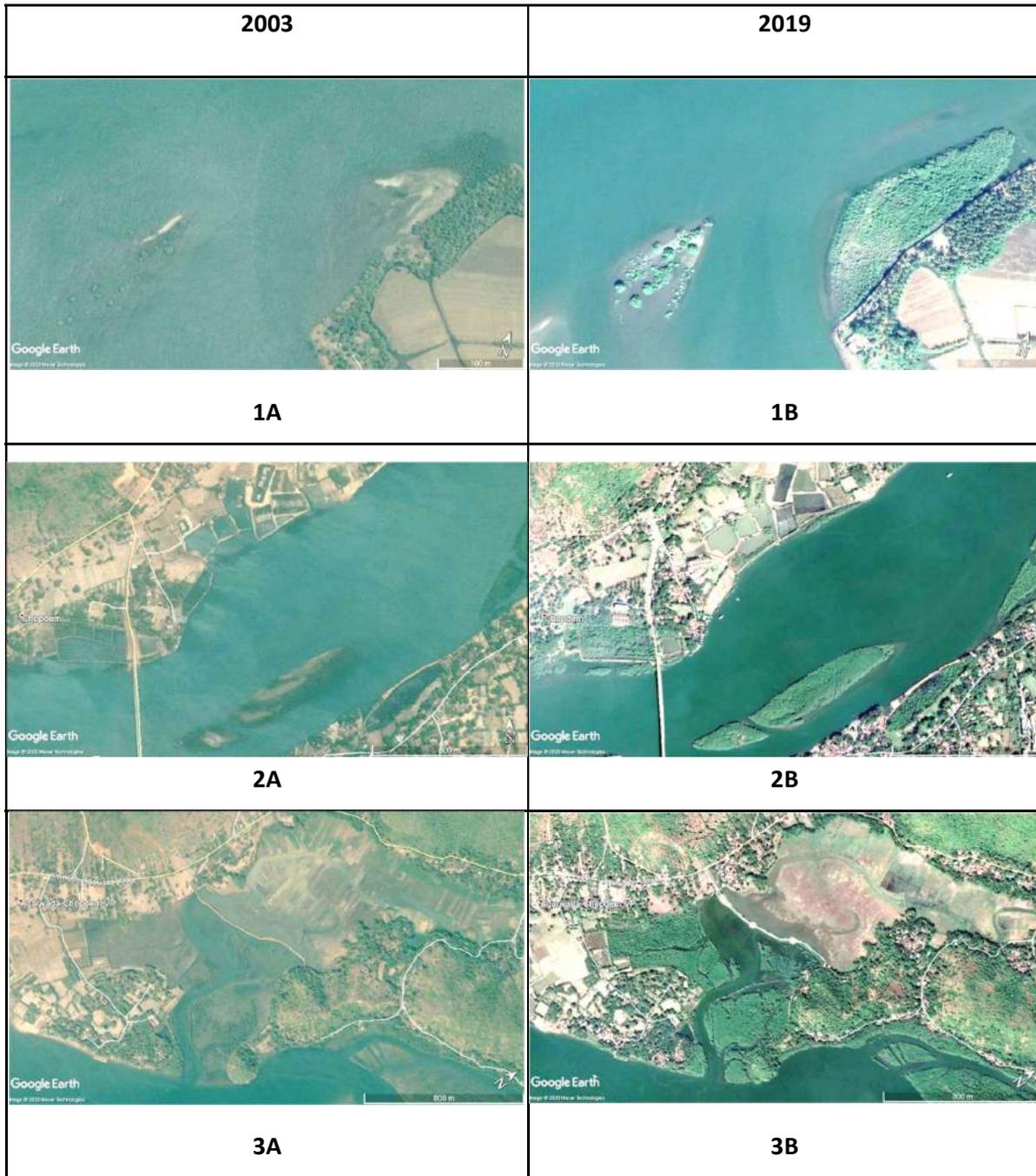
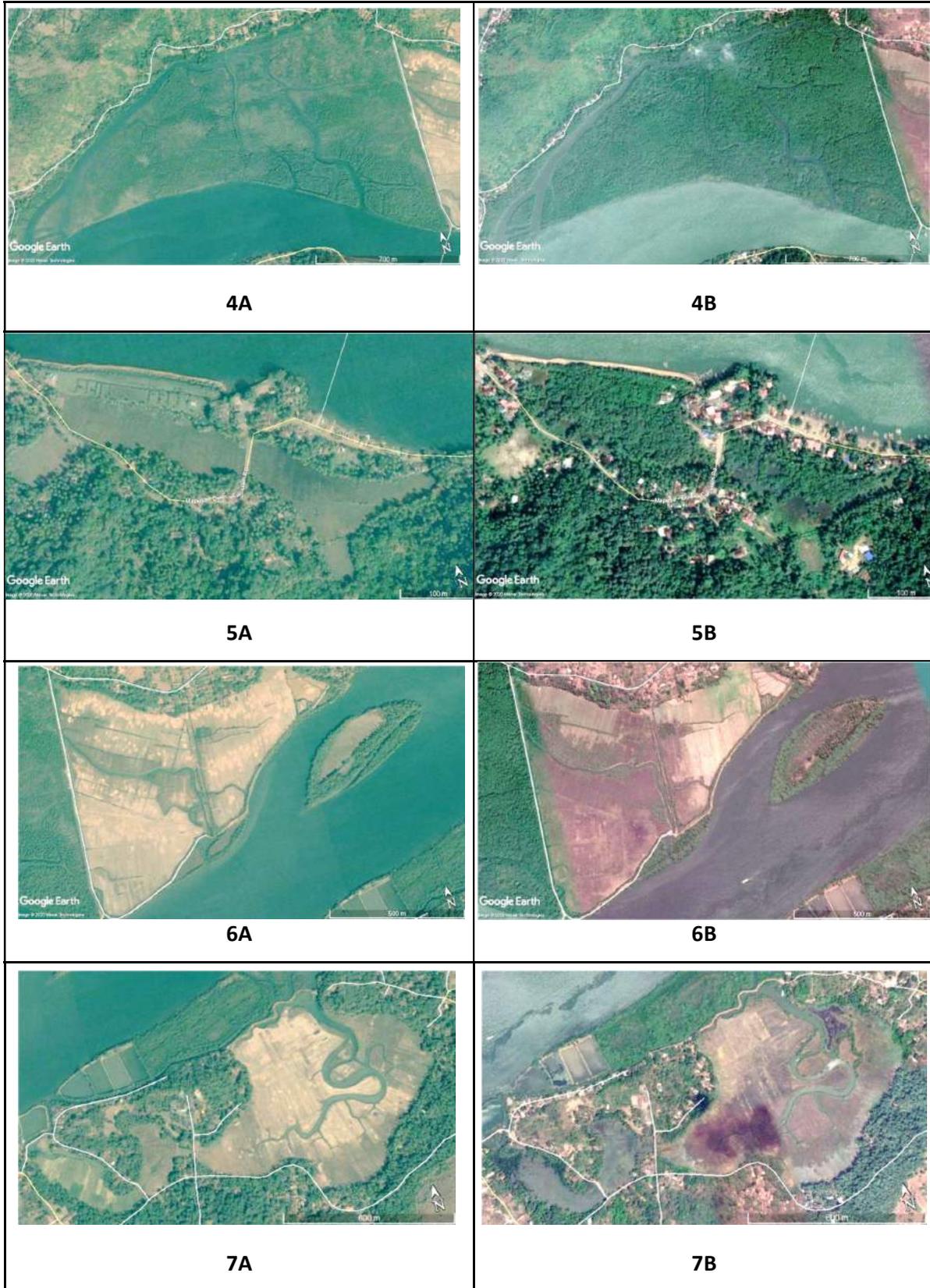


Figure 7.4: Two sections of the rivers depicting areas highlighted in the subsequent Figure 7.5 for land use changes.







8A



8B



9A



9B



10A



10B



11A



11B



12A



12B



13A



13B



14A



14B



Figure 7.5: Areas depicting Land Use Land Cover along the Chapora Estuary.

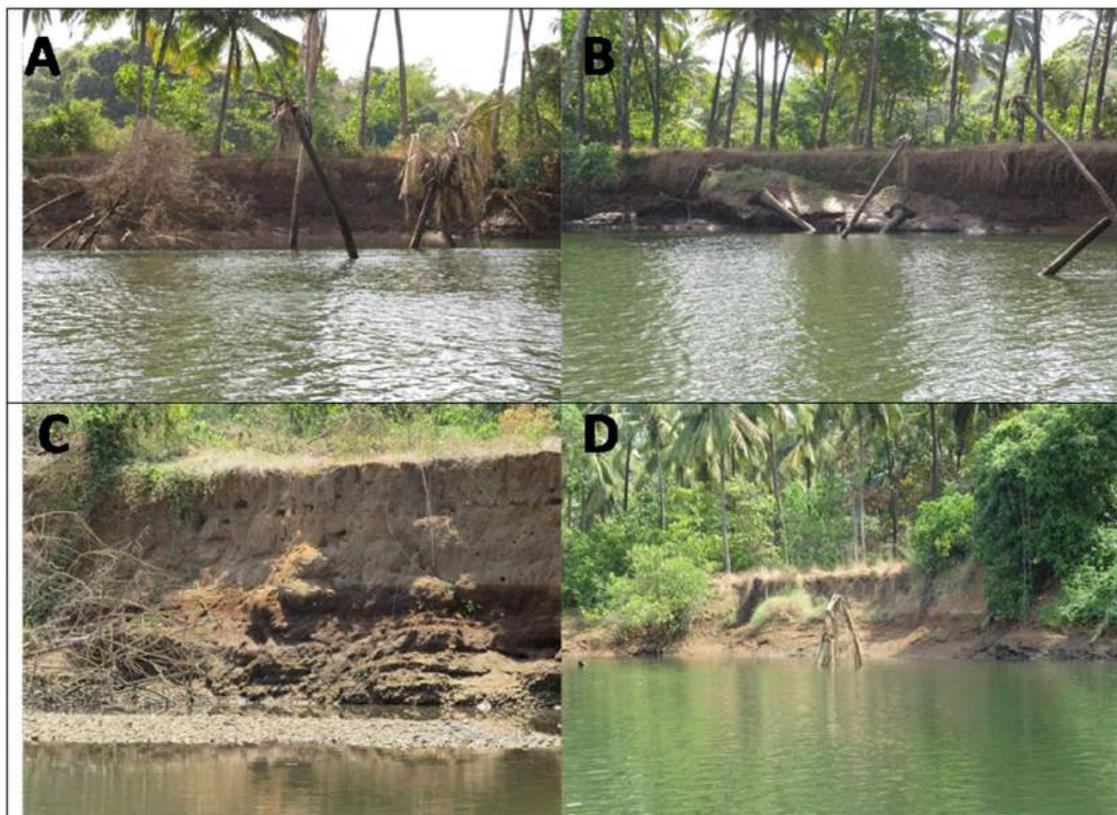


Figure 7.6: Erosion of banks in the upstream stretches of Chapora Estuary.



CHAPTER 8 MITIGATION MEASURE

The aim of the mitigation guidelines to ensure that the sand mining is carried out in an environmentally sustainable and socially responsible way, improve the effectiveness of monitoring of mining and transportation of mined out material, conservation of river equilibrium and its ecosystem health, no obstruction of the river flow, water transport and restoring the riparian rights and in-stream habitats, to prevent river pollution and water quality deterioration. The extraction of sand and gravel from the river bodies has to be regulated and done with the adoption of required environmental safeguards. Mapping of the sand resources at the district level, identification of appropriate sites for extraction, appraisal of the extraction process, putting in place the required environmental safeguards and rigorous monitoring of the volume of extracted material is required to ensure the sustainability of the entire process. In broader sense, the impacts of sand mining can be reduced or avoided and mitigating it may only imply replenishment (which may happen over a course of time during which the magnitude and expanse of impacts might change thus making it difficult to comprehend).

8.1 Protection of river embankment

Site-specific evaluation is needed to evaluate each proposed operation to minimize disturbance and maximize the stability of the channel. In downstream areas, sand mining can lead to damage of bunds, which causes saline water intrusion into fields, leads to abandonment of fields. Mining lease should be preferably granted for those locations which have the least possibility of an impact on the environment and nearby habitation. Demarcation of the mining area with pillars and geo-referencing should be done before the start of mining to ensure that sand extraction is going on only within the permitted area. The permanent boundary pillars need to be erected after the identification of an area for deposition of mined sand outside the river bank at a safe location. The distance between boundary pillars on each side of the bank shall not be more than 100 m.

Sand and gravel shall not be allowed to be extracted where erosion may occur, such as at the concave bank. Sand and gravel shall not be extracted up to a distance of 1 kilometer (1 km) from major bridges and highways on both sides, or five times (5x) of the span (x) of a



bridge/public civil structure (including water intake points) on up-stream side and ten times (10x) the span of such bridge on the down-stream side, subjected to a minimum of 250 meters on the upstream side and 500 meters on the downstream side as per the guidelines issued by National Green Tribunal. The borrow area should preferably be located on the riverside of the proposed embankment because they get silted over time. For low embankment, less than 6 m in height, the borrow area should not be selected within 25 m from the toe/heel of the embankment. In the case of the higher embankment, the distance should not be less than 50 m. In order to obviate the development of flow parallels to the embankment, crossbars of width eight times the depth of borrow pits spaced 50 to 60-meter center-to-center should be left in the borrow pits.

River bed sand mining shall be restricted within the central 3/4th width of the river/rivulet or 7.5 meters (inward) from river banks but up to 10% of the width of the river. The mining area must be demarcated at a minimum distance of at least 50 m away from the river embankment on either side. The boundaries of the quarries may be fixed concerning the existing survey marks from the survey fields adjacent to the river. Sand quarrying lease area shall be demarcated on the ground with pucca stone or concrete pillars to show the present natural bed level, and the depth of mining allowed. The zone of river bed mining shall ensure that the objective to minimize the effects of riverbank erosion and consequential channel migration are achieved to the extent possible. In general, the area for removal of minerals shall not exceed 60% of the mine lease area, and the scientific report shall adequately support any deviation or relaxation in this regard.

8.2 Annual replenishment of sand

It is necessary to ascertain the rate of sand replenishment in the river bed. A regular replenishment study needs to be carried out to keep a balance between deposition and extraction. Replenishment would need to occur before subsequent extraction could take place. The concept of annual replenishment accounts for the episodic nature of sediment transport. For example, during monsoon, high stream flows result in a high contribution of sediment from hill slopes and tributaries, and during the dry periods, low stream flow led in little sediment supply. The use of monitoring data is essential in measuring when actual replenishment occurs.



The use of the concept of annual replenishment protects long-term channel stability as well as aquatic and riparian habitat by extracting a sustainable volume of sand. Sand mining must not be done on one site, but in alternating sites, to reduce over-extraction, which damages the environment beyond rehabilitation.

According to best practices, the distance between any two sand mining clusters should not be less than 2.5 km to reduce the cluster formation. Mining lease should be defined in such a way that the total area of the mining leases in a cluster should not be more than 10 Ha. After every year, a mandatory audit of the quantity extracted and quantity permitted along with the replenishment rate.

8.3 Maintenance of flood capacity

Flood capacity in the river should be maintained in areas where there are significant flood hazards to existing structures or infrastructure. Sand and gravel could be extracted from the downstream of the sand bar at river bends. Retaining the upstream one to two-thirds of the bar and riparian vegetation is accepted as a method to promote channel stability. Mining depth should be restricted to 3 meters, and distance from the bank should be $\frac{1}{4}$ th or river width and should not be less than 7.5 meters.

8.4 Seasonal ban on sand mining activity

There shall be no river bed mining operation allowed in the monsoon period. The period as defined by IMD Nagpur for each state shall be adhered to. The cumulative riverine impact of all mining activity should be reviewed on an annual basis to minimize long-term impacts and inequities in permits between adjacent mining operations.

8.5 Limiting sediment impact

Minimize activities that release fine sediment to the river. No washing, crushing, screening, stockpiling, or plant operations should occur at or below the streams "average high-water elevation," or the dominant discharge. These and similar activities have the potential to release fine sediments into the stream, providing habitat conditions harmful to local fish.

8.6 Prevention and mitigation of pollution

Proper entry and exit points for the movement of loading vehicles in and out of the sand mining sites shall be carefully located, taking into consideration the habitations/settlements



in the area. Construction of separate gravel roads for tipper trucks to reduce traffic congestion, accidents, as well as noise and air pollution, maybe consider. All the vehicles should be serviced regularly according to the existing Govt. guidelines to minimize noise and air pollution. The transportation route so selected should be verified by the Goa Government for its carrying capacity. Movement of heavy vehicles from public roads to pit sand, gravel, and river sand collection points need access roads. To prevent air pollution due to the dust during sand mining operations and safeguard the workforce in the sand mining and depot site, constant water sprinkling on the pathways and dust prone areas may be conducted. The sand loaded vehicles are to be covered with a tarpaulin before moving out of the quarries/depots. Plantation needs to be done with the consultation of the state forest department beside the sand transportation road to curtail the dust pollution.

The air and water quality should to be checked periodically to ensure that no pollution is caused due to sand transport operations. Safety gadgets such as earplugs, goggles, respiratory devices, luminescent vests may be provided to the workers at the sand mining site. First aid kit with all essentials shall be kept ready at all quarry/depot sites, in case of any emergency. Independent environmental audits need to be carried out at least once in a year for each mining site by reputed third party entity and report of such audit be placed in the public domain.

8.7 Protection and management of groundwater

To monitor the groundwater level during sand extraction operations, a network of existing wells may be established around the sand mining area, and new piezometers must be installed at all sand mining sites. The monitoring of groundwater quality in the vicinity (one Km radius from the sand mining site) shall be carried out once in two months. If, at any stage, it is observed that the groundwater table is getting depleted due to the mining activity, necessary corrective measures shall be carried out, which may include immediate stopping of the mining operation.

GSPCB has been monitoring water quality for Chapora and has not found significant change in water quality (Action Plan Report on River Chapora, 2019) wherein sand extraction was an on-going activity thus representing cumulative results. The report delineates several activities



for the rejuvenation of Chapora River and considering these proposed actions, the management aspects in this report have been proposed.

8.8 Soil management

Sand mining can cause weakening of soil in adjacent areas, which can lead to erosion of river banks. Sand mining destabilizes soil structure, river banks and often leaves isolated islands of trees; the subsequent flow will erode the banks and islands. Construction of soil conservation structures like river embankments/bundhs, extensive plantation drive, and mitigation of afforestation are some of the prerequisites to reduce soil erosion. Mangroves around the Chapora estuary are crucial habitats that serve as feeding and breeding ground to many ecologically and economically organisms like oysters and clams, crab, fishes. Mangroves also protect the river embankment and an excellent source of carbon sequestration. Hence, ultimate care needs to be taken to protect the mangrove habitat.

Soil salinity is a major global issue owing to its adverse impact on agricultural productivity and sustainability. It should be noted that no single approach can deliver a complete solution to fix/reclaim the soil salinity problem. Soil salinity undermines the resource by decreasing soil quality and can jeopardize the integrity of soil's self-regulatory capacity. Therefore, regular salinity mapping of the river bank may assist in taking necessary and timely actions to tackle the increased soil salinity and to avoid a further spread of soil salinity to a new area. Different methods, such as physical (levelling, salt scraping, tillage, subsoiling, and sanding); chemical (use of soil amendments such as elements, acids, gypsum to rectify soil sodicity problems and to improve soil health); hydrological (irrigation systems: Surface, flood, basin, drip, sprinkler, subsurface irrigation, leaching, and drainage), and biological (biosaline agriculture: Salt tolerant crops, and a serial biological concentration approach), may be employed to manage and prevent soil salinization.

8.9 Alternative resource generation

Promotion of manufactured sand, artificial sand, and alternative technologies in construction materials and processes are also required for reducing the dependence and demand on naturally occurring sand and gravel. Reusing and recycling of building material to reduce demand for river sand, pit sand, and gravel.



CHAPTER 9 ENVIRONMENTAL CONSERVATION AND MANAGEMENT PLAN

9.1 Background

Under the Environmental Impact Assessment notification of 2006 issued by the Ministry of Environment, Forests and Climate Change (MoEFCC), Govt. of India, which forms the legal basis for environmental impact assessment of development projects in India, mining of minerals with a lease area of less than 5 hectares did not require prior environmental impact assessment (EIA), until 2012 when the Supreme Court of India ruled that EIAs were mandatory for minor minerals, irrespective of the lease area. Pursuant to this, the MoEFCC, in response to the increase in the EIA applications requiring scrutiny devolved the process of environmental clearance to the district level. This included amending the EIA Notification of 2006 to create District-level authorities for screening and evaluating EIAs for mining of minor minerals, including sand. Since this directive was enacted, the National Green Tribunal and other courts have issued repeated directives to halt illegal sand mining, based on the environmental impacts arising from the activity. These have included a 2015 National Green Tribunal directive to ban sand mining in Madhya Pradesh during the monsoon, but the ban was lifted within a month (SANDRP, 2016). In 2016, the Union Ministry of Mines (Ministry of Mines, India, 2016) released a press release addressing the administrative responsibilities associated with legal and illegal sand mining in rivers, stating that:

- Sand mining is regulated at the state level under powers granted by the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act).
- States can grant mineral concessions for minor minerals and enact regulations to control these activities.
- The same Act empowers state governments to frame rules to prevent illegal mining, transportation and storage of mineral sands, and therefore the control of illegal activities is under the legislative and administrative jurisdiction of the state governments.

9.2 Legal requirements

As per the provisions of the EIA Notification issued on 14th September 2006 and subsequent amendments till date:



All projects and activities are broadly categorized in to two categories – Category A and Category B. Category ‘A’ in the Schedule requires prior environmental clearance from the MoEFCC and Category ‘B’ in the Schedule, from the State/Union Territory Environment Impact Assessment Authority (SEIAA). An application seeking prior environmental clearance in all cases shall be made in the prescribed Form –I along with the pre-feasibility project report. “Scoping” refers to the process by which the Expert Appraisal Committee in the case of Category ‘A’ projects or activities, and State Level Expert Appraisal Committee in the case of Category ‘B1’ projects or activities, determine detailed and comprehensive Terms of Reference (TOR) for the preparation of an Environment Impact Assessment (EIA) Report in respect of the project or activity for which prior environmental clearance is sought. However, after the introduction of standard TOR for each sector amendment of EIA notification the issued on 10th April, 2016 it was stated that “Standard TOR developed by the Ministry in consultation with the sector specific Expert Appraisal Committees shall be the deemed approved TOR for the projects or activities. These standards TOR shall enable the Project Proponent to commence preparation of an Environment Impact Assessment Report after successful online submission and registration of the application. All Category ‘A’ and Category B1 projects or activities shall undertake Public Consultation. But now as per Gazette notification amendment S.O. 3977(E) dated on 14.08.2018 issued by the MoEFCC of India, the Public consultation are not required for B2 Sub-category under B category project.

Acts and legislations applicable for sand mining leases

- The Mines Act 1952
- The Mines and Mineral (development and Regulation) Act 1957
- Mines Rules 1955
- Mineral Concession Rules 1960
- Mineral Conservation and Development Rules 1988
- The Environment (Protection) Act, 1986
- EIA Notification (and amendments) 2006
- Wildlife Protection Act, 1972
- The Forest (Conservation) Act, 1980
- Water (Prevention and Control of Pollution) Act (and subsequent amendments) 1974



- The Water (Prevention & Control of Pollution) Rules 1975, Cess Act 1977 & Cess Rules 1978.
- Air (Prevention and Control of Pollution) Act (and subsequent amendments) 1981
- Solid Waste Management Rules, 2016
- CRZ notification 2019

9.3 Mining plan

A mining plan has to be prepared by each lease owner and accordingly the state/district level committee may issue the permits. The basic information required in the mining plan is given below which has to be prepared as per the guidelines of EIA Notification (2006).

- Location & Basic Information of the Mining Lease Area (quantities Haulage and Surface Transport Plan.
- Brief layout of mine working & layout mine faces.
- Demarcation of Mining Lease Area.
- Mining methodology (Should include tools and machinery used, energy requirement, water, manpower, waste [solid, liquid & air emissions]).
- Yearly schedule of sand mining.
- Facilities and amenities for workers (Porta-cabins, toilets, fuel, health check-up as per Mines Rule 1955).
- Compensatory plantation and CSR activities.

Sustainable Sand Mining Management Guidelines, (2016) and Enforcement & Monitoring Guidelines for Sand Mining (2020) by MoEFCC are being followed for formulating this management and subsequent monitoring plan. Sustainable sand mining guidelines in India have been developed by the Ministry of Environment Forest and Climate Change (MoEFCC, 2016). The guidelines are based on the premise that sand extraction from rivers is required for construction, but it is also required for maintaining river health. The Guidelines recommend the following process be followed and included:

- a) Identification of areas of deposition where mining can be allowed; and identification of areas of erosion and proximity to infrastructural structures and installations where mining should be prohibited. Use of satellite imagery for identifying areas of sand deposit and quantity is done.



- b) Calculation of annual rate of replenishment and allowing time for replenishment after mining in area.
- c) Identifying ways of scientific and systematic mining.
- d) Identifying measures for protection of environment and ecology.
- e) Determining measures for protection of bank erosion.
- f) A bench mark (BM) with respect to mean sea level (MSL) should be made essential to in mining channel reaches (MCR). Below which no mining shall be allowed.
- g) Identifying steps for conservation of mineral.
- h) Permanent gauging facilities (for discharge and sediment both) should be made compulsory for the sites having excessive mining in consultation with Central Water Commission or any competent State Agency.
- i) Implementing safeguards for checking illegal and indiscrete mining.

Sand extraction from riverbanks and river channels areas causes local disruptions which can be anticipated and prevented through appropriate studies. After various environmental problems of river sand mining in various physiographic zones, an EIA was carried out to suggest appropriate Environmental Management Plan (EMP) for regulating the mining activities on a sustainable basis. The river environments in all the three physiographic zones such as highlands, midlands and lowlands are deteriorated drastically due to illicit scooping of sand even from prohibited areas close to bridges and water intake structures. Hence, an attempt has been made to analyse the environmental impacts caused by river sand mining to identify and address the key environmental issues that results in from the activity. The main intention of the effort is to mitigate the negative impacts and enhance the positive ones.



Figure 9.1. Schematic diagram of management of sand mining

9.4 Strategy for the management plan

Following requirements are suggested for defining a mechanism for monitoring of mining activities which will help in identification of mining which is operating either illegally or are violating the regulatory provisions. All precaution shall be taken to ensure that the water stream flows unhindered and process of natural river meandering doesn't get affected due to mining activity. Survey shall be carried out for identifying the stretches having habitation of freshwater turtles or turtle nesting zones. Similarly, stretches shall be identified for other species of significant importance to the river ecosystem. Such stretch with adequate buffer distance shall be declared as no-mining zone and no mining shall be permitted. The regulatory authority as defined for granting Environmental Clearance, while considering the application of issuance of ToR and/or EC for the adjacent block (to non-mining zone) of mining shall take due precaution and impose requisite conditions to safeguard the interest of such species of importance.

District administration shall provide detailed information on its website about the sand mines in its district for public information, with an objective to extend all information in public domain so that the citizens are aware of the mining activities and can also report to the district administration on any deviation observed. Appropriate feedback and its redressal mechanism shall also be made operational. The details shall include, but not limited to, lease area, geo-coordinates of lease area and mineable area, transport routes, permitted capacity, regulatory



conditions for operation including mining, environmental and social commitments etc. (Figure 9.1).

9.5 Management plans:

a) River bed mining recommendations

Permit mining volume based on measured annual replenishment in the first year following adoption of the management plan, a volume equal to the estimated annual replenishment could be extracted from the reach of channel. Replenishment (up to the elevation of the selected channel configuration) would need to occur before subsequent extraction could take place. The concept of annual replenishment accounts for the episodic nature of sediment transport. For example, during wet periods with high stream flows, and a high contribution of sediment from hill slopes and tributaries, monitoring data would show that sand and gravel bars are replenished quickly. During drought periods with low stream flow, and little sediment supply or transport, monitoring data would likely show that bars were replenished at a slower rate.

The use of monitoring data is essential in measuring when actual replenishment occurs. The use of the concept of annual replenishment protects long-term channel stability as well as aquatic and riparian habitat by extracting a volume sustainable by watershed processes.

B) Establish an absolute elevation below which no extraction may occur (minimum enveloped level or redline)

The absolute elevation below which no mining could occur or “redline” would be surveyed on a site-specific basis in order to avoid impacts to structures such as bridges and to avoid vegetation impacts associated with down-cutting due to excessive removal of sediment. An extraction site can be determined after setting the deposition level at 1 m above natural channel thalweg elevation, as determined by the survey approved by mine plan approving authority.

c) Limit river bed extraction methods to bar skimming

If mining is limited to the downstream end of the bar with a riparian buffer on both the channel and hill slope (or floodplain) side, bar skimming would minimise impacts. Other methods such as excavation of trenches or pools in the low flow channel lower the local base

level, and maximizes upstream (head cutting and incision) and downstream (widening and braiding) impacts.

d) Extraction of sand/ gravel from the downstream portion of the bar

Retaining the upstream one to two thirds of the bar and riparian vegetation while excavating from the downstream one to two third of the bar is accepted as a method to promote channel stability and protect the narrow width of the low flow channel necessary for aquatic life. Sand and gravel would be re-deposited in the excavated downstream one to two thirds of the bar (or downstream of the widest point of the bar) where an eddy would form during sediment transporting flows. In contrast, if excavation occurs on the entire bar after removing existing riparian vegetation, there is a greater potential for widening and braiding of the low flow channel.

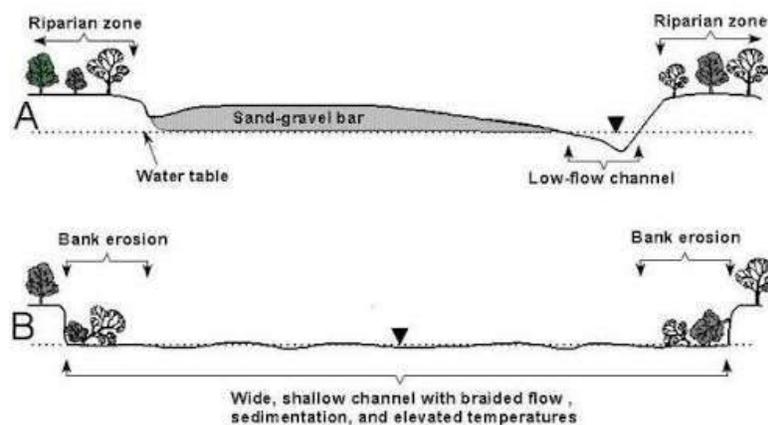


Figure 9.2. Diagram of channel cross sections showing

9.2.a typical sand-gravel bar in relation to the low-flow channel, riparian zone and water table, and (B) the wide shallow channel that results from unrestricted mining and that is characterized by bank erosion, braided flow, sedimentation, and increased water temperatures. (Source: http://threeissues.sdsu.edu/three_issues_sandminingfacts01.html).

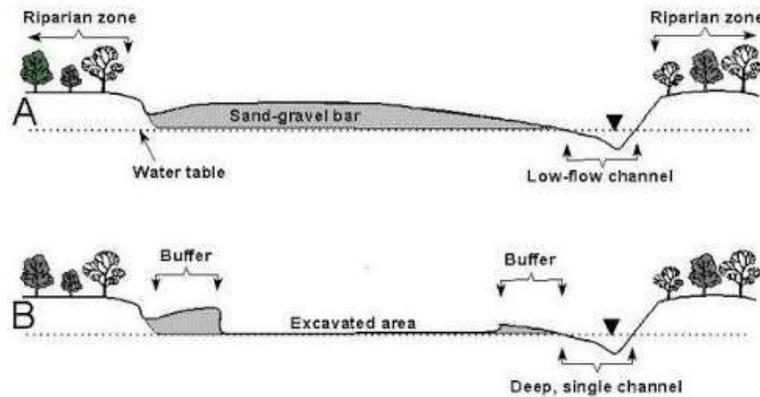


Figure 9.3. Diagram of channel cross sections showing

9.3(A) a typical sand-gravel bar in relation to the low-flow channel, riparian zone and water table, and (B) the protected deep, single channel and channel banks when mining is restricted within a buffer of designated width and above the water table. (Source: http://threeissues.sdsu.edu/three_issues_sandminingfacts01.html).

e) Concentrate activities to minimise disturbance

River bed extraction activities should be concentrated or localised to a few bars rather than spread out over many bars. This localisation of extraction will minimise the area of disturbance of upstream and downstream effects. Skimming decreases habitat and species diversity – these effects should not be expanded over a large portion of the area.

f) Review cumulative effects of sand and gravel extraction

The cumulative impact of all mining proposals should be reviewed on an annual basis to determine if cumulative riverine effects or effects to the estuary are likely.

g) Maintain flood capacity

Flood capacity in the river should be maintained in areas where there are significant flood hazards to existing structures or infrastructure.

h) Establish a long-term monitoring program

Monitoring of changes in bed elevation and channel morphology, and aquatic and riparian habitat upstream and downstream of the extraction would identify any impacts of sand and gravel extraction to biological resources. Long-term data collected over a period of decades as sand and gravel extraction will provide data to be used in determining trends.



l) Minimise activities that release fine sediment to the river

No washing, crushing, screening, stockpiling, or plant operations should occur at or below the streams average high water elevation, or the dominant discharge. These and similar activities have the potential to release fine sediments into the stream, providing habitat conditions harmful to local fish.

j) Retain vegetation buffer at edge of water and against river bank

Riparian vegetation performs several functions essential to the proper maintenance of geomorphic and biological processes in rivers. It shields river banks and bars from erosion. Additionally, riparian vegetation, including roots and downed trees, serves as cover for fish, provides food source, works as a filter against sediment inputs, and aids in nutrient cycling. More broadly, the riparian zone is necessary to the integrity of the ecosystem providing habitat for invertebrates, birds and other wildlife (Figure 11.2 & Figure 11. 3).

k) Seasonal ban in sand mining

The River bed mining should only be allowed during the dry season. No River bed mining should be permitted during rainy season.

l) An annual status and trends report

This report should review permitted extraction quantities in light of results of the monitoring program, or as improved estimates of replenishment become available. The report should document changes in bed elevation, channel morphology, and aquatic and riparian habitat. The report should also include a record of extraction volumes permitted, and excavation location. Finally, recommendations for reclamation, if needed should be documented.

m) Prevention and management of illegal mining

Prevention and mitigation to illegal mining can be achieved through close monitoring, cancellation of mining license of violators, imposing heavy penalties including long-term jail for mining on sensitive areas, and confiscation of mining machinery and vehicles. Department of Mines, law and order authorities need to restrict some areas for example, riverbanks, near schools, clinics, or residential areas. Only miners with licenses should be allowed into mining areas and stop illegal miners through tight security; additionally, 24x7 security to be employed to apprehend illegal miners daily. Night surveillance by night-vision drones may be employed



to control illegal mining incidents. The committees formed to guard and monitor mining should control and restrict the number of truckloads per day. The districts/state sharing the boundary shall constitute the combined task force for monitoring of mined materials, mining activity.

n) Management of infrastructure

Temporary access roads or Katcha roads shall be formed between the banks of the river and the mining area with locally available bio-degradable materials such as sugarcane waste, hay, etc. The preliminary works such as the construction of temporary sheds, bio-toilets, drilling of bore wells, waste management facilities need to be developed before mining operations. CCTV cameras need to be installed at the entry and exit points. Cameras may be installed at all quarries/depots to monitor illegality if any is taking place. All such points should have 24X7 CCTV coverage of the footage of which should be made available to the district administration. The entry/exit points should have boom barriers which will record the vehicles entering and exiting the plot to reduce unrecorded dispatch.

o) Management of pollution

Proper entry and exit points for the movement of loading vehicles in and out of the sand mining sites shall be carefully located, taking into consideration the habitations/settlements in the area. Construction of separate gravel roads for tipper trucks to reduce traffic congestion, accidents, as well as noise and air pollution, maybe consider. All the vehicles should be serviced regularly to fulfil the existing legal framework to minimize noise and air pollution. The transportation route so selected should be verified by the Goa Government for its carrying capacity. Movement of heavy vehicles from public roads to pit sand, gravel, and river sand collection points need access roads. To prevent air pollution due to the dust during sand mining operations and safeguard the workforce in the sand mining and depot site, constant water sprinkling on the pathways and dust prone areas may be conducted. The sand loaded vehicles are to be covered with a tarpaulin before moving out of the quarries/depots. Plantation needs to be done with the consultation of the state forest department beside the sand transportation road to curtail the dust pollution.

The air and water quality may be checked periodically to ensure that no pollution is caused due to sand quarrying operations. Safety gadgets such as earplugs, goggles, respiratory



devices, luminescent vests may be provided to the workers at the sand quarry site. First aid kit with all essentials shall be kept ready at all quarry/depot site, in case of any emergency. Independent labour camp and environmental and its need to be carried out at least once in a year for each mining site by reputed third party entity and report of such audit be placed in the public domain.

9.6 Development of green belts and Nursery

This helps in prevention of dust and screening noise, maintaining ecological balance, increasing aesthetic value, plantation to be carried out on both sides of the roads/river, saplings will be planted with recommended interval. Channel erosion often occurs on riverbanks with no or minimum vegetation cover; hence, plantation is prerequisite to improvement of river banks.

- Development of nursery can help in providing sapling for the region. It is recommended to cultivate nursery (for grasses, palms and other native tree including mangrove species) that are helpful in river bank protection and erosion control.
- A plantation plan developed by a plant ecologist familiar with the flora of the river for areas (in consultation with the Forest Dept.).
- River bank should be stabilized by means of compaction and then planting with vegetation.
- Any access routes without vegetation, especially if they are not beneficial to the local community should be ploughed and replanted with native species.
- Plantation along the riverbanks with no or minimal vegetation need to be conducted, irrespective of signs of erosion or not (ensure that species selected are indigenous).

9.7 Mangrove management and conservation

In Chapora, the mangroves are well represented in the lower stretches of the river. Most of the mangroves are well grown and there has been a steady growth in the mangrove cover along this river. As shown in the (Figure 9.4 A&B) many mangrove trees have developed buttresses, which is the sign of loose soft sediment and/or low nutrient regimes. There are

also indications of mangrove cutting (Figure 9.4 C&D) in some parts of the estuary. Considering these threats, it is essential to protect the mangroves areas that are degraded and which are vulnerable in terms of direct and indirect impacts.

There is no requirement of mangrove plantation in the study area but management of the existing mangrove vegetation is essential. The areas which are intruded by saline water need protection and the mudflats need to be maintained. Areas with newly recruited mangrove saplings can be blocked by restricting the tidal influx so that land use change can be avoided (from paddy fields to mangrove).

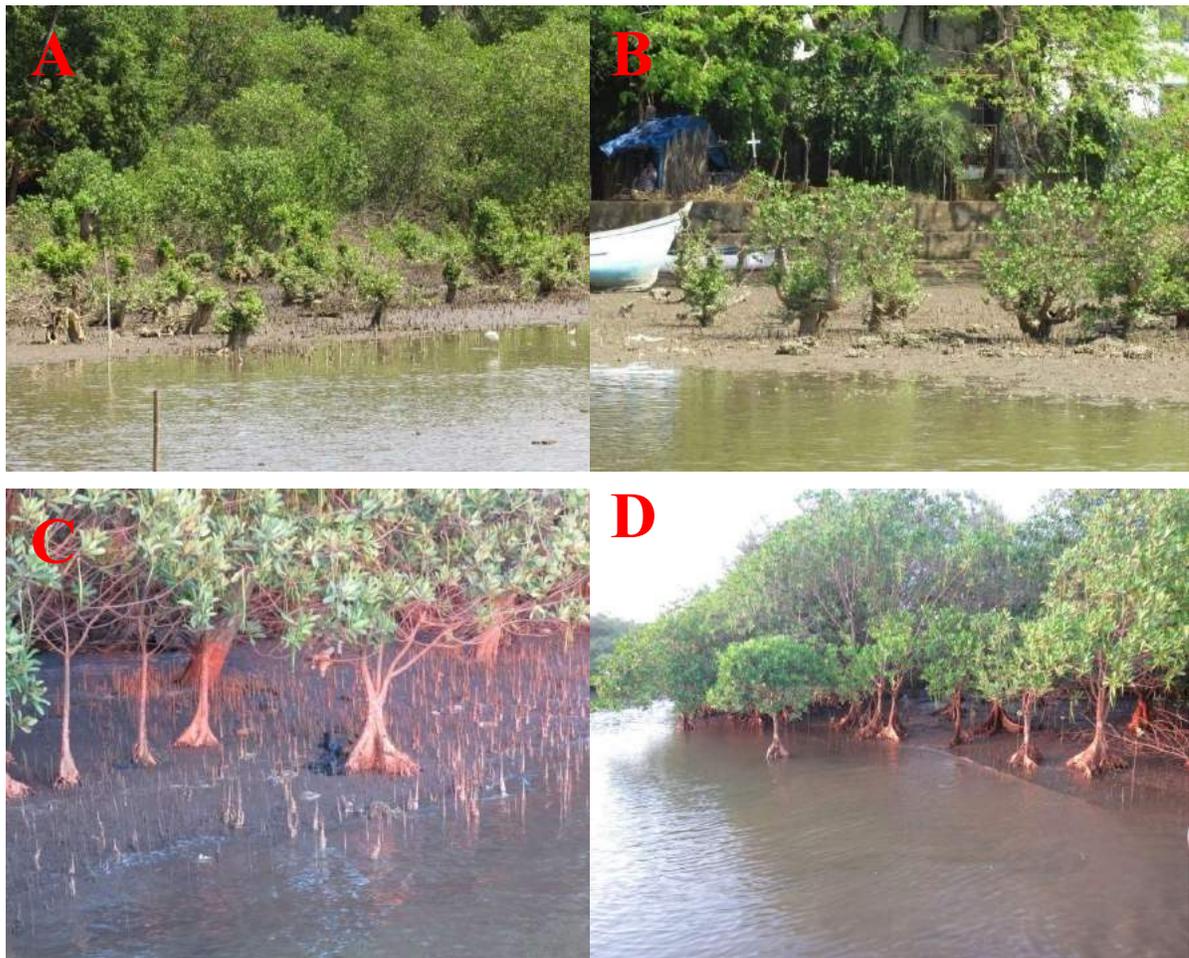


Figure 9.4: Exposed mangrove cutting and root buttresses of Chapora Estuary.



9.8 Embankment protection and restoration

This river is comparatively small and traditionally managed by construction of embankments so that floodplain can be used for paddy cultivation. The region is also represented by coconut plantation. Embankments have been constructed mostly by mud, silt and soil with protection of laterite bricks/boulders as lining between the estuarine river and land. Regular maintenance of embankments is an essential activity and failure to maintain results in saline water intrusion towards the landward side and turns the paddy fields into saline marshy areas rendering them uncultivable fallow lands.

- One saline surge can destroy the paddy fields and render them fallow lands as well as it can damage the houses; thus, it is imperative to protect the riverbank sensitivities constantly. In recent times there are few stretches of the river where construction of concrete embankments is completed.
- The areas adjacent to the river with paddy field and villages/ houses will require safeguarding from saline intrusion and flooding. Bunds have to be made with traditional means and should ensure maintenance. The authorities may also consider new methods that are innovative and sustainable for protection of bunds, restrict erosion and arrest saline intrusion.
- Some of the areas do not have embankments (mostly in the upstream areas of the river) and eroding banks area visible phenomenon (Figure 11.2). Such areas require protection, as these areas have soft sedimentary strata that can be easily washed away by stronger riverine currents.
- The vulnerable (soft sediment bank walls of the river) areas should be protected and no sand extraction shall be permissible in these regions.
- In the down-streams of the river (Figure 11.5), embankments are regularly maintained to protect the paddy field, funds and team for maintaining these embanks is essential.



Figure 9.5: Constriction of protective wall/embankment opposite Sal water treatment plant.

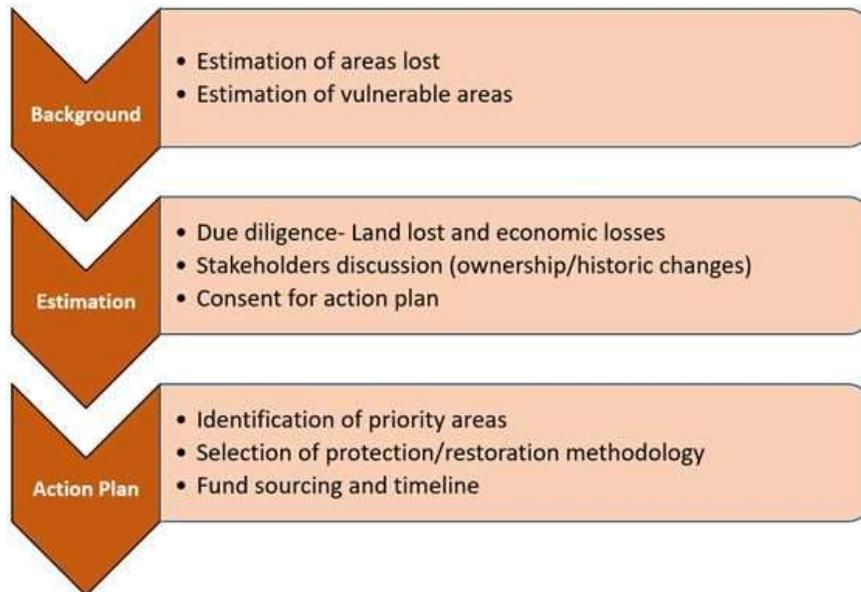


Figure 9.6: Schematic diagram of river bank protection and restoration plan



9.9 Biodiversity conservation & management plan

Several habitats in the study area are important habitats for several species of conservation importance. It is important to protect not only the species but the resources and habitats on which they are dependent. No doubt the proposed activities are deleterious to the ecosystem, no matter how sustainable we make it. Thus to compensate the negative impacts, proactive conservation efforts have to be undertaken to minimize the impacts and to further enhance biodiversity, improve conservation and add ecosystem services.

Being an area of edible natural resources, necessary protection should be provided to promote the traditional fishing by public consultations and if necessary through environmental protections.

Objectives

- To minimize direct and indirect disturbance to marine flora and fauna other than within the immediate works areas.
- To ensure turbid plumes from the works and re-suspension of material from the disposal site do not impact the long term ecological values and integrity of the adjacent benthic assemblages and important faunal groups.
- To reduce the impacts to the intertidal sensitive habitats to the maximum extent possible.

9.9.1 Conservation plan for fauna

The estuarine region is a known habitat (based on secondary information) for Otters, Crocodiles, marine turtles (Olive Ridley's) and Dolphins. Sea turtles are seen in the open waters and occasionally in the estuarine areas whereas crocodiles are found near the mangrove forests and inland marshy areas. The otters inhabit the mangrove areas and frequent the river banks and sub-tidal estuarine waters for foraging. These species require minimal human disturbance therefore they thrive well if given protection and their habitat is well conserved. Several birds visit the river and adjoining habitats for foraging as well as nesting. There are few species that are long distant migrants (especially waders) as well as local migrants. Mangroves and banks of the rivers are used as nesting sites by several species.

Following measures have to be followed to ensure the conservation of marine fauna and their habitat:



- An on-site expert (observer) has to be deployed for periodic monitoring of the important species in the entire stretch of the river which is being carried out in the region and the same activity can be extended to the proposed areas
- Vessel movement has to be regulated. Vessel movement has to be immediately halted at the sighting of any marine mammals/reptile in the active working zone. The excavation of sand as well has to halt until the animal leaves the area.
- Monitoring and conservation initiatives at Morjim beach by the State Forest Department are to be assisted and added measures and actions for conservation of Turtle nesting sites are to be supported.
- Management of marine litter, garbage and plastic is one of the important aspects with respect to each active mining zone.
- Noise levels, air pollution and sewage discharge has to be kept at minimum and have to be within limits as prescribed by laws.
- Capture, trade or killing of any scheduled species has to be reported and accordingly non-conformance action has to be initiated by the team/committee.

9.9.2 Conservation & natural resource utilization

The estuarine region and river bed harbour important benthic faunal and floral diversity. In order to conserve these habitats, they are needed to be monitored regularly as they are dynamic habitat and are constantly exposed to anthropogenic pressures. Hence proper management plan for solid waste and oil pollution is needed to be followed and precautionary measures for any incident should be in place. The entire hard substratum within the study area is a good site for the growth of green mussel (*P. viridis*) and oyster (*Crassostrea madrasensis* and *C. gigas*). However, in the recent times (information based on interaction with local stakeholders) due to various reasons, the annual stock of edible mussels showed great fluctuations and the population in recent times have decline drastically. Shellfish in the study area are exploited due to its high price as a food source. Due to frequent localized extraction, and no scope of growth, shellfish size has decreased over the years and at many places, there population has been replaced by other species. Restoration and sustainable use of such species helps in good ecological and economic gains. Several species of clams of commercial importance occur in the study area. These clams mostly inhabit the mudflats/sandflats and preferably collected during the low tide. Species of *Paphia*



malabarica, *Paphia textile*, *Meretrix meretrix*, *Meretrix c. asta*, *Villorita ceprenoides*, *Anadra* sp. And *Polymesoda erosa* are found in the mudflats, sand flats and mangrove sediments in the study area. According to local artisanal fisherman, these species have shown a drastic reduction in the population and their revival is very important. The team/committee appointed for this plan can further carry out these activities and should make village level teams for monitoring and implementation of all the activities. Following practices have to be followed for sustainable utilization of these resources:

- Harvest of the natural population requires regulation and regular restoration. It is necessary to block certain areas as no harvest zone, so as to ensure their population to replenish. Integrated sustainable aquaculture as given below (sub-sections of this plan) is to be implemented to harvest and rejuvenate these ecologically and economically important species.
- Quota system should be implemented by each village so that depletion of natural stock can be avoided.
- Cleaning programs, by participatory approach for sustainable resource utilization from mudflats, a rocky shore is essential.
- There should be size restriction for each species wherein, care should be taken to harvest natural populations so that they attained reproductive size.
- The empty shells after extraction of edible flesh should be placed back in the same habitat as they serve as recruitment substratum for new spat. The cues from the dead shells attract larvae for settlement that aids in avoiding succession for establishment of another species as well.
- Conservation of habitat for the above mentioned commercially important species will also aid in conserving other species that are not commercially important but are ecologically very vital for sustenance of healthy and functional ecosystem.

9.9.3 Community participation

The existing mangrove management strategy is a combination of conservation through statutory compliance, community awareness and sustainable utilisation of natural resources through cooperative management. In 1952, Government of India (GoI) formulated National Forest Policy, which classified Indian forests into four classes, viz. i) Protected forests, ii) National forests, iii) Village forests and iv) Tree lands. Forest Conservation Act of 1980



encourages reasonable use of natural forest resources while National Forest Policy of 1988 invites community participation for the regeneration and management of forest through Joint Forest Management (JFM) program. This gives rights to local inhabitants to exploit forest resources to some extent like collection of fuel wood, fodder, fish, shrimp, honey and wax and thus provided mutual benefit to community and forest department. Presently, almost all mangrove habitats of India enjoy legal protection under Wildlife Protection Act of 1972 and Forest Conservation Act of 1980. Gadgil (2002) lists the following 6 factors as important considerations in a participatory assessment program;

- Motivating local people to revive and build on their traditional conservation practices;
- Establishing a positive relationship between local communities and government agencies;
- Identifying and establishing a system of positive incentives for local communities to adopt conservation management;
- Enhancing elements of good governance such as efficiency, participation and transparency;
- Incorporating local information into the formal system of scientific knowledge so as to make it richer and more immediately relevant; and
- Ensuring that folk knowledge of conservation management and sustainable resource use is preserved and at the same time giving recognition to the validity of such knowledge.

Based on the above concepts it is imperative to carry out the conservation, restoration and monitoring with community participation. Local village committee/ Biodiversity Management Committees (BMC already exist) to carry out the responsibilities of the restoration and conservation plan. These committees adhere to the people's biodiversity register (PBRs) and can form self-help groups (SHGs). A technical team of experts is usually attached for the smooth working and guidance from subject experts. These procedures will help to develop responsibility and equitable sharing of resources as well as conservation of the area (Goa State Biodiversity Board [GSBB] carries out these responsibilities regularly for the entire state).

Below mentioned techniques and methods are can be mostly financed by several available governmental schemes. There are several schemes which provide training, start- up grant and



technical guidance to carry out sustainable integrated fishery and cultivation. The schemes are fully or partially funded, wherein the role of technical team and experts is important to bridge the gap between the involved stakeholders. The financial support in case of a prerequisite can be taken up by the respective project proponent as part of their CSR.

9.10 Floodplain management (saline marshlands)

The areas with saline intrusion have been converted to saline marshlands followed by mangroves and many areas are at different stages of progression towards these habitats. If these areas are unattended, not maintained or taken care of, they will be ultimately succeeded by mangroves. Once mangroves are established, the spread to adjoining areas is usual as they tend to accumulate more sediment and concurrently the embankments are penetrated by salinity due to natural deterioration of embankments. There are various reasons for the deterioration of embankments such as sea level rise, high tide surges, other extreme events and floods. Overall, over the time to come, if protections by embankments are penetrated by saline water more floodplain areas will be dominated by salinity.

Considering the present status of this river and the adjoining land use in the floodplain areas there is already intrusion of salinity, and it is important to manage these areas (depicted in Fig.9.5). Restoration of bunds should be undertaken on priority basis along with management and maintenance of sluice gates. Following activities are proposed for sustainable use of existing lands;

- There are developed varieties of saline resistant rice species. Such species can be recommended for cultivation in areas of saline intrusion.
- Various state level schemes and subsidies are available for carrying out the paddy cultivation which can be tapped via the committee members of this plan.
- Traditionally, paddy cultivation has been a community activity and the same can be extended to manage the saline marshland and its cultivation.
- Village level SHGs, BMCs, Farmer's group can be formed/ a sub-committee including members of concern state government officials and technical expertise as well for the smooth running of the schemes.

These areas which do not have mangroves can be utilized for sustainable aquaculture practices.



9.11 Development of sustainable integrated aquaculture

Several options are suitable for the rivers in Goa which have estuarine region with mangroves and mudflats, thus the suggestions given below are added after consultation with State Fisheries Dept., Goa and ICAR, Old Goa.

Integrated aquaculture is a technique of sustainable aquaculture which includes raising fish with combination of rice, pigs, and ducks as well as poultry which helps in rising family income. Since animal waste make good fertilizer it can save upto approximately 60 percent of the cost of fish farming which goes for feed. This technique includes different types of farming: paddy cum fish farming, composite culture and polyculture. Several species are available that give good economic gains and if a compatible mix species culture can be carried it reduces the risk of losses. The team for the plan can suggest the combination of species and the methods accordingly considering the site, locations, area, tidal regime, physico-chemical parameters and economics.

The important estuarine fish species caught are *Mugil cephalus*, *Osteomugil cunnesius*, *Etroplus suratensis*, *Lates calcarifer*, *Chanos chanos*, *Leptomelanosoma indicum*, *Eleutheronema tetradactylum*, *Eubleekeria splendens*, *E. thoracata*, *N. blochii*, *Sillago sihama*, *Nematalosanus*, *Ilisha toil*, *Escualosathoracata*, *Leiognathusbrevirostris*, *Thryssamystax*, *Alepeskleinii*, *Tenualosailisha*, *Harpadonnehereus*, *Pamapama*, *Setipinnasp*, *Coiliadussumieri*, *Msysugulio* etc. The major penaeid species caught in the estuary are *Fenneropenaesmerguiensis*, *F. indicus*, *Marsupenaeusjaponicus*, *Metapenaeusaffinis*, *M. brevicornis*, *M. dobsonii*, *Penaeussemissulcatus*, *M. monoceros* and *Parapenaeopsisstylifera*. The major crab resources are *Scylla serrata*, *S. tranquebarica*, *Portunuspelagicus*, *P. sanguinolentus*, *Charybdis feriatus*, *C. natator* and *C. lucifera*. The mollusks such as clams (*Villoritacyprinoides*, *Paphiamalabarica*, *Polymesodasp.*, *Tegillarcagranosa*, *Marcia opima*, *Meretrixmeretriand M. casta*) oysters (*Crassostreamadrasensis* and *Saccostreacucullata*) and mussels (*Pernaviridis* and *Pernaindica*) are also harvested from the estuarine habitats. From the available statistics, the approximate fish production from the east coast and west coast estuaries are 30,000 and 20,000 tonnes respectively. However, there is always a scope revising, reclassifying, and adding the estuarine systems in order to formulate an estuarine monitoring network along the Indian coast. Therefore, we would be able to understand the



major gaps in the fisheries data of estuaries, which would enable us to focus on these ecosystems to explore its diversity, fish biomass, and landing patterns.

Development of shrimp farming from a traditional activity to a highly commercial farming enterprise in a span of about one decade has been one of the most spectacular achievements of aquaculture in India. The government of India enacted the Coastal Aquaculture Authority Act, 2005, enabling the establishment of the Coastal Aquaculture Authority for enforcing proper regulatory measures for sustainable eco-friendly aquaculture. The Act encompasses all forms of aquaculture to be practiced in saline or brackish water in the coastal areas.

The brackish water aquaculture can also further go ahead with the means of diversification of species used in the farming practices. Seabass, *Lates calcarifer* is a fast growing, high valued carnivorous fish ideal for Indian conditions. The technologies are available for seed production and grow out culture. However, the demand for seed needs to be met through the development of more hatcheries along the coastal states. The total area under seabass farming is 2500 ha with a total production of 5000 tonnes. At present 30, 000 farmers are employed in this farming practice and project a huge potential for the future. The other candidate species for the brackishwater aquaculture are Milkfish (*Chanos chanos*), Pearlsport (*Etroplussuratensis*), Mud crab (*Scylla serrata*), and Grey mullet (*Mugil cephalus*), Red snapper (*Lutjanus argentimaculatus*), and Silver pompano (*Trachinotus blochii*) etc.

Apart from the species diversification, the diversification of aquaculture systems is essential to provide access to a large number of farmers to support their livelihood through brackishwater aquaculture. Cage culture of finfish in brackish waters provides a great opportunity for farmers with access to open waters to adopt aquaculture as a livelihood option. However, the availability of the quality seed and feed are the major hurdles that need to be addressed through indigenous seed production systems to address the demand.

Goa state encompasses huge potential for fishery activities with a coastline of 105 km, continental shelf area of 10 million ha, estuarine area of 13,157 ha (covering 8 estuaries), brackishwater area of 3500 ha, Khazan land of 18,000 ha, 555 km length of rivers, 100 ha freshwater ponds, 3250 ha of reservoirs and mine reject pits of 200 ha. The fish production of state currently stands as 1.05 lakh tonnes of which 1 lakh comes from marine and 5000 comes from inland fisheries (95% from estuarine and brackishwater resources). On the other hand, inland fish production is gradually decreasing and there is ample scope for coastal



aquaculture for further improvement in production on account of greater demand. The estuarine area of Goa is not utilised for development of coastal aquaculture. There are several culture systems that can be practiced in the estuaries of Goa, which has higher productivity and abundant natural seed resources. The government of Goa has introduced various schemes to encourage development of aquaculture in the state (Table 9.1).

Table 9.1: Schemes for aquaculture in Goa (Source: Fishery department)

1.	Financial Assistance to Brackish Water Aquaculture Pond	<p>A. <u>Financial Assistance for Construction and Renovation of Farms</u> 25% subsidy limited to Rs.2.00 lakh per ha of which Rs.45, 000/- per ha will be the Central Share. Up to 2 ha after 5 years.</p> <p>B. <u>Financial Assistance for purchase of farming equipments:</u> 50% subsidy limited to Rs.1.00 lakh per ha. Up to 2 ha after 5 years.</p> <p>C. <u>Financial Assistance for purchase of feed:</u> 25% subsidy of the cost of feed limited to Rs. 30000/- per crop per ha for 2 crops in a yr. Eligible every year.</p>
2.	Financial Assistance for setting up of Crab farming Unit in Goa	<p>A. <u>Financial Assistance for setting up of the crab culture unit:</u> 25% of the actually cost limited to Rs.1,50,000/- per ha. Farmer will be eligible to 2 ha.</p> <p>B. <u>Financial Assistance for purchase of seed and feed:</u> 50% of the actual cost limited to Rs.75, 000/- ha. Limited to 2ha per yr.</p>



3.	Financial Assistance to Freshwater Aquaculture farm	<p>A. <u>Financial Assistance for Construction and Renovation of Farm:</u> 25% subsidy limited to Rs. 2.00Lakh per ha. Eligible every after 5 yr.</p> <p>B. <u>Financial Assistance for purchase of seed and feed:</u> 25% subsidy limited to Rs.50,000/- per ha. Limited to 2 ha. Eligible on seed and feed once in every year.</p> <p>C. <u>Financial Assistance for purchase of Farm Equipments:</u> 50% limited to Rs. 60,000/- per ha. Eligible after every 5 years.</p>
4.	Financial Assistance to Mussel Culture and Oyster Farming in Goa	<p>A. <u>Setting up of unit in estuarine waters:</u> 50% subsidy limited to Rs.25,000 per unit, maximum for 2 units. Each unit in the estuarine water will be of size 4 mtrs X 4 mtrs.</p> <p>B. <u>Setting up of unit in open sea</u> 50% limited to Rs.40,000 per unit, max for 2 units. Each unit in the open sea will be of size 6 mtrs X 6 mtrs.</p>
5.	Financial Assistance for setting up of Ornamental Fish Unit in Goa	<p>A. For setting up of Breeding unit-50% of the actual cost limited to Rs.1, 50,000/-.</p> <p>B. For setting up of Rearing unit-50% of the actual cost limited to Rs.1, 50,000/-.</p> <p>C. For setting up of Rearing unit and Breeding unit- 50% of the actual cost limited to Rs.2,50,000/-.</p>



Following are some of the known aquaculture species that are well suitable for considering as small scale business model.

9.11.1. Paddy cum fish farming (freshwater)

This system explained here produces mix species of fishes with paddy. Process of culture starts from growing two crops of paddy; the one which is tall variety and the other is high yielding variety in wet season and dry season respectively with single crop of fish. In freshwater, Rohu (*Labeorohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus cirrhosis*), and fast growing species like Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idella*) and Common carp (*Cyprinu scarpio*) were used as pelagic, mid pelagic and benthic fishes. Prawns also grow well on paddy fish culture plots. Optimum stocking density that is usually practiced in case of carps is 6,000- 20,000 number of seeds per hectare.

Selection of site: Water holding capacity of selected plot should be good enough. Clay-loamy soils are suitable for paddy- fish culture. Low laying area with high rainfall is suitable for culture. Either side of the central line dug deep to act as main supply or drain canal. Each plot is bordered with bundhs with 0.3m height and 0.3m width. Dike or bundh is provided by inlet and outlet made up of bamboo shoots. These are placed in the middle and fitted with screens to avoid entry of predators as well as escape of cultured fishes.

Culture of paddy-fish together: Generally this technique is practiced in moderate or low paddy fields where water source exists for 4-5 months naturally. Carps or other fishes like Tilapia are cultivated along with the rice.

Fish culture after harvesting rice: In this technique, fishes are stoked after the harvesting of rice crops. This will provide 6-7 months of rearing fishes.

11.11.2. Oyster culture

Some Oysters are edible and its culture is widely practicing in India. Four species are commercially cultivated in India. They are: *Crassostrea madrasensis*, *Crassostrea gryphoides*, *Crassostrea rivularis*, *Saccostrea cuculata*.

Site selection: Site must have good water quality, open sea from strong wave action and salinity range should be 25-31ppt. Avoid sites prone to toxic algal bloom.

Seed production: Seed requirement for culture is met either from wild or from hatcheries.



Spat fall prediction: Gonadal maturity stage helps in spat fall prediction. When 70% of female are with ripe gonad spat collectors used to collect the spat. If they are placed much earlier or after the spat, fall they get silted or fouled and make them unsuitable for spat settlement.

Intensive culture: Containerized production of oysters is referred in intensive culture. Containerized production includes floats, bags, rafts, long line system, racks etc. for predator protection. This system has to face impacts from storms, fouling organisms etc. Therefore, selection of site should be based on water quality, wave action and predation level. This type of culture is more expensive as it requires more labour for gear and product maintenance.

Extensive culture: This culture refers to spat on shell or clutched production. Oyster larvae from hatchery are set on clean oyster shell and planted directly on the bottom and grow out in clusters. This method is not expensive as the other one but in this methods mortality rates are higher as there is very less maintenance.

Feeding: Oysters feed on algae especially *Isochrysisgalbana* and *Chaetocero* ssp.

Farming methods: Seed oysters could be grown either on bottom or off bottom culture methods. Rate of production depends on culture methods. Bottom should be firm and free from predators and silting. There are different types of culture methods: Rack and Tray Method, Stake Method and Rack and String Method.

Rack and tray method: The young oysters are scrapped from the tiles and transferred to box type cages and covered with synthetic twine. After two months of rearing by suspending cages from racks, the grown oysters are transferred to rectangular trays. 20 trays each of 200 oysters are reared on rack and at the end of the year oysters attain length from 78mm-105mm. The approximate production rate in this method of culture is 120t/ha/year.

Stake method: Stake is a support used to keep spat on spat collector above bottom. It may be Casuarina or eucalyptus pole of 1.50m. To protect spat from predation pole can be covered with piece of fabric. Production rate may be 20t/ha/year.

Rack and string method: A string can hold six shells valves holding 80-100 spats and the strings are enclosed in a bag. These suspended from racks should keep in calm and good water movement site. After 2 months of rearing the bags are removed and the oysters are transferred to oyster farm. In this method the production rate is 80t/ha/year.



Threats: Pest and predators can cause considerable damage. Common predators are barnacles, serpulids, anemones, sponges and gastropods.

Harvesting: Harvesting season depends on spawning season which is March-April and August-September. Harvested oysters go through depuration which is cleaning and reducing the bacterial load on shellfish and shucking which is the process of removing meat from depurated oysters. Meats of the oysters are edible and shells are used in spar settling and manufacturing of calcium, lime etc.

11.11.3. Mussel culture

India has a long history of mussel farming that dates back to the 13th century. They are considered as popularly eaten and delicious food by the people of West Cost. The main producers are India, China, Korea, Spain, France, New Zealand and Netherlands. Three different types of mussels are cultivated in India. They are: *Perna viridis* (Blue green mussel), *Mytilus edulis* (Blue mussel), *Modiolusmetacalfie* (Brown mussel).

Site selection: Estuarine areas which are free from strong wave actions may be selected. Clear water with high plankton production is ideal for mussels. Depth of culture should be 2m and salinity should be 30-35 ppt. and should be free from industrial pollution.

Seed collection: Healthy seeds from natural habitat are collected. Seeds are healthier if they are from submerged tidal area. Size of the seed should be 20-25mm. Nylon rope or coir rope is used for seeding. Cotton cloth or cheap net is used to cover seeds on the rope. After placing the rope over the seed, the net is tightly stitched in such a way that seeds spread uniformly around the rope.

Culture methods: There are 3 main types of culture methods in mussels.

- A. Deep Water Culture
 - Raft Culture
 - Long Line Culture
- B. Intertidal and Shallow Water Culture
 - Rack Culture
 - Hanging Method
 - Stake Method
 - Tray Method



- Buochot Method
- Wigwarm Method

C. Bottom Culture

Raft culture: The depth of the site may vary from 5-10m and rafts measured 5×5m or 8×8m. Teakwood, Casuarina and bamboo shoots are used to make poles in raft construction. Empty oil drums are used as floats. Seeds of 2.6-2.8mm length are seeded on coir or rope. Depending on the depth length of the rope varies. Ropes are spaced 0.6-1m apart. Average growth rate is 9-11mm/month and can be harvest in 5-6 months. Production rate in this type of culture is high.

Long line culture: Long lines are long ropes anchored at each end supported by plastic barrels. Depth may be 10-15m. It can withstand severe climatic conditions. The rope is 60 m long with 20-24m thickness anchored at both the ends with 150kg concrete and barrels are fixed at 3m intervals. A long line unit of 60×60m rope can accommodate 12 horizontal ropes and 900-1000 seeded ropes. The production rate was 15.32kg/net bag/5 months.

Rack culture: Fixed structures are constructed in the waters at the depth of 3 m. Bamboo or *Casurina* pole are driven at the bottom at 1-2m interval. Wooden frame built on ropes used to suspend seeded bags. Once the mussel seeds are placed the netting is wrapped and both the ends are stitched with cotton twines. In about six months mussels reach around 65-77m length. The production rate is approximately 33.5kg/net bag/5 months.

Hanging method: Nylon ropes are threaded with coco fibres supported by empty oyster shells to collect spat. Piece of stone is attached at the end of the rope to prevent surface floating.

Stake method: Bamboo pole of 4-6 m length are staked at the bottom at the depth of 3 m. collected spats are allowed to grow for 6 months until they reach marketable size. Around 2000-3000 seeds are attached to 1 m stake below low water level.

Tray culture: Tray culture is limited to detached clusters of mussels. Bamboo or metal trays are used. They are either hang between pole of hanging or stake methods.

Bouchotculture: They are also called Pole Culture. Poles which are used are big branches of oak tree around 4-6 m which are staked 0.7m apart on soft, muddy bottom of intertidal zones. Mussel seeds are collected on coco fibers and are attached to oak branches in spiral fashion



until they grow marketable size. Production was 14kg/pole of 15.7mm average length mussels.

Bottom culture: This method is widely practiced all over the world. Mussels are grown directly on the bottom. Firm bottom is required with adequate tidal flow with silt deposition and provide sufficient oxygen. If the natural ground is unsatisfactory then those seeds can be transferred to private farming ground. Natural conditions control quality and quantity of food as well as water flow. This type of culture requires minimum investment however it is prone to heavy predation such as oyster drills, crabs, starfish etc.

Harvesting: Harvesting takes place after 6 months and meats as well as shells are used in various fields.

9.11.4. Clam culture

Clams, as a general term, can be used to describe any bivalve mollusc species which buries itself in the sediment. There are numerous commercially important clam species which are cultivated in India. Some of the species are given below: *Villoritacyprinoides*, *Paphiamalabarica*, *Meritrixcasta*, and *Anadaraganosa*.

Site selection: Intertidal and sub-littoral locations are best. They are buried in the substrate. Their survival is better in sand or gravel substrates but it is possible to grow them in muddy areas too. Salinity should generally be above 25 ‰.

Cultural techniques: Their stocking density should be approximately 400 to 500 seed at 8mm shell length. Manual methods can be used for small-scale cultivation but mechanisation is needed for laying mesh and harvesting as scale of production is increased. Seed are available from commercial hatcheries at a range of sizes from 4 to 30 mm shell length. Clams are usually grown in plots under lengths of netting to protect them from predators. The edges of the netting should be buried in the substrate down to 10 cm and kept in place with rope stapled round the edges with metal hooks every 0.5 m pushed through the mesh into the substrate. It will be necessary to change the netting at least once during culture period increasing the mesh size since the clams will take around 3 years to grow to a harvest size. Clams can also be grown in oyster bags sunk into the sand in rectangular plots and staked into place leaving about 2.5 cm protruding above the sand.

Harvesting: Harvesting takes place when they reach marketable size.



9.11.5. Seabass culture

Pond culture of Asian Seabass (*Latescal carifer*) is one of the commercially important finfish. This variety is much-in-demand with huge export potential. Small and marginal farmers can adopt this method of culture as it is cost-effective manner. This is a euryhaline fish, growing rapidly up to 3-5 kg within a growing period of 2-3 years in both freshwater and brackish water environments. It is a voracious carnivorous fish; juveniles are omnivorous, feeding mainly on crustaceans and other small fishes. It attains maturity at the age of 3-4 years at a length and weight range of 60 to 70 cm and 2.5 to 4.0 kg respectively.

Nursery: The main purpose of the nursery is to culture the fry from hatchery to juvenile size. During nursing period, the juveniles can be graded into different size groups and stocked in separate grow-out ponds. Nursing the fry in concrete tanks is not recommended as accumulation of excess feed on the bottom of the tank cannot be avoided. Such accumulation can cause bacterial disease.

Nursery pond: Nursery pond size ranges from 500 to 2000 m² and water depth should be 50–80 cm. The pond has separate inlet and outlet gates which facilitate water exchange. Pond bottom should be flat and sloping towards the drainage gate.

Stocking: Stocking of 1 kg fish biomass/m³ is recommended for a 100 tonne of water.

Culture methods:

- Cage Culture
- Traditional Culture

Cage Culture: Seabass culture can be done in more organized manner as a large scale activity in cages. The size of the cage may be 50 m (5 x 5 x 2 m) with mesh size depending upon the size of the fish to be stocked. In cage culture, both floating and stationary net cages are used.

Traditional culture: In ponds, juveniles of various sizes collected from estuarine areas are introduced and fed with the trash fishes like tilapia, shrimps and prawns. These ponds receive water from adjoining brackish water or freshwater canals or from monsoon flood. Harvesting is done after 6-8 months of culture. Production can go up to 2 ton/ha/7-8 months.

Pond culture: The two-week nursery reared fingerlings are ideal for pond culture. Pond can have concrete walls and a soft bottom with water depth of up to 2 m and salinity of 5-10 ppt.



Seabass culture in ponds can be carried out either by monoculture or by polyculture method. Monoculture is that type of culture where a single species of animal is produced and Polyculture is method which involves incorporation of a species of forage fish with the main species in the pond. The choice of forage fish will depend on its ability to reproduce continuously in quantity sufficient to sustain the growth of seabass throughout the culture period. The forage fish must be such a species that could make use of natural food produced in the pond and does not compete with the main species in terms of feeding habit such as *Oreochromis mossambicus*, *Oreochromis niloticus*, etc.

Pond preparation: The pond is at first dried, tilled, levelled and manured with raw cow dung @ 1000 kg/ha. If required, lime is added @ 50-200 kg/ha to maintain soil pH above 7. Sea water/fresh water is then filled to a depth of 60-70cm in the pond. When the pond water becomes light green in colour indicating sufficient development of algae in the pond, forage fishes are introduced.

Feeding: The fish feed methods has to be carried out as per the following. In the first method, the fish are fed exclusively with chopped trash fish and in the other; the food is made available in the pond in the form of forage fish like Tilapia (*Oreochromis mossambicus*). Pelletized feed can also be given.

Harvesting: Harvesting is done with the help of seine-netting the pond or by draining. After harvesting they are usually transported live in tanks by truck.

9.11. 6. Shrimp culture

Shrimp is one of the most traded seafood commodities, and aquaculture of shrimp is considered to be one of the success stories of modern aquaculture. Shrimp farming generated millions of employments, and provides foreign exchange to developing countries. Modern practices with growth on scientific basis using hatchery produced seeds, formulated feeds water management methods have been initiated over the last 20 years. Although growth of shrimp aquaculture is remarkable, the sector has been facing several issues such as viral diseases, issues in marketing, and poor farm level performances. For optimum utilization of the resources and increased production, productivity and returns to the farmer, improvement in the existing technology is necessary. Such improvements should aim at the following:

- a) Improved farm design – for operational ease



- b) Optimum soil and water condition
- c) Removal of pests and predators
- d) Qualitative and quantitative aspects for stocking shrimp larvae
- e) Supplementary feeding
- f) Soil and water quality management
- g) Monitoring of growth and health
- h) Improved methods of harvesting post-harvest management

According to Brackish Water Fish Farmers Development Agencies (BFDA), the topography of Goa is ideally suited for prawn farming, as the seawater is regulated only on the basis of high and low tides and the flooding of water is almost negligible. The BFDA also claims that Goa has good tidal amplitude as well as spring-tides which facilitate natural flushing. Moreover, there are no turbulences or fast currents. Coastal Aquaculture Authority (CAA) guidelines were formed to ensure orderly and sustainable development of shrimp aquaculture in the country. The guidelines are intended to lead to environmentally responsible and socially acceptable coastal aquaculture and also enhance the positive contributions that shrimp farming and other forms of aquaculture can make to socio-economic benefits, livelihood security and poverty alleviation in the coastal areas.

Stocking: The most suitable species for culture in India are the Indian white prawn *Penaeus indicus*, White leg shrimp *P. vannamei* and tiger prawn *P. monodon*. Apart from these candidate species other commercially important species such as *Metapenaeus*, *M. monoceros*, *M. brevicornis*, *P. semisulcatus* and *P. merguensis* are also potential species that can be grown in India.

Site selection

Selection for a suitable site is a critical activity and must be carefully determined before establishing of a shrimp farm. Site evaluation is not only undertaken to determine if a site is suitable for shrimp farming. It is also valuable in determining what modifications are needed concerning layout, engineering, and management practices to make shrimp farming possible at a given site. Factors involved during site selection are topography and climatic condition, infrastructure, accessibility, electricity, security, availability of labor and other factors, water



supply, soil conditions. Besides these, the environmental and socio-economic aspects covering social, economic and legal issues are important parameters to be considered while finalizing the site for setting up a shrimp farm.

Pond design and construction: Shrimp pond should be designed according to the characteristics of the selected site and the culture system. There is no unique design, but optimum and functional farm layout plan and design should be based on the physical and economic conditions prevailing in the locality.

Culture systems: There are three types of shrimp culture being practiced in most countries.

Traditional/extensive cultures: Extensive Freshwater Prawn Culture extensive culture means rearing in ponds (but also in other impoundments such as reservoirs, irrigation ponds and rice fields), which produce less than 500 kg/ha/yr of freshwater prawns. They are stocked, often from wild sources, with PL or juveniles at 1-4/m². There is no control of water quality; the growth or mortality of the prawns is not normally monitored; supplemental feeding is not normally supplied; and organic fertilisation is rarely applied.

Semi-intensive culture: Semi-intensive systems involve stocking PL or juvenile freshwater prawns (usually from hatcheries) at 4-20/m² in ponds, and result in a range of productivity of more than 500 kg/ha/year and less than that defined as intensive in this box. Fertilisation is used and a balanced feed ration is supplied. Predators and competitors are controlled and water quality, prawn health and growth rate are monitored. This form of culture is the most common.

Intensive culture: The ponds are usually of 0.5-1 ha in size and are designed to keep the water at 1.5-2.0 m deep. A reservoir of at least 30 % of the pond area is usually required. High stocking density of 25-60 PL/m² with feeding rate of 4-6 times daily and strong aeration is maintained.

Open system: This system requires a high supply of good quality water because it needs water, exchange of more than 20% of the total pond volume at one time, in order to reduce pond wastes and the density of the plankton. Seed can be stocked up to 60 PL/m² and will grow to 25-35 grams within 120 days.

Re-circulation system: In order to avoid deterioration of the environmental conditions, several advanced and company run farms have adopted the re-circulation system to minimize



contact with poor quality water from outside the farm. Farms must devote 40-50 % of the area for the construction of water storage/reservoir, sedimentation pond, and treatment pond and drainage canals. Stocking density for this system generally varies between 30-50 PL/m² and the culture period is between 110-130 days.

Minimal water exchange system: To reduce contact with the water from outside the farm, the minimal water exchange system or closed pond system is practiced in some countries, particularly in Thailand. The system involves filling up the pond with cleaned seawater, treating it with chemicals to eradicate predators and competitors. Then the shrimps are stocked up to 30 PL/m² and cultured for a period of less than 100 days to attain the average weight of 10-20 gm.

Ponds: Pond preparation is an essential part of culture practices during which the metabolite load and contaminants (chemical and biological) in the soil from the previous culture cycle is removed through tilling, ploughing and drying. During pond preparation, the pests and predators are removed and pH and nutrient levels in the water and soil are brought to optimal concentrations through application of lime, organic manures and inorganic fertilisers.

Water quality and its management: The quality of the water available in the site has a strong influence on the success of the shrimp farm. Water quality parameters like pH, salinity, dissolved oxygen (DO) and the presence of toxicants/ pollutants should be ascertained. The water source should be free from any industrial/ agricultural pollution. The presence of contaminants and their levels should be considered in the light of the tolerance and also sub-lethal effects on the species to be cultured.

Seed selection and stocking: Seed quality has a direct relationship with the survival and growth of the cultured shrimps and the stocking density has a strong bearing on the level of waste generated in the pond. Only healthy and pathogen-free seed from registered hatcheries should be used for stocking. Before stocking the seeds must be acclimatized to prevailing conditions of temperature, salinity and pH conditions in the pond by gradual mixing. In areas with very low salinity, salinity adjustments are to be made over a period of 4 –5 days and hence should be done at the hatchery itself.

Feed and feed management: Using good quality feed in reasonable quantities, water and soil quality in ponds remains in optimum conditions. This reduces stress on shrimp, there is less



likelihood of disease, and they convert feed more efficiently to improve the feed conversion ratio and minimize feed costs.

Health management of shrimps: The health management approach includes reduced stocking of disease free seed, better handling, maintenance of good pond environment, and optimal feed management to reduce the stress and prevent most infectious and non-infectious diseases. Disease should be diagnosed immediately with the help of trained pathologists/ microbiologists. Treatment should be undertaken only when a specific disease has been diagnosed and it is known that this disease is treatable.

Harvest and post-harvest: Successful harvesting can be achieved if the shrimp can be harvested in good condition within a short period of time. The harvesting technique should not damage or excessively contaminate the shrimp with waste. Rapid harvesting will reduce the risk of bacterial contamination and the shrimp will still be fresh when reaching the processor.

Methods of harvesting: Harvesting can be done by completely draining the pond either by gravity or through pumping and hand picking or trapping.

The water drained out for harvesting should be pumped into the waste stabilization ponds and kept for a few days for settlement before releasing into the open water. Icing should be done immediately after harvest.

9.11.7. Mud crab culture

Among the marine edible crustaceans, crabs are one of the most important shellfish by virtue of its delicacy, demand and price. Since 1987, live mud crabs (*Scylla* spp.) are exported to an extent of 1500 tons annually, valued at Rs. 30 crores. Most of the commercially important crabs belonged to the family Portunidae and they can be recognized by the presence of flattened last pair of legs, which help them in swimming in the columnar waters. Species belonging to genera *Scylla*, *Portunus* and *Charybdis* which grow to 0.2 to 2.3 kg are considered as commercially important portunid crabs as they are utilized for both local consumption and export trade.

Mud crabs stand first in the context of both capture and culture fisheries due to their larger size, great demand and higher price. Mud crab is one of the components in the traditional fish/shrimp farming system of Indian and Southeast Asian countries. Due to their great



demand, monoculture of mud crabs is being practiced in most of the Southeast Asian countries. These mud crabs have a remarkable habit of remaining alive after capture for considerable time, say 5 to 8 days. There are only two species of mud crabs *Scylla serrata* and *Scylla tranquebarica* occurring in most of the Indian brackish water areas and inshore seas. They usually grow to a maximum size of 0.7 kg in case of *Scylla serrata*.

Though both the species co-exist in the same habitat, they differ in habits. The larger species remains buried under sand or mud. While the smaller species makes a deep burrow either at the bottom of estuary or in earthen bunds of canals/ponds. This differential habits make them more abundance in specified habitats. For example, the larger species is more abundant in the open inshore seas backwaters and coastal lakes, while the smaller species is more in number in mangrove areas.

The size-frequency studies indicated that male and female of mud crabs grew at rate of 9 and 10 mm in CW per month respectively. *Scylla serrata* attains a size of 0.7kg. In an experimental field culture the early juvenile mud crabs (15 to 60 mm in CW (Carapace width)/3 to 20 g in total weight-TW) grew at a rate of 7 to 12 mm/3 to 13 g per month, while juvenile crabs (61 to 80 mm/25 to 70 g) exhibited a monthly growth of 1 to 12 mm/145 to 97 g. In the sub-adult and adult stages, the monthly growth worked out to 8 to 10 mm/100 to 130 g.

Mud-crab farming involves the following steps nursery rearing, soft-shell crab rearing, grow-out culture and fattening. Nursery rearing involves the rearing of megalopa (0.003 g)/crablets (0.03 g) to juveniles in two phases, namely, up to 3 g (in hapas) and 3 g to 25 g (in nursery ponds). Soft shell crab rearing includes the stocking of juvenile crabs (50 to 100 g of *S. serrata*) individually in small plastic cage till they moult. Grow-out culture refers to farming of nursery grown juveniles of about 25 g (seed crabs of *S. serrata*) for a period of 3-6 months to produce marketable size crabs. During this growth period, the crabs undergo several moults (shedding of old skeleton).

Fattening refers to the holding of marketable sized crabs for about 3 to 4 weeks time, during which period, the stocked crabs gain weight. The live mud crab export from India has started in 1987-88 and exported mostly to south east Asian countries. The live crabs are packed in perforated carton boxes lined with thermocole sheets and air-lifted. In order to conserve and protect the natural stock from overexploitation and to meet the ever increasing demand for local consumption and export trade, mud crab farming with hatchery produced seed will be



the best option and as such collection of wild juvenile crab for farming/fattening needs to be discouraged.

In Goa due to low yields from salt-tolerant local varieties of paddy seeds like Korgutt and Azgo, Khazan fields in Goa are generally neglected by farmers. In order to provide farmers with alternative source of income, crab aquaculture can be taken up by these farmers. Goa has about 18,000 hectare of Khazan fields and there is huge opportunity for farmers to harness this to their benefit.

Site Selection: The mandatory guidelines enlisted for shrimp culture for the selection of sites for coastal farms should be strictly adhered to in the site selection for mud crab pond construction. In addition to the guide lines, there are other parameters should be addressed such as physiochemical condition, water quality, flow rate and temperature should be, appropriate for the species concerned. Other factors that must be considered for site selection are weather, shelter, depth and substrate.

Criteria for pen culture in mangrove areas: Mangrove areas should have sufficient supply of marine or brackish water throughout the year. Water depth at high tide should range between 0.3 to 1.0 m. Salinity should be ranging from 10 to 35 ppt and temperature between 25 and 30°C. The site must be free from big waves and pollution, protected from environmental hazards such as big waves and floods and secure from vandals and poachers.

Pond preparation: Pond preparation strategies generally employed in shrimp aquaculture can also be adopted in mud crab aquaculture. However, it is generally believed that meticulous and stringent pond preparation is not required. The installations like net fencing, earthen mounts should be considered. Pond should be drained and kept dry for 1 week to kill pests.

Nursery rearing: Nursery rearing in mud crabs is carried out in two stages as nursery phase - 1 and nursery phase - 2. During first phase, hatchery produced megalopa, which are very small in size are reared with maximum care to attain a size of about 3 g. These 3g sized crablets are further reared in second phase to attain a size of about 25 g

Transport and stocking: Crab juveniles are relatively easy to transport by using cane basket, carton lined with moist sea weeds or mangrove leaves. Chelae are tied to prevent fighting among crabs. Stocking should be done with individuals having intact appendages, and without



injury, further seeds should of uniform size. Different sizes leads to cannibalism. Stocking density has a major effect on crab growth, survival and production, and it is generally ranged between 0.5 and 3 crabs per square meter.

Nutrition and feeding: In grow out culture management, locally available cheap protein sources (trash fish, molluscs) at the rate of 8-10%W of biomass can be given. The crabs can be fed a mixed diet of 25% fish by catch (trash fish) and 75% fresh flesh of mollusc or crustacean.

Harvest and post-harvest: Culture period is generally 3 to 6 months and is dominated mainly by the size at stocking and the preference and demand, existing in the market. For *Scylla serrata*, culture duration will be 120 days with an initial size of 25 g and harvestable size of 200-300 g if the stocking density will be 1 crab per square meter. To obtain larger sizes (400-500 g), culture period can be extended to further 3 months. Partial harvest can be made with baited lift nets and bamboo cages. To have a total and complete harvest, crabs are to be handpicked after completely draining the culture pond. Crabs should be tied immediately after their capture in order to curb their movement and to avoid the fighting among them. The tied-up crabs are to be initially washed with fresh sea water and subsequently sent for local marketing after packing them in bamboo baskets.

9.11.8. Milkfish (*Chanos chanos*) culture

Semi-intensive pond farming of Milkfish fingerlings of 7-15 cm size can be stocked @ 8000-10,000/ha and formulated grow-out feed can be applied. Periodical manuring can be done to facilitate the growth of phytoplankton, as food item for the cultured fish. In 5 to 8 months, this fish can attain 0.5 to 0.6 kg body weight and a production of 3 to 4 t ha⁻¹ can be obtained. Milk fish can also be raised in cages and however, this method is not commonly adopted.

11.11.9. Pearlsport fish culture

Pearlsport, *Etroplus suratensis* (locally known as “Kalundhar”) is another important candidate species for culture in ponds, cages and tanks. Polyculture of pearlsport with other brackishwater fish species like milkfish, grey mullet or liza species is commonly practiced. Monoculture of pearl spot is commonly practiced in low volume cages. More recently, cage culture (2 to 4 m³ for 7 to 9 months) is commonly practiced by small scale farmers in estuarine



waters and feeding can be carried out using locally prepared feed, agro waste and kitchen discards.

9.11.10. Grey Mullet (*Mugil cephalus*) culture

Grey mullet, *M. cephalus* (locally known as “shevto”) can be culture in monoculture or polyculture with other brackish water species (Pearlspot and milk fish and other mullets such as like *Liza tade*, *L. parsia*) for about 8 months. Size of species stocked is more than 50 to 60 g, with a stocking density of 6000 to 8000 no. ha⁻¹. A total production of 2 to 3 t ha⁻¹ can be expected from the system. Feeding is carried out by supplementary feeding and fertilisation of the pond.

9.11.11. Red snapperculture

Mangrove Red snapper (locally knows as “Tamso”) can be cultured both in the pond and cages. Cage culture of *L. argentimaculatus* is being practiced in Karnataka and Maharashtra by stocking the wild collected seed in the cages/ponds either by monoculture or polyculture methods.

9.11.12. Ornamental fishculture

There are also some important ornamental fishes from the estuarine areas which can be promoted for domestic and international markets. Major species are silver-moony, *Monodactylus argenteus*, and orange chromide, *Etroplus maculatus*. At present, scarcity of seeds in adequate quantity is creating burden on the wild stock and increasing the price in the ornamental industry. Seed production technology is being standardised by various research institutes such ICAR-CIBA, that offer scope for development of the culture fisheries for these ornamental fish.

9.11.13. Seaweed farming

Seaweed is marine algal species that functions as renewable source of food, energy, bio-chemicals and medicines. It provides a valuable source of raw material for industries like health food, medicines, pharmaceuticals, textiles, fertilizers and animal feed. One of the most important uses of seaweed is for the production of agar, alginates & carrageenan. In India, currently sea weed farming is practiced in Mandapam, especially for the extraction of carrageenan and also to use as a bio-fertiliser. The cultivation of *Kappaphycus alvarezii* and



other commercial seaweed are grown by the fishing community in Tamil Nadu specifically in Ramanathapuram, Thoothukudi, Pudukottai and Thanjavur region. Seaweed is grown in three different ways. One of the most popular in India is using the Single Rope Floating Raft (SRFR) method (Coir Rope & Nylon Rope). This involves building of tethered rafts and spreading them out in the sea. After around 45 days, the seaweed is harvested, dried and carrageenan is extracted from it. The second method is using a Fixed Bottom Long Line method (Coir Rope & Nylon Rope). And the third is the less practiced, and however, offer wide scope as a component of the Integrated Multi Trophic Aquaculture (IMTA) method. The input costs for sea weed farming are almost nil and from a single raft, the dried seaweed earns up to Rs. 86,000 annually.

9.11.14. Integrated Multi-Trophic Aquaculture (IMTA)

Coastal brackish water systems face challenges of waste water management, which can be addressed through culture of species in multi-trophic levels a model Integrated Multi-Trophic Aquaculture can include combination of fish, seaweed and shellfish culture systems. Successful culture trials of Milkfish culture with other species like Shrimp (*P. monodon*), Tilapia (*Oreochromis niloticus*) and red seaweed (*Gracilaria* spp.) has been investigated and offer scope for the future prospects in this sector.

9.12. Development of eco-tourism

Ecotourism is now defined as “responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education. Ecotourism is catering for holiday makers in the natural environment without damaging it or disturbing habitats. It is a form of tourism involving visiting fragile, pristine, and relatively undisturbed natural areas, intended as a low-impact and often small scale alternative to standard commercial mass tourism. It means responsible travel to natural areas, conserving the environment, and improving the well-being of the local people. The origins of the term ‘ecotourism’ are not entirely clear, one of the first to use it appears to have been Hetzer (1965), who identified four ‘pillars’ or principles of responsible tourism: minimizing environmental impacts, respecting host cultures, maximizing the benefits to local people, and maximizing tourist satisfaction. The major objectives of eco-tourism are as follows:



- Build environmental and cultural awareness and respect.
- Provide positive experiences for both visitors and hosts.
- Provide direct financial benefits for conservation.
- Generate financial benefits for both local people and private industry.
- Design, construct and operate low-impact facilities.
- Recognize the rights and spiritual beliefs of the native community and work in partnership with them to create empowerment.

Ecotourism in Goa: Goa is gifted with abundant natural beauty as it a part of the Western Ghats. Goa is rich with over 1512 documented species of plants, over 48 genera of animals, over 275 genera of birds, over 48 genera of animals and over 60 genera of reptiles along with very rich marine biodiversity.

The river Chapora has a good potential for development of ecotourism activities. These activities can not only help in employment generation it helps in the development of villages along the river. Historic sites along river include Chapora fort, Alorna fort, as well as many religious places. Chapora Estuary also has a good diversity of birds hence bird watching tours, mangrove walks could be conducted. Water sports such as kayaking, river cruises in smaller boats. Nature trails can also be promoted. Recreational fishing could also be developed. Spice garden plantations and picnic spots can also be developed. Cycling tourism, photography tourism, meditation and rejuvenation tourism, cultural tourism can also be developed.

The above tourism activities should employ people from the local communities, as it helps in the regions development. These activities should be sustainable and waste generation should be minimised by reuse, reduce and recycling materials. The government on its part to incentivize ecotourism should provide schemes and funding to interested people as well as training courses in various fields such as culture, language, management, identification of flora and fauna etc.

Guidelines to be adopted for sustainable ecotourism suggested by some experts specifically for Goa are as follows:



1. The management plan areas proposed for eco-tourism should be prepared through professional ecotourism experts and in consultation with the local community as well as other stakeholders.
2. To avoid conflicts, inclusive and integrated planning should be adopted.
3. The architectural programme for eco-tourism centers should include controlled access points and cabins, roads, self-guided nature trails. Transportation options, interpretive signs, observation towers, adequate but unpretentious lodging and dining facilities, water docks, garbage disposal facility etc.
4. Structures creating visual pollution, unaesthetic values and non-compatible architecture should be controlled.
5. Exclude development in geologically unstable zones and define development and buffer zones after proper environmental impact assessment. For example, on beaches Coastal Regulation Zone (CRZ) regulations must be followed.
6. Establish standards, building codes and other regulations.
7. Specify environmental, physical and social carrying capacities to limit development activities.
8. Ensure continuous monitoring of adverse effect of tourism activities and initiate suitable corrective measures.
9. Recognize and award quality labels to eco-tourism operators.
10. Provide visitor information and interpretation services covering particularly i) what to see ii) how to see iii) how to behave.
11. Prepare and widely distribute codes of conduct to all visitors.
12. Launch training programmes on eco-tourism to tourism administration planner's operators and general public.

9.13. Development of team and funds for the plan

For management, monitoring and smooth running of the entire plan which will be spread across the river-scape, a well-coordinated team is essential. As there are several activities involved pertaining to sand mining and environmental conservation it is imperative to have a multi-disciplinary team to undertake activities as well as co-ordination between various stakeholders.

Stakes of all the interest groups is essential thus the team should have the representation of each group, community and related agencies, which also ensures discussion to reach consensus and transparency. This generic structure allows freedom to each of the bodies to discuss within themselves as well as with other bodies and decide the responsible team member. Given below is the structure of the team to be appointed after a consultative meeting (Figure 9.7).

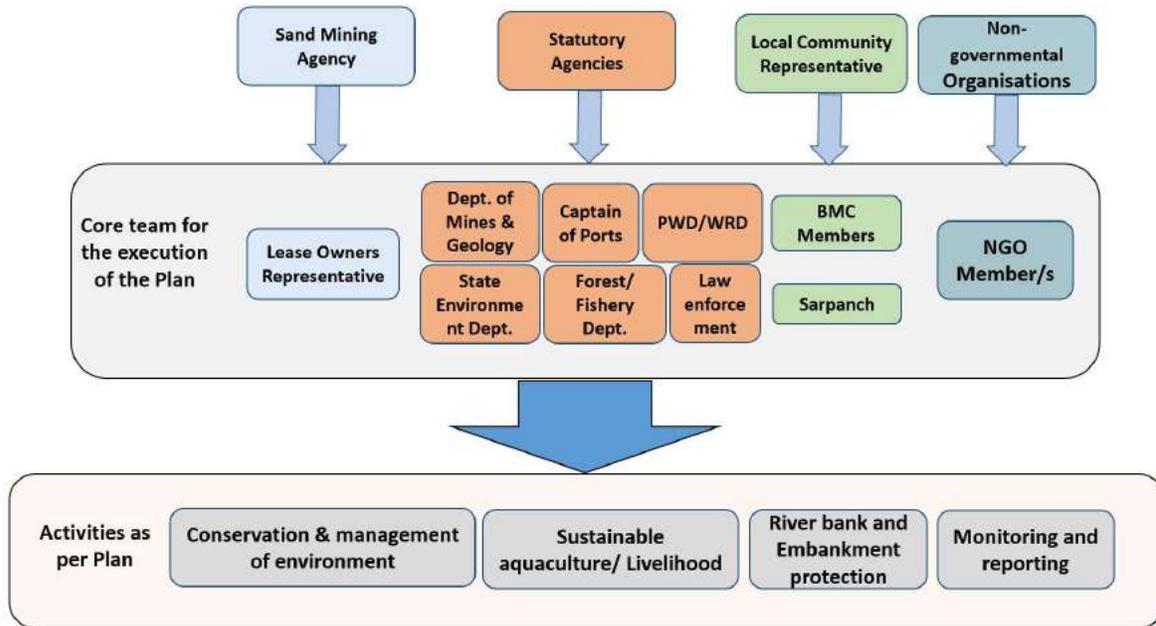


Figure 9.7. Schematic diagram depicts execution of management plan

11.13.1 Funds for the plan

A mechanism has to be formulated to impose minimum burden on the government for mitigating the impacts. Considering this perspective, as per the guideline provided by MoEFCC, the funds to carry out the activities to mitigate the impacts of sand mining, environmental safeguard and restoration need to be acquired from the lease holding agencies. A share of proportionate amount has to be assigned to carry out the aforementioned activities of the plan as part of CSR/CER.

Funds also have to be deviated towards sustainable aquaculture practices and eco-tourism, for which initial seed money can be provided from a corpus fund to bind with government schemes and subsidies. At the initial stage the interest group can also contribute for the small scale businesses in which they would like to participate.



11.13.2 Role and responsibility of the team

The plan gives freedom to discuss and decide the roles and responsibilities of each of the member as well as the rights to the team to appoint additional team members as felt necessary. Following are the responsibilities of the team:

- Monitor all the sand mining lease holder's activities and compliances.
- Carry out conservation activities and promote eco-tourism.
- As the expanse of the river spans across many villages with changing land use and activities, the team may appoint sub-teams to properly execute each activity. The sub-teams can be made or committees can be formed or SHGs can be formulated depending on the interests of the stakeholders and interest groups.
- Implement, supervise, monitor and take corrective actions for sustainable livelihood schemes as deemed fit considering the environmental conditions, available land, local expertise and willingness.
- The team has to monitor the activities of the sub-teams or the groups formed and weigh the achievement of work undertaken, suggest corrective measures and way forward for undertaken activity or projects.
- The team members (representatives of statutory agencies) shall help the activities by extending the available schemes and subsidies to the required stakeholders so as to support environmental conservation, sustainability and livelihood.
- Instruct actions to stop any environmental degradation (e.g.: tree cutting, garbage dumping, species decline/loss, embankment damage, saline intrusion etc).
- Carry out training for capacity building and to promote sustainable livelihood practices.
- The team is required to maintain all the records, handle complaints, incident and non-conformance and keep its record.

9.13.3 Corrective action/contingency plan

Any unlawful activity or failure to meet the performance criteria shall be recorded as a non-conformance incident and be reported. In the event of any incident, the team has to take immediate actions, document the incident, and report it to statutory authorities. This has to



be followed by remedial actions as directed by the Dept. of Mine and Geology and Environment Department (eg: GSPCB/GSBB).

9.13.4 Documentation and record keeping

Efficient and accurate record-keeping is essential for the application of a plan. Following necessary aspects are to be considered for record keeping and documentation-the DPR & Management plan, list of important areas (in terms mine lease, ecological sensitivities etc.) and details of priority areas for action. According to the size of the lease and areas/expanse of each lease area, the team needs to formulate and document a manual for their own working which shall include: critical limit determination, analysis, procedures -e.g. standard operating procedures, corrective action procedure, work instructions, monitoring activities, deviations and associated corrective actions, verification procedures performed, modification to the plan, training undertaken, periodic records, visual inspection reports, team meeting records, processing records.

11.13.5 Complaint handling procedures

Every complaint is different but the steps for dealing with them should be the same. As well as having a complaint policy, comes under best practices which will have a procedure handling protocol prepared by the team. A complaint handling procedure ensures complaints are dealt with the same way every time (**Figure 9.8**).

9.13.6 Incident and non-conformance reporting

Non Conformance report which is work done without approval of any concerned documents/not related to the standards (Construction Standards/Contract specification). Especially some works are not followed by the standards and specifications. Non-conformance report shows the exact possible error due to not following or deviate the procedure, while corrective action shows that, how the process or method will follow the right procedure. There is a formalized way of reporting environmental incidents i.e. uncontrolled events that have or could have had an impact on the environment, such as chemical/ oil spills; contamination of land, flora or fauna; damage to listed structures/building/embankments etc.

The objectives of the procedure are to:

- Ensure all relevant contractors are made aware of environmental incidents/ violation of lease granted and its handling procedure. Complaints can be forwarded to the appointed committee or to the office of Mamlatdar/ Dy. Collector/ Police. The complaint can be given manually or by electronic means to be devised by the committee.
- Ensure site workers and stakeholders understand the immediate environmental incident reporting requirements.
- Ensure all concerned stakeholders understand reporting timeframes, including statutory requirements.
- Ensure incidents are reported to enable monitoring, sharing of lessons learnt and response to emerging environmental incident trends.
- Comply with statutory obligations to report certain environmental incidents to regulators and other relevant government agencies for further action.

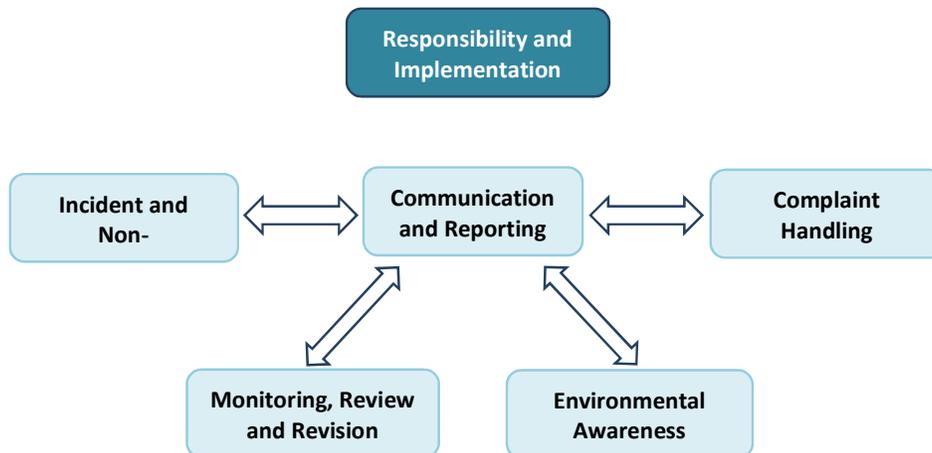


Figure 9.8. Schematic diagram of development and functioning of team

9.13.7 Attempts to deal with the illegal trade (WWF, 2018)

The Directorate of Mines & Geology, the Coastal Police, the Captain of Ports and the District Magistrate, North Goa, shall ensure maintenance of regular vigil in the area. As suggested by Honourable NGT, CCTV camera installation is essential at important location that have been leased as well as other critical areas vulnerable for mining need to be monitored. Wherever the monitoring shows that the guidelines and legality is not followed or violated, actions shall be taken as directed by the Honourable NGT order date 12/12/2019 (No: 28/2015 (WZ)).



Numerous approaches have been adopted by District, State and the Central Government to attempt to curb the illegal mining and the associated environmental, ecological and social impacts, including:

- Development of sustainable sand mining guidelines. The guidelines provide detailed information and recommendations on how to extract sand sustainably, but they are non-binding.
- Completion of sediment audits to identify sustainable sediment extraction limits. This approach was applied to Kerala in 2015 and resulted in the banning of sand mining from six rivers with severe restrictions placed on others.

The establishment of a complaint cell to receive and investigate complaints regarding sand mining. Legal authorities have been instructed to conduct raids, seize vehicles that engage in the illegal activity and take custody of illegally mined sand for subsequent sale at government rates, and to provide armed police to provide protection for revenue squads (Jha, 2013).9.13.8 Alternatives to river sand mining (WWF, 2018)

Alternative sources to river sand have been identified and adopted by most western countries, and similar shifts in developing countries could reduce pressure on the resource. However, without improved governance changing the primary sources of construction materials is difficult as alternatives are likely to cost more due to additional handling, processing and transport costs. Any increase in the cost of 'legal' sand as compared to illegally derived river sand drive an increase in illegal activities. Alternative sources and substitutes for sand in concrete is an area of active research. A literature review found the following examples.

9.13.9 Recycling of concrete for use as road bases (Smith, 2018)

Development of bacteria and fungi that can produce calcium carbonate can be used to repair existing concrete structures, increasing their lifespan. This may be particularly useful when applied to the huge highway systems of the world that are requiring repair or replacement (Smith, 2018). Replacement of sand with other materials should focus on the recycling of waste materials. It is notable that a web search of this topic returned many recent articles by Indian researchers, all of which highlight the need to identify replacement materials to



diminish sand mining and its related environmental impacts. Examples (not all from India) include:

- Backfilling of mining voids using fly ash composites in place of river sand in India due to a decrease in the availability of river sand. Finding an alternative use for fly ash is also desirable as it would reduce landfill (Mishra & Karanamk, 2006).
- Use of walnut shell and PET-fibres as a replacement for aggregate in lightweight shotcrete suitable for roadway or mine supports (Cheng, et al., 2017).
- Use of fly ash and polypropylene or steel fibers to produce high quality concrete (Raut & Deo, 2017).
- Use of rubber tyres and copper slag as aggregate in concrete (Blessen, et al., 2012).
- Replacing aggregate with recycled concrete sand in masonry and mortar design for indoor use (Fernandex-Ledesma et al., 2016).
- The use of residual materials such as kaolinitic waste, sewage sludge, schist fines and wasted glass to create light weight granules suitable for light concretes, road engineering and waste water treatment (Kanari et al., 2016).
- The use of crushed oil palm shell as a replacement for aggregated in concrete. Investigations have found that replacement rates of between 50% and 75% can be used to produce a lightweight concrete for use in non-load bearing structures, and structural concrete can be created at replacement rates of about 25% (Muthusamy et al., 2013).
- The replacement of river sand with manufactured (crushed) sand. Manufactured sand is a by-product of the production of coarse aggregate and has historically been used for road bases and land fill. Replacement of river sand with manufactured sand at a rate of 75% was found to produce concrete with properties suitable for use as high performance concrete (Prasanna et al., 2017).
- Replacement of river sand with crushed waste stone, dust and polish slurry generated by the production of dimension stone (stone quarried and cut to specific sizes or shapes, e.g. ornamental stone). Replacement of 100% of river sand in concrete by 85% stone waste and 15% slurry waste resulted in a very high-quality concrete product (Rana et al., 2017).



- Use of iron-ore tailings to replace sand in concrete. The inclusion of the tailings reduced the workability of concrete, but all other strength modulus of elasticity data was consistently higher than conventional replacement at all levels of replacement (25% to 100%). The use of tailings is recommended to minimise environmental problems, cost and natural resource depletion (Shettima et al., 2016). Note, this approach would not be suitable for tailings containing sulfides.



CHAPTER 10 ENVIRONMENTAL MONITORING PLAN

Environmental monitoring program includes periodic analysis of air, soil, noise and water, flora and fauna. Environmental monitoring should be conducted on regular basis to assess the pollution level in the mining lease area as well in the surrounding areas. Therefore, regular monitoring program of the environmental parameters is essential to take into account the changes in the environment.

Mining of sand and all the activities listed out in the conservation and management plan require periodic monitoring. Considering the activities and the monitoring results the team may decide to suggest additional management strategies to be implemented as appropriate. Competent outsourced certified organization/laboratory (eg: GSPCB) should be appointed to conduct the monitoring parameters wherever there are samples involved.

10.1 Mining activity monitoring:

1. Daily quantity of sand to be extracted from each lease should be based on the quantity given in the permit/ EC conditions.
2. De-casting from river beds should be monitored on a regular basis to keep a track of excavated quantity.
3. Every years, a mandatory audit of the quantity extracted and quantity permitted along with the replenishment rate should be carried out.
4. Depth should be up to 3.0m from the existing riverbed level and not less than one meter from the water level of the River channel.
5. Peizometer and eco-sounder (for depth measurement) should be used by each lease holder and daily records of these measurements should be made available to the monitoring team.
6. Monitoring team should ensure that sand mining activity in Monsoon season and during night time is not carried out.

10.2. Sand Transport Monitoring:

1. Mandatory e-pass/ e-permit should be made available at each lease area for transportation of any sand by an GPS enabled vehicle with the provision of entering the vehicle number of the vehicle carrying sand and expected delivery address and customer name/ mobile number.



2. Documents should be made available for stockyards/ stockiest of sand. In the case of nomination based (controlled pricing) business model, the margin of private stockiest should be capped over a fixed percentage of notified prices.
3. At the stockyard, the stock supervisor should verify the authenticity of payment receipt before issuing the transit pass. The loading of sand should be monitored electronically and all transporting vehicles should pass through an electronically monitored weighbridge.
4. To make transportation monitoring effective and useful, all the sand carrying vehicles (tractors/ trucks) should be registered with the department and GPS equipment should be installed in all the sand carrying vehicles.
5. There shall be one entry and exit point provided for trucks/vehicles. The said entry point should have facilities as mentioned above. In case, it is necessary to have more than one entry/exit points, all such points shall have checkpoints with facilities as mentioned above. All other possible ways of entry/exit should be closed using barriers like compound, trench, etc. All provisions shall be made to not make it possible for any vehicle to enter or exit without entry into the computerized system.
6. The Project proponent has to enter the destination, distance between plot and destination, vehicle number etc in the system. After scanning, unique bar code number, invoice date time and validity date-time are generated by the software which gets printed individually on each TP Validity of TP is calculated based on the distance between plot and destination. After validity time is over the TP stands invalid.
7. Weighbridges with CCTV should be installed at all the stockyards, active reaches to ascertain the exact quantity of sand being transported in the vehicle. Check posts with CCTV cameras should be established near all major consumption centers to check if all the transporting vehicles are carrying a valid transport permit.
8. The transport permit generated should contain advanced security features so that one permit cannot be re-used by generating photocopies of the permit.
9. It is necessary to prevent any truck/vehicle from transporting sand out of the identified plot bypassing the strong IT enabled system. Therefore, at each of the sand plot, the following additional measures should be taken.
10. All such points should have 24X7 CCTV coverage, the footage should be made available online to the district administration. In cases, where sufficient internet bandwidth is



not available, it may be deposited with the district administration on a weekly basis. If possible, the entry/exit points should have boom barriers which will record the vehicles entering and exiting the plot.

10.3 Surveillance & monitoring:

11. Constantly monitor mining with drones and if possible night surveillance of mining activity through night- vision drones.
12. Project Proponent must ensure that CCTV camera, Personal Computer (PC) or laptop, Internet Connection, Power Back up, access control of mine lease site; and arrangement for weight or approximation of weight of mined out material on basis of volume of the trailer of vehicle used at mine lease site are made available for monitoring.
13. Even after all the regulatory procedure and policy being in place, there are instances where illegal mining is taking place. The monitoring agencies can monitor the sites remotely by using Unmanned Artificial Vehicles (UAVs)/Drone which are now a viable option. The drone can also be used for reserves estimation, quantity estimation, land use monitoring. Other options for the monitoring team may also be made available for possible use of IT/Satellite/Drone technology for effective monitoring of sand mining.
14. The officials involved in monitoring should be provided with mobile application and/or bar code scanners using which the TP can be checked anywhere on road. As soon as the bar or QR code on TP gets scanned through using the mobile application and/or scanner or vehicle number is entered into the application or sent by SMS to a predefined number, all details of TP such as plot details, vehicle details, validity time, etc. should be fetched from the server. This means if anything is re-written on TP and attempt is made to reuse the same, it can be traced immediately. Various reports can be generated using the system showing daily lifting reports and user performance report. This way the vehicles carrying sand can be tracked from source to destination.
15. The facility to fetch details using mobile app, website and SMS may be made available to the general public as well. If the citizen finds that the vehicle doesn't have such a permit, as ascertained from mobile app or website or SMS, he should alert local authorities, who shall then take further action as per the law.



16. Land contamination (by diesel, oil etc.) due to movement of site vehicles: Vendors of state pollution control board will be contracted for collection of hazardous waste (used oil) & oil spill kit will be provided with each vehicle used for transport. Monitoring team will ensure the log books are updated and accordingly check any signs of violation, accidents, spillage etc.
17. Monitoring wells should be established adjacent to each excavation area to record changes in ground water levels. Measurements should be taken monthly. This should help analyse surface water and ground water interaction around the lease area as well as for monitor the salinity intrusion into freshwater bodies.
18. River mining from outside shall not affect rivers; no mining shall be permitted in an area up to a width of 25m from the active edge of embankments.
19. A monitoring report should review permitted extraction quantities in light of results of the monitoring program, or as improved estimates of replenishment becomes available. The report should document changes in bed elevation, channel morphology, and aquatic and riparian habitat. The report should also include a record of extraction volumes permitted, and excavation location. Finally, recommendations for reclamation, if needed should be documented.
20. Sand mining has to be monitored as per The Mines Act 1952 and The Mines and Mineral (development and Regulation) Act 1957, Mines Act 1952, Mines rules 1955, Mineral Concession Rule 1960, Mineral Conservation and Development Rules 1988.

10.4. Air quality Monitoring

As per the EIA Notification (2006) and subsequent amendments, Air Environment is one of the pollution sources from mining sector which needs to be categorically addressed. Measuring and understanding air pollution provides a sound scientific basis for its management and control. If concentration of pollutant is higher than threshold limit values are observed, the source of fugitive emissions will be identified and necessary measures will be taken. If the levels are high, suitable measures as detailed in Environment Management Plan will be taken. The criteria for pollutants measured are Particulate Matter 10 (PM₁₀), Particulate Matter 2.5 (PM_{2.5}), Sulphur dioxide (SO₂), Oxides of Nitrogen (NO_x), and Carbon Monoxide (CO) concentration in downwind direction considering predominant wind direction, at the source and a distance of 500 meters from the following dust generating



sources shall be measured. Air pollution has to be monitored as per Air (Prevention and Control of Pollution) Act (and subsequent amendments) 1981. The air pollution impacts from the present baseline activities are of low nature as the sand extraction is from water therefore minimum dust emission. Hence emission from transportation and fugitive emission are to be taken care off using best practices in the industry.

10.5. Water Quality monitoring plan

Enforcing environmental monitoring. Plan is the responsibility of the assigned team and the major objective is to follow the best practices and legislative provisions for the prevention of environmental degradation. Thus the main actions would be:

- Pooling and communicate the results of the environmental monitoring.
- Proposing mitigation measures based on the results of the monitoring.
- Introducing environmental education programme among the workers and the villagers.

Mines can affect surface runoff and groundwater quality through contamination with dissolved and suspended materials. Mines can de-water groundwater aquifers some distance from shafts or open pits, which can make nearby wells or groundwater bores run dry or saline. Monitoring should inspect the water against the release of chemically or radiologically contaminated water. The sample collection, procedures for sample preservation and methods of analysis are followed as per Standard Methods. Monitoring of water samples will be done at a frequency of once in each season as per CPCB Guidelines for waste water: and Ground water (BIS-10500:2012). Water quality has to be monitored as per the law of Water (Prevention and Control of Pollution) Act (and subsequent amendments) 1974 and the water (Prevention and Control of Pollution) Rules 1975, Cess Act 1977 & Cess Rules 1978. GSPCB carries out regular monitoring of river water quality, same can be extended to the proposed stretches of the river with added parameters to fulfil the legality.

10.6 Solid waste management

Solid waste management is one of the most acute environment issues. Site clearance and tidiness is very much needed to have less visual impact of mining. Dumping of waste shall be



done in earmarked places as approved in Mining Plan. Thus, team/operator can monitor the bin and waste receptacles at the site, storage, segregation and its lawful disposal to a registered vendor. Monitoring has to be carried for each lease area and area of operation follows the Solid Waste Management Rules 2016. Monitoring team should ensure a record/log will be maintained for general and regulated waste disposal. The log shall record the type of waste, and the point and date of disposal.

10.7. Marine Environmental Monitoring

Water quality monitoring is an important aspect which needs to be monitored. A water quality monitoring system is required to signal, control or predict changes or trends of changes in the quality of a particular water body, so that curative or preventive measures can be taken to restore and maintain ecological balance in the water body. Project team should collect water parameters to check the physico-chemical parameters. Along with the parameters, the project team has to collect sediment sample to check the benthic faunal diversity. The monitoring has to be done as per The Environment (Protection) Act, 1986 and EIA Notification (and amendments) 2006.

Water quality is the main cause for the damage to marine environment and can be monitored by conducting training / awareness programs once a year for all the relevant staff/stakeholders.

The project teams also have to identify floral diversity like native and invasive species along the estuarine and riparian region of the estuary. The station locations identified in the baseline are to be monitored every six months (covering pre- and post- monsoon season) as given in table 10.2.



Table. 10.1: Water quality monitoring parameters and schedule.

Sr. No	Cluster	Parameters measured	Locations	Operation Phase
1	Sea Water	Temperature, Salinity, DO, BOD, OC, Nutrients	14 locations	Once every six months
2	Sediment	Texture, Grain Size, OC	14 locations	Once every six months
3	Plankton & Benthos	Phytoplankton, Zooplankton, Meio & Macro- fauna	14 locations	Once every six months
4	Flora & Mega fauna	Seaweeds, Marine mammals, reptiles & avifauna	Identified habitats in the study area	Once every six months
5	Sensitive habitats	Mudflats, Mangroves, Sand flats and Rocky shores	Identified habitats in the study area	Once every six months
6	Fisheries	Benthic & Demersal fish species & intertidal shellfish.	One bottom trawl & intertidal survey	Once every Six months

10.8 Embankments management and protection:

Embankments are the oldest known forms of flood protection works and have been used extensively for this purpose. They serve to prevent inundation, when the stream spills over its natural section, and safeguard lands, villages and other properties against damages. The embankment needs to be monitored as per the Environment (Protection) Act, 1986, CRZ notification, 2019.



- These embankments should be monitored on monthly basis and care must be taken to ensure the proper condition of the embankments. Damaged during the mining activity may leave many riparian zones vulnerable as they are known to protect from floods and soil erosion.
- Other areas should be monitored where there is no protection and it requires embankment construction.
- Saline intrusion in the adjoining areas should be monitored.
- Any repair work and construction of embankments should be monitored are recorded in site visit reports.

10.9 Monitoring of conservation plans:

Conservation of ecosystem is the most neglected aspect of any developmental project or mining activity as such. The present area is rich in biodiversity and requires serious conservation efforts. Otters, crocodiles, turtles play an important role in maintaining riverine ecosystem. As this ecosystem provide promising habitat for these species but it might be a difficult task for their survival because of sand mining, iron ore mining, dynamite fishing etc. Construction along the banks of river like embankments, check dams cause negative impact on their habitat. Cutting and loping of trees along the banks, should be also be monitored. Mass public awareness campaign should be undertaken to educate people, especially fishermen inhabiting closer to estuarine habitats about the ecological role of the important species and their habitats which ultimately provides goods and services to the human society. All the aspects given in the conservation have to monitor to note the status of species, their habitat and actions to be taken for their improvement and enhancement. Conservation of the ecosystem has to be monitored as per Wild life Protection Act, 1972, Forest (Conservation) Act 1980

10.10 Monitoring of Plantation Plan:

Mining activities will not cause any harm to riparian vegetation cover as the working will not extend beyond the offset left against the banks. Plantation should be followed along the bank of river and along road sides of approach roads. While selecting plant species preference will be given for planting native species of the area and shall have soil binding capacity. The state forest department will supply saplings to surrounding villagers for green belt development in their villages and encourage the plantation by means of social forestry. Green belt



development as per the scheduled plan will be reviewed every year plantation records will be maintained for period of plantation, area under plantation, length of avenue plantation, type of species density of planted area and survival rate. Monitoring of Plantation needs to be monitored as per Environment (Protection) Act, 1986

- The implementation for development of green belt will be of paramount importance as it will not only add up as an aesthetic feature, but also act as a pollution sink.
- The species to be grown in the area should be dust tolerant and fast growing species so that permanent green belt is created.
- To stabilize the river bank erosion the plants having good growth will be planted along the river bank.
- Apart from the green belt and aesthetic plantation for elimination fugitive of emission and noise control, all other plantation efforts shall be decided and executed with the assistance and co-operation of the local community.

10.11 Integrated Aquaculture and eco-tourism

The discharge of nutrients, sediment, BOD, bacteria, and pathogens into estuarine waters is one of the problem which impacts the aquaculture and to be covered by existing programs. Land based facilities can be regulated under the existing waste discharge laws and regulations. The impacts are site specific and controllable with any other source of water to estuaries.

- The site of the aquaculture should give more important to the conservation; such importance can be maintained by monitoring the norms to be followed as per national guidelines and best practices in aquaculture.
- Aquaculture farms should not pose a significant threat to the surrounding environment. The potential impact of the aquaculture must be understood and an accurate assessment made to monitor the water quality changes.
- The feed is a primary cause of direct and indirect pollution of water resources used for aquaculture. Therefore, the assessment of feeds should be considered as important practices and monitored frequently.
- Land based facilities can be regulated under the existing waste discharge laws and regulations. The impacts are site specific and controllable with any other source of water



to estuaries. Potential problems exist where water quality standards either do not exist for some pollutants (eg: Nitrate or phosphate in estuarine waters).

- The eco-tourism activities planned and carried out should be monitored, for their impacts (negative and positive).
- It should be monitored that the native community gets maximum benefit from the eco-tourism schemes.
- It is to be monitored that the eco-tourism activities should be non-polluting and should be carried out using indigenous material.
- The number of tourists/foot fall should have a cap every season and the activities also should have upper limit considering the carrying capacity of the region/habitat/area.



RECOMMENDATION:

Sand mining is one of the most sensitive subjects in India as well as other parts of the world. It has been the issue of social conflict, environmental sustainability and administrative issues. 'Sand Mining' has been one of the most revenue generating business as direct extraction of natural resources does not require much investment or skillset or purchases of raw material for production. It has to be considered as limited natural resource with a limited ability to be replenished over long term duration. But the impacts of sand mining have been deleterious and sustainability of sand mining is always difficult. Being the most important commodity, sand is required for construction and thus the holistic development and urbanization.

The Chapora River in the State of Goa is a small river which opens up in the Arabian Sea. The present status of the river has been detailed out in this report. Considering the on-going activities including sand mining, site sensitivities, national guidelines, international best practices and concerns raised by local community as well as directions by Hon'ble NGT, following are the recommendations:

- Considering the results of the baseline, Chapora estuary has been impacted by cumulative anthropogenic activities and natural riverine and costal processes.
- These effects have changed the geo-morphology and bathymetry at many stretches of the river/estuary. Over the years sand extraction has caused many pits and deep gorges in the lease areas as well as outside the lease areas.
- The lower stretches of the estuary are influenced by higher salinity regime thus the adjacent banks have been protected by traditional embankments. These embankments allow the locals to carry out agriculture- predominantly paddy. These traditional embankments consistently face the problem of saline water intrusion and require continuous repair and maintenance. There are several reason for the damage of embankments viz; high tidal surges, subsidence of land, removal of sand/sediment from the river bed, non-maintenance of embankments and flooding due to upstream water flow.
- The salinity intrusion has also changed the land use, converting many paddy fields and riparian zones and mudflats into mangrove areas.
- The upper stretches of river banks have experienced bank erosion at many locations and many more areas are vulnerable and prone to bank erosion.



- Based on the baseline data and the prevailing site conditions (cumulative impacts herein) sand extraction at unregulated rates or in the sensitive area will have negative impacts on the environment. Therefore minimum areas recommended by SSMG (2016) & Hon'able NGT are to be followed. Accordingly, certain areas in the stretches of the river have been demarcated where sand extraction from the river bed requires restrictions.
- The difference between the pre- and post-monsoon seismic data did not show major significant changes in the depth across the Chapora river except in few regions where the local depositions are seen with a maximum depth difference of ~0.3-0.4 m. In few regions localized changes in the river bed morphology and spatial adjustment of sand bar are observed.
- In the Chapora river the bed level changes for the post-mining scenario are mostly around -0.15 m to 0.15 m. The changes in bed morphology in the post-mining scenario at different sections of the river are highly dynamic and patchy in nature. Considering the stretches which have low sensitivities, can be considered for sand extraction while following the national statutory and legal guidelines. While recommending the lease areas the authority shall conduct a reconnaissance site survey and a consultative discussion with the stakeholders and accordingly work out areas that do not have conflict of interest.
- The sand extraction has to be conducted by traditional (manual) method only. No mechanized boats or machinery to be operated. The activity shall be restricted to the available areas (given the Fig 7.1) only and the depth of extraction should not exceed 3m from the existing baseline profiles.
- Once the lease areas are issued, the delineated "Environmental Conservation and Management Plan" needs implementation. The plan also describes the team/committee which should be capable to address, execute and monitor all the aspects of the plan. Furthermore the team/committee should appoint sub-teams, SHG's, Village committees on requirement basis as per the plan.



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