BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL
WESTERN ZONE BENCH AT PUNE

APPEAL NO. 38 OF 2021 (WZ)

THE GOA RIVER SNAD PROTECTORS
NETWORK ... APPELLANT

VERSUS

THE GOA STATE ENVIRONMENT IMPACT
ASSESSMENT AUTHORITY & ORS ... RESPONDENT

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Place: Panaji Goa

Date: 25.02.2022

Advocate for Respondent no.1

NOTARY
Venefreda C.P.P.B. Gracias
STATE OF GOA
Reg. No. 301
Expiry Date
27/2/2024
GOVT OF GOA

BEFORE NATIONAL GREEN TRIBUNAL TRIBUNAL,

WESTERN ZONE, BENCH PUNE

Appeal No:38/2021(WZ)

THE GOA RIVER SAND PROTECTORS NETWORKS

...APPELLANTS

V/S

THE GOA STATE ENVIRONMENT IMPACT

ASSESSMENT AUTHORITY & ORS...RESPONDENTS

AFFIDAVIT IN REPLY OF THE RESPONDENT NO. 1

I, Dasharath M. Redkar, major of age, Indian National, Member Secretary of the Goa State Environment Impact Assessment Authority, the Respondent No.1 herein above, having office at 4th floor Dempo Tower Patto Panaji Goa do hereby on solemn affirmation state on oath as under:

1. I say that I am presently working as the Member Secretary of the Goa State Environment Impact Assessment Authority i.e. the Respondent No. 1, and I am authorized to file the present Affidavit. I state that I am filing the present affidavit based on the records available with my office and I am able to depose thereto.
2. I state that I have read and understood the contents of the said Appeal and I am filing this reply in response thereto. I say that I am conversant with the facts and circumstances of the issues involved in the present Appeal. I state that at the moment I am not dealing with each and every averment/ contention raised in the Appeal, but only with the allegations made as against the Affiants office and the contentions/ averments which have not been traversed and/or denied by me may not be taken to have been admitted by me. I crave leave of this Hon'ble Tribunal to file a detailed Affidavit, if

required.

3. At the outset, I deny each and every averment set out by the Appellant in the said petition, to the extent, the same are inconsistent with the case set out by me herein below.

4. I say that the Goa State Environment Impact Assessment Authority (hereinafter referred to as the Goa-SEIAA) had granted Environment Clearance for extraction of sand by manual method vide Orders bearing Nos.3-181-2010/STE-DIR/159 dated 01/10/2015 and No.3-181-2010/STE-DIR/158 dated 01/10/2015 to the District Collector North Goa and the District Collector South Goa, respectively, in the year 2015. I say that the said Environmental Clearances were granted by the Goa-SEIAA based on the Prefeasibility Report prepared by the Respective District Committees, which reports were verified by the Directorate of Mines and Geology. Annexed hereto and marked as **Annexure A colly** are copies of the Environmental Clearances issued by the GSEIAA and the copy of the Prefeasibility Report.

5. I say that on the basis of the said Environmental Clearances the Department of Mines and Geology had issued permits to 16 & 442 number of individuals for extraction of sand by manual method in South Goa & North Goa respectively . Annexed hereto and marked as **Annexure B** is a copy of the list of permits granted in the year 2015.

The permits issued for the year 2015-16 & 2016-17 can be briefly seen as under.

Permits Issue	**Nos. of Permission Granted**
South Goa	16
North Goa	
Mandovi Cluster 1	85

Mandovi Cluster 2	1
Mandovi Cluster 3	17
Mandovi Cluster 4	68
Mandovi Cluster 5	17
Mandovi Cluster 6	2
Mandovi Cluster 7	1
Mandovi Cluster 8	49
Chapora Cluster 1	35
Chapora Cluster 2	30
Chapora Cluster 3	12
Chapora Cluster 4	32
Terecol cluster -1	8
Terecol cluster -2	26
Terecol cluster -3	59
Total Cluster North Goa	**442**

P.P.B. Gracias
OF GOA
No: 301
Date
/2/2024
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6. I say that the Federation of Rainbow Warriors thereafter filed a PIL Writ Petition bearing No. 14/2018 before the Hon'ble High Court of Bombay at Goa, therein challenging the Environmental Clearances' s granted by Goa-SEIAA in the year 2015. I say that the Petitioner i.e. the Federation of Rainbow Warriors therein contended that the said Environmental Clearances were not in compliance with the sustainable Sand Mining Management Guidelines 2016 issued by the MoEF&CC. Copy of the orders passed by the Hon'ble High Court in the said PIL Writ Petition is hereto annexed and marked as **Annexure C colly**.

7. I say that as the validity of the said Environmental Clearances issued by Goa-SEIAA in the year 2015, expired in the year 2020, the State Government conducted the EIA/ EMP and modelling studies for sand

mining clusters in the rivers of Goa. I say that the report for Chapora Estuary was prepared through the CSIR-National Institute of Oceanography, Dona Paula Goa (hereinafter referred to as the CSIR- NIO). I say that the said EIA/EMP and modelling studies for Chapora Estuary in detail provides the Numerical Modelling studies, Anticipated Impacts, Mitigation measures, Environment Conservation and Management Plan, Biodiversity Conservation and Management Plan and Environmental Monitoring Plan.

8. I say that in the said report the CSIR-NIO has assessed the availability of sand in the Chapora Estuary as well as recommended the extraction of sand at certain locations. Additionally, the CSIR-NIO has upon a careful study even demarcated the areas in the stretches of the river where sand extraction from the river bed requires restriction.

9. I say that as the validity of the Environmental Clearances mentioned herein above expired in the year 2020 and on the basis of the afore stated report of the CSIR-NIO the District Collector, North Goa vide Applications dated 03.09.2021; 04.09.2021; 05.09.2021 and 06.09.2021, applied to the Goa-SEIAA for the grant of Environmental Clearance for the extraction/mining of sand in Chapora river/estuaries by manual methods to be undertaken by traditional communities. I say that the said Applications were made for 7 stretches(zones) of the Chapora River. The said zones are as follows; Estuary Region (Zone 1), Morjim Jetty (Zone 2), Near Sateri Temple (Zone 3, Part 1), Near Sateri Temple (Zore 3, Part 2), Near Railway Bridge, Revora (Zone 4), Near Sati Devi Temple (Zone 5), and Ozorim Tormas Bridge (Zone 6).

10. I say that the report prepared by the CSIR-NIO with respect to the Chapora Estuary is a comprehensive document which in detail covers all the aspects which are expected to be dealt with in a District Survey Report. I say that

likewise, a Report on EIA/EMP and modelling studies for the sand mining clusters in the rivers of Goa has also been prepared by the CSIR-NIO for the Mandovi Estuary. Annexed hereto and marked as **Annexure D colly** are copies of the Reports prepared by the CSIR-NIO pertaining to the Chapora Estuary and the Mandovi Estuary.

11. I say that with respect to the Chapora Estuary, the CSIR-NIO report under the caption '*Conclusions*' records that the total volume and the total weight of sand availability in Chapora river is as follows;

Sr.No	Region	Length	Volume(cubic M)	Weight (Tons)
1	Estuary region	1570	524283	1389350
2	Morjim jetty	1850	1674221	2678753
3	Wadji Supermarket	1700	773160	1237057
4	Sateri Temple	2300	1618575	2589720
5	Camurlim Ferry Terminal	2441	1988240	3181185
6	Our Lady piety Chapel	2170	1168952	1870323
7	Sateri Temple Ambrewada	950	833393	1333429
8	Railway Bridge Revora	1644	610894	977431
9	Raneache Zuem	1620	5753126	9205002
10	Near Sati Devi Temple	1900	544284	870855
11	Pirna Ozarim bridge	1000	216771	346835
12	Ozorim Tormas	1250	1028294	1645271

	Bridge			
	Total=	20395	16734193	27325211

12. I say that the said report further records that based on the EIA/EMP study conducted by NIO in Chapora river, the CSIR-NIO has identified 6 feasible sand mining regions. The said six feasible sand mining regions are as follows;

Sr. No	Region	Length	Volume (cubic M)	Weight (Tons)	Volume for 3 - meter Thickness (cubic m)	Weight (Tons) for 3 - meter thickness
1	Estuary region	1570	524283	1389350	357072	571316
2	Morjim jetty	1850	1674221	2678753	1037146	1659434
3	Sateri Temple	2300	1618575	2589720	254245	406791
4	Railway Bridge Revora	1644	610894	977431	302923	484676
5	Near Sati Devi Temple	1900	544284	870855	341031	545650
6	Ozorim Tormas Bridge	1250	1028294	1645271	1028294	1645271
	Total =	10514	10514	8856520	3320711	5313138

13. I say that the Goa State Expert Appraisal Committee (*hereinafter referred*

to as GSEAC) in its 138th meeting held on 22/09/2021 considered the report of the CSIR-NIO, the inputs of the Directorate of Mines and Geology, as well as the presentation prepared by the Scientist of CSIR-NIO.I further say that upon considering the 6 feasible sand mining regions in light of the guidelines for sustainable sand mining and other environmental concerns the sand extraction by use of manual methods alone was recommended only at Locations 1, 2 and 6, 7 in the first instance with 50 and 10 percent respectively to be extracted annually subject to the compliance of the Environmental Management plan and monitoring plan recommended by CSIR-NIO as well as the guidelines for Sustainable Sand mining. I further say that it was therein decided that detailed specific conditions were also imposed on the project proponent. Annexed hereto and marked as **Annexure E** is a copy of the minutes of the meeting of the GSEAC held on 22/09/2021.

14. It is pertinent to note that with respect to the mouth of the river Chapora there is regular deposit of sediment which results in the formation of sand bars. I say that as such the Captain of Ports is therefore required to dredge the riverbed at regular intervals in order to maintain the navigational channel for fishing boats and trawlers. I say that this stretch of the mouth of the River Chapora which otherwise ordinarily requires periodic dredging falls within the limits of one of the demarcated zones wherein extraction of sand has been permitted by the GSEAC.

I say that the State of Goa is a small State, possessing an inherently unique geomorphological environment. I say that this aspect has been considered in particular by the CSIR-NIO whilst preparing the EIA/ EMP and modelling studies for the sand mining clusters in the rivers of Goa. An illustration of the said uniqueness is that unlike the rest of the country, a majority of the

riverine expanse in Goa is under the influence of salinity. Further the average distance of the rivers in the State of Goa from its origin to the Sea is about 25km or less, and in light of such short distance and the amount of geogenic material brought to its lower reaches by typical process of sediment erosion and denudation the overall process of sand and gravel formation is deficient and truncated. I say that in light of such characteristics of the riverine ecosystem which is unique to the State of Goa the CSIR-NIO has upon a detailed study stated that

'These unique traits of rivers in Goa make it difficult to apply the SSMMG which is generically designed considering the diverse nature of rivers in the entire country. Understandably, the SSMMG fits well for important and large river basin that are major sand producing sites contributing a significant precentile of the national requirement. Therefore, at times it becomes difficult to follow all the guidelines delineated in the SSMMG, although this report tries to adopt all relevant plans and implement them for the greater interests of the State of Goa'. (SSMMG referred to therein being the Sustainable Sand Mining Management Guidelines).

15. I therefore say that in light of the peculiar situation that is local to the State of Goa the Sustainable Sand mining Management Guidelines cannot be stringently applied to the facts and circumstances prevalent in the State of Goa.

16. I say that the Goa-SEIAA in its 64th meeting held on 05.10.2021 deliberated upon the applications for EC for sand excavation in Chapora River. I say that the Goa-SEIAA therein decided as follows;

'After considering the Committees recommendation and scrutinizing the application and documents submitted by Project Proponent, the Authority decided to recommend proposal for extraction of sand at Chapora river by

traditional (manual) method only at zone 1, 2, 5 and 6 in the first instance with 50% capacity for first 3 years respectively and then to decided further capacity thereafter. Whereas proposals pertaining to zones 3 (Part 1 and 3) and 4 may be referred back SEAC to conduct further scientific study in the matter.'

Annexed hereto and marked as **Annexure F** is a copy of the minutes of the Goa-SEIAA held on 05.10.2021.

17. I say that despite the fact that the Environmental Clearances have been issued by the Goa-SEIAA to the District Collector, North Goa, no permits have been issued to the individuals by the Directorate of Mines and Geology.

18. I therefore most respectfully submit that in light of the afore stated factual and legal position, the Appellant is not entitled to any of the reliefs as prayed for in the present petition.

19. I say that what is stated by me in paragraphs 1 to 19 of the Affidavit in Reply are true to my knowledge and based on the records maintained by my office to which I have access, and the submissions made therein are legal submissions based on legal advice, which I believe to be true.

Solemnly affirmed at Panaji, Goa.

On this 24th day of February, 2022.

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NOTARY Venefrada C.P.P.B Gracias STATE OF GOA Reg. No 301 Expiry Date 27/2/2024 GOVT OF GOA

24/02/2022
Deponent

Solemnly affirmed before me
Dasharath M. Redkar
Who is identified before me by

At Calangute - Goa

Sr. No. 20/02/2022
Date. 24/02/2022

Venefrada C.P.P.B Gracias
Advocate & Notary Goa State

Annexure A

GOA STATE ENVIRONMENT IMPACT ASSESSMENT AUTHORITY

EIA-Goa State Secretariat,
3rd Floor, Dempo Towers, Patto, Panaji, Goa – 403 001
Phone nos.: 2438528 Fax. no.: 2438567
e-mail: goaseac@gmail.com

No: 3 – 181 – 2010/STE-DIR/158 *Date:01/10/2015*

To,
The Collector& District Magistrate,
South Goa, District,
Mathany Saldanha Administration Complex,
Margao, Goa.

Sub.: Extraction of Sand / Pebble in rivers/ estuaries at South Goa District by manual methods by traditional Communities – Environmental Clearance reg.

Sir,

This has reference to your application bearing no. 39/40/2010/Sand Mining/ MAG/2793 dated 03/03/2015 seeking prior environmental clearance for extraction of sand / pebble in rivers/ estuaries by manual methods by traditional Communities at various stretches of rivers / estauries in South Goa District. The proposal is for obtaining environmental clearance (EC) for sand/pebble extraction from total 12 stretches (i.e. 8-riverine stretches + 4-estuarine stretches) covering 78,481.57 Sq.mts of lease area with total extraction capacity of 1, 20,000 m^3 per annum.

Subsequently, the Goa State Expert Appraisal Committee (hereinafter referred to as 'the Committee', in short) has conducted site-inspections of each and every stretch on 19th / 20th / 29th May and 9th June 2015 along with the representatives from stakeholder Departments of the State Government viz. Directorate of Mines and Geology (DMG), Captain of Ports (CoP), Water Resources Department, South Goa Collectorate, etc. The Committee during its site-visits interacted with local stakeholders as well, for ground truthing. During the process of project appraisal, the Committee perused – **(i) Office Memorandum (O.M.) no. J-13012/12/2013-IA-II (I) dated. 24th December 2013** notified/published by the Ministry of Environment, Forests and Climate Change (MoEF & CC) and noted that the proposal is categorized under Category-B-2 (*i.e. to be appraised based on Form-1, pre-feasibility report with relevant documents / details*) and (ii) **Office Memorandum (O.M.) no. 11-83/2005/-IA-III (Vol.III) dated. 8th November 2011** notified/published by the Ministry of Environment & Forests (MoEF) on the subject matter of removal of sand in the Coastal Regulation Zone area of rivers / estuaries by manual methods by traditional communities. In addition, the Committee also perused **(i) The EIA Notification 2006, as amended** and **(ii) The Goa Minor Mineral Concession (Amendment) Rules, 2012** published by the State Government vide Gazette Notification

(Extraordinary) series 1, no. 24 dated 17th September 2012 and (iii) **'Order' of the National Green Tribunal (NGT), Principal Bench, New Delhi pronounced on 5th August 2013** in a matter of Original Application no. 171 of 2013 (*National Green Tribunal Bar Association V/s Ministry of Environment & Forests & Ors.*,). **Judgement dated 13/01/2015 passed by the Hon'ble National Green Tribunal (NGT), Principal Bench, New Delhi in the Original Application (OA) No. 123 of 2014** (in the matter of Himmat Singh Shekhawat V/s State of Rajasthan & ors) **and Judgement dated 29/05/2014 passed by the Hon'ble National Green Tribunal (NGT) (Western Zone) Bench, Pune in the Application No. 34(THC)/2013(WZ)** in the matter of *AWAAZ Foundation V/s State of Maharashtra & ors* and (iv) a Model Document on **'Impacts and Methodology of systematic and Scientific mining of the river-bed material'** published by the Geological Survey of India (GSI) and (v) **'Order' dated 27/02/2012 of Hon'ble Supreme Court in I.A No. 12-13 of 2011 in SLP (C) No.19628-19629 in the matter of Deepak Kumar etc V/s State of Haryana and ors.**

Prior and during the technical presentation by the PP, the Committee sought to examine in details all the available documents in substantiation of the baseline environmental character of the proposed sites, provided by the PP for the purpose of environmental impact appraisal of the proposed activity.

Subsequently and after detailed deliberations vis-à-vis compliance submitted by the PP, and appraisal based on available data and ground-truthing, the Committee, during its 47th Meeting, held on 10th September 2015, decided to recommend for grant of EC for sand extraction as specified in the submitted proposal except two site-specific locations / clusters proposed within (i) Khandepar river at Piliem in Dharbandora Taluka on account of its immediate proximity to the laterite-quarry which may cause river-bank instability on account of stone removal from terrestrial end and proposed in-stream sand/gravel removal from river-bed and (ii) Khushavati / Gulathi river at Sirvoi in Quepem Taluka on account of site inaccessibility from the nearest road to enable desired transportation of the extracted material. *(Refer Table. A & B below).*

The Goa State Environment Impact Assessment Authority (hereinafter referred to as 'the Authority', in short) on detailed perusal and in agreement with the Committee's recommendations and after referring to draft **'Sustainable Sand Mining – Management Guidelines'** published by the Ministry of Environment, Forests and Climate Change (MoEF & CC) in September 2015, has decided to grant prior environmental clearance (EC), as mandated in the EIA Notification, 2006 (*as amended till date*) and in terms of the directions contained in the Judgement of Hon'ble Supreme Court and National Green Tribunal for

extraction of sand / pebble by manual traditional methods at following 10 stretches / clusters identified / proposed by the South Goa District Collector (SGDC), Margao, Goa.

A. Proposed site-specific locations for traditional method of manual sand extraction (*riverine stretches*)

Sr. No	Taluka	Village	Sy nos	Area in sq. mts.	Estimated Total minable reserve	Latitude (from)	Longitude (to)	S.O.I. Toposheet no. (s) on 1:25,000 scale	River
1	Dharbandora	Collem	21	8202.88	10,000 m^3	15 20'46.11"	74 14'07.10"	48I/3/SE	Dudhsagar
2	Dharbandora	Sigao	70 & 97	5598.17	10,000 m^3	15 20'16.69"	74 13'17.84"	48I/3/SE	Dudhsagar
3	Dharbandora	Aglote	56	8735.46	10,000 m^3	15 24'50.50"	74 11'16.36"	48I/3/NE	Ragada
4	Sanguem	Rivona	20 & 14	4668.74	10,000 m^3	15 10'50.89"	74 06'13.98"	48I/4/NW	Kushavati
5	Sanguem	Uguem	63	5737.76	10,000 m^3	15 13'33.70"	74 12'22.82"	48I/4/NE	Ugvem
6	Sanguem	Sanguem	81	6205.98	10,000 m^3	15 13'35.00"	74 09'49.17"	48I/4/NE	Sangem
Total clusters – 06 nos.		**Total Lease Area– 36,775.66 sq.mts.**			**Total extraction capacity – 60,000 m^3 per annum**				

B. Proposed site-specific locations for traditional method of manual sand extraction (*estuarine stretches*)

Sr. No	Taluka	Village	Sy nos	Area in sq. mts.	Estimated Total minable reserve	Latitude (from)	Longitude (to)	S.O.I. Toposheet no. (s) on 1:25,000 scale	River
1.	Quepem	Xelvona	62	10341.64	10,000 m^3	15 16'33.20"	74 04'44.99"	48I/3/SW	Zuari
2.	Salcete	Talaulim	244	2861.53	10,000 m^3	15 13'54.04"	73 57'17.20"	48E/16/NE	Sal
3.	Salcete	Macazana	60	4387.22	10,000 m^3	15 17'44.16"	74 03'01.29"	48I/3/SW	Zuari
4.	Salcete	Loutulim	497	10933.15	10,000 m^3	15 20'49.84"	74 00'18.00"	48I/3/SW	Zuari
Total clusters – 04 nos.			**Total Lease Area - 28, 523.54 sq.mts.**		**Total extraction capacity – 40,000 m^3 per annum**				

Further, Authority has rejected the following two stretches / clusters proposed / identified by SGDC for the purpose of sand/rubble extraction from the riverine portion.

(i) **Khandepar river at Piliem in Dharbandora Taluka** on account of its immediate proximity to the laterite-quarry which may cause river-bank instability on account of stone removal from terrestrial end and proposed in-stream sand/gravel removal from river-bed and

(ii) **Khushavati / Gulathi river at Sirvoi in Quepem Taluka** on account of site inaccessibility from the nearest road to enable desired transportation of the extracted material.

Further, the Authority has decided to stipulate the conditions (*i.e. General and Specific*), compliance to be mandated by Project Proponent not only during the sand-extraction activities but also during pre and post issuance of leases to prospective sand extractors. The details of these conditions are as under:

A. General conditions

1. The Project Proponent, while granting a lease / licences or permits for 'sand/pebble extraction', should ensure that sand/pebble extraction is strictly restricted within the prescribed lease boundary / cluster only. Accordingly, lease area should be properly surveyed and mapped with the help of GPS to assign geo-coordinates and accordingly display the same appropriately on the landward side of the proposed cluster / lease so as to avoid unwarranted / unscientific and illegal extraction. Thus, the extraction of sand / pebble should be done only in area / stretches identified as indicated above in table **(A) & (B).**

2. The PP should erect a 'Display Board" along both river banks on either side of the proposed lease/cluster. This board should display name and contact details of nodal person concerned to enable timely redressal of sand-extraction related complaints received from general public.

3. The lease holder should adhere to only traditional method of manual extraction using wooden or FRP-boat without the use of any mechanical equipments, excavator, shovel, heavy-machinery, pump, dredgers, etc. No blasting shall be resorted in river/estuaries.

4. The EC holder / PP/ Permit/license holder shall keep a correct account of quantity of mineral extracted, dispatched from the site, mode of transport, registration number of vehicle, person-in-charge of vehicle and mine plan, details of Lessee / permit holder etc.

5. The lease/ licence/ permit/license holder should ensure proper access to enable transportation of extracted material from the lease to desired stacking at the site or elsewhere. Transportation of extracted material shall be done by covering the

trucks with tarpaulin so that no spillage of material / dust pollution takes place en route. Vehicles only with fitness and PUC Certificate should be used.

6. The lease / licence / permit shall not create any impediments at the site of any extraction / stacking by way of erection of barricades, to enable any competent State Authority to inspect such sites for the purpose of effective monitoring and enforcement.

7. Number of vessels deployed in sand extraction / transport in the vicinity of an Island/ Protected Area, if any, be regulated to avoid disturbance to the residents and migratory bird fauna.

8. Number of vessels deployed in sand extraction / transport in the vicinity of river banks be regulated to avoid damage to coconut/palm fringes, as and where they exist in the riparian habitat along the river banks.

9. Safety gadgets and health-care facilities should be provided to workers engaged in the extraction, on and off-board vis-a-vis maintenance of hygiene surrounding the proposed lease boundary along the banks of river/estuary.

10. It shall be ensured that restoration of riparian and in-stream habitats, restoration of river-geometry causing degradation on upstream and downstream be taken care of by the lease / permit / licence holder at his own cost. Various lease holders operating in a given cluster / stretch may evolve appropriate mechanism for mitigation of likely impact caused by sand extraction.

11. Due care be taken to avoid discharge of fuel / engine oil either in the river water or banks sediments during any phase of sand extraction / transportation. Any accidental discharge of a significant scale must be immediately reported to the concerned State Agency for remediation.

12. Any change (*i.e. modification / expansion / alteration*) in proposed clusters / traditional method of extraction / extraction capacity / scope of working / environment management plan (EMP) shall require re-appraisal by this Authority as per the provisions of the EIA Notification, 2006 (*as amended*).

13. Considering the probability of ecological impacts due to sand/gravel extraction of riverine ecosystem the Authority mandates that the Goa State Biodiversity Board (GSBB) periodically monitors riverine and riparian biodiversity on a sampling mode.

14. This environmental clearance (EC) does not absolve the PP / lease holder to obtain other statutory and administrative clearances / NoCs'/ Permissions, as applicable, from other statutory and administrative authorities concerned.

15. An appropriate mechanism be evolved to ensure an assured back-flow of share of revenue generated, to a revenue village; in whose jurisdiction sand extraction is carried out.

16. This prior Environmental Clearance (EC) is valid for a period of five years (05), or lease validity whichever is later.

B. Specific Conditions

1. "Patrolling-cum-Flying Squad" – a complaint / monitoring mechanism, comprising of senior-level representatives from stakeholder departments and authorities to be constituted for effective implementation and monitoring of stipulated 'General' and 'Specific' conditions vis-a-vis redressal of complaints, preferably at district-level. A dedicated helpline number may be provided for effective redressal of complaints. The said squad / committee shall enforce the conditions of this clearance and be authorised to file FIR / criminal case in case of violations and also to stop the illegal sand extraction and to seize equipments, vehicles etc used in illegal sand extraction.

2. Capping of sand / pebble extraction *(i.e. permissible quantity of sand/ pebble extraction per year per cluster/stretch)* from these designated stretches / clusters be established in technical consultation with the Directorate of Mines and Geology (DMG), being a Nodal Department dealing with mineral resources.

3. There shall be voluntary moratorium on worked-out leases/ stretches for a desired period in consultation with the Directorate of Mines and Geology (DMG) for effective sand replenishment of the extracted mineral.

4. The depth of the sand/pebble excavation within the designated cluster in estuarine regions should be restricted to a maximum depth of 3 mts. While, for dry river-beds, the depth of excavation should not exceed 2 mts.

5. The lease holder shall undertake adequate safeguard measures during sand/ pebble extraction and such activities should be limited to timings between **06.00 a.m. to 06.00 p.m. only.** No sand/ pebble extraction and allied activities are allowed during monsoon season (**1st June to 30th September**).

6. No removal/extraction be allowed/carried out within (a) the buffer zone of 25 mts. (at-least) from both the banks within the proposed riverine / estuarine cluster to control and avoid river-bank erosion, (b) safety zone (*i.e. 300 mts. upstream and downstream*) of any bridge or any cross-drainage structures, (c) No sand-extraction related activities be allowed within the peripheral limits of 50 mts. surrounding the island area within the estuarine region.

7. It shall be ensured that sand-extraction does not disturb the turbidity, velocity and flow-pattern of the river/estuary to the extent possible. Further, sand-extraction be avoided along the concave-portion of the meandering river/estuary to prevent bank erosion.

8. PP should ensure that riverine/estuarine bottom is always higher than the bed-depth of nearby water bodies (*i.e. well / lake / pond, etc.,*) so that the river/estuary is always a recharge source.

9. Further, the Authority mandates that above conditions be mandatorily transferred and be reflected in the **"Agreement"** between the State Nodal Agency (*i.e. the District Collectorate concerned or Directorate of Mines & Geology, as the case may be*) and the prospective Leasee / licence holder/permit holder and be legally binding on the latter.

10. The authority may alter / modify the conditions or stipulate any further condition in order to protect the local ecology and environment.

11. The directions given by the Hon'ble Supreme Court vide order dated 27/2/2012 in Deepak Kumar case [SLP(c) Nos. 19628-19629 of 2009], various orders passed by the Hon'ble National Green Tribunal and guidelines issued by the Ministry of Environment, Forests and Climate Change, Government of India time and again in the matter shall be strictly followed.

12. Any appeal against this prior environmental clearance shall be with the National Green Tribunal within a period of 30 days as prescribed under section 16 of the National Green Tribunal Act, 2010.

Yours faithfully,

(Srinet Kothwale)
Director/Ex-officio Jt. Secy. (Environment) &
Member Secretary, Goa-SEIAA

Copy for necessary action to:

1. **The Director, Directorate of Mines and Geology (DMG),** Udyog Bhavan, Panaji, Goa – 403 001.

2. **The Assistant Engineer, Subdivision–II, Water Resources Department (WRD),** Baixo, Aquem, Rawan fond, Margao- Goa.

3. **The Member Secretary, Goa State Pollution Control Board,** 1st Floor, Dempo Towers, Patto, Panaji, Goa.

4. **The Captain, Captain of Ports Department**, Government of Goa, Dayanand Bandodkar Road, Panaji Goa.

5. **The Director, Department of Fisheries**, Government of Goa, D.B. Bandodkar Marg, Panaji Goa.

6. **The Member Secretary, Goa Coastal Zone Management Authority,** 3rd Floor, Dempo, Patto Panaji Goa.

7. **The Member Secretary, Goa State Biodiversity Board,** C/o. Department of Science, Technology & Environment, Opp. Saligao Seminary, Saligao Bardez Goa.

Copy for favour of information to:

1. **The Principal Secretary (Environment), Government of Goa,** Secretariat, Alto-Porvorim, Goa.

2. **The Principal Chief Conservation of Forests, Forest Department, Government of Goa, Panaji-Goa.**

3. **The Director, (IA Division), Ministry of Environment, Forests and Climate Change (MoEF &CC)**, Paryavaran Bhavan, C.G.O. Complex, Lodhi Road, New Delhi – 110510.

4. **Dr. Pramod V. Pathak, Chairman, Goa-SEIAA**, Satyam, Pundalik Nagar, Behind Sanjay School, Porvorim – 403521.

5. **Prof. Antonio Jaime Afonso, Chairman, Goa-SEAC**, Bairo Foro, St. Istevam, Tiswadi – 403 106.

GOA STATE ENVIRONMENT IMPACT ASSESSMENT AUTHORITY

EIA-Goa State Secretariat,
3rd Floor, Dempo Towers, Patto, Panaji, Goa – 403 001
Phone nos.: 2438528 Fax. no.: 2438567
e-mail: goaseac@gmail.com

No: 3 – 181 – 2010/STE-DIR/ 159 *Date: 01/10/2015*

To,
The Collector& District Magistrate,
North Goa District,
Collectorate Building,
Panaji -Goa

Sub.: Extraction of Sand in rivers/ estuaries at North Goa District by manual methods by traditional Communities – Environmental Clearance reg.

Sir,

This has reference to your application bearing no. 39/8/2013-MAG/DC/SAND EXT/2613 dated 12/06/2015 seeking prior environmental clearance for extraction of sand in rivers/ estuaries by manual methods by traditional Communities at various stretches of rivers / estuaries in North Goa District. The proposal is for obtaining environmental clearance (EC) for sand extraction from 14 stretches of 2,00,000 Sq.mts each i.e.8 stretches from Mandovi estuary, 02 stretches from Terekhol estuary and 04 stretches from Chapora estuary with total extraction capacity of 1,68,00,000 M^3 per annum **(i.e. @ 60,000 M^3/year per 10,000 M^3)**.

Subsequently, the Goa State Expert Appraisal Committee (hereinafter referred to as 'the Committee', in short) has conducted site-inspections of each and every stretch on 16th / 20th July and 10th September 2015 along with the representatives from stakeholder Departments of the State Government viz. Directorate of Mines and Geology (DMG), Captain of Ports (CoP), Water Resources Department, North Goa Collectorate, etc. The Committee during its site-visits interacted with local stakeholders as well, for ground truthing. During the process of project appraisal, the Committee perused – **(i) Office Memorandum (O.M.) no. J-13012/12/2013-IA-II (I) dated. 24th December 2013** notified/published by the Ministry of Environment, Forests and Climate Change (MoEF & CC) and noted that the proposal is categorized under Category-B-2 (*i.e. to be appraised based on Form-1, pre-feasibility report with relevant documents / details*) and (ii) **Office Memorandum (O.M.) no. 11-83/2005/-IA-III (Vol.III) dated. 8th November 2011** notified/published by the Ministry of Environment & Forests (MoEF) on the subject matter of removal of sand in the Coastal Regulation Zone area of rivers / estuaries by manual methods by traditional communities. In addition, the Committee also perused **(i) The EIA Notification 2006, as amended** and **(ii) The Goa Minor Mineral Concession (Amendment) Rules, 2012** published by the State Government vide Gazette Notification (Extraordinary) series 1, no. 24 dated 17th September 2012 and (iii) **'Order' of the National**

Green Tribunal (NGT), Principal Bench, New Delhi pronounced on 5th August 2013 in a matter of Original Application no. 171 of 2013 (*National Green Tribunal Bar Association V/s Ministry of Environment & Forests & Ors.,*). **Judgement dated 13/01/2015 passed by the Hon'ble National Green Tribunal (NGT), Principal Bench, New Delhi in the Original Application (OA) No. 123 of 2014** (in the matter of Himmat Singh Shekhawat V/s State of Rajasthan & ors) **and Judgement dated 29/05/2014 passed by the Hon'ble National Green Tribunal (NGT) (Western Zone) Bench, Pune in the Application No. 34(THC)/2013(WZ)** in the matter of *AWAAZ Foundation V/s State of Maharashtra & ors* and (iv) a Model Document on **'Impacts and Methodology of systematic and Scientific mining of the river-bed material'** published by the Geological Survey of India (GSI) and (v) **'Order' dated 27/02/2012 of Hon'ble Supreme Court in I.A No. 12-13 of 2011 in SLP (C) No.19628-19629 in the matter of Deepak Kumar etc V/s State of Haryana and ors.**

Prior and during the technical presentation by the PP, the Committee sought to examine in details all the available documents in substantiation of the baseline environmental character of the proposed sites, provided by the PP for the purpose of environmental impact appraisal of the proposed activity.

Subsequently and after detailed deliberations vis-à-vis compliance submitted by the PP, and appraisal based on available data and ground-truthing, the Committee, during its 48th Meeting, held on 14h September 2015, decided to recommend for grant of EC for sand extraction as specified in the submitted proposal. (*refer table below*)

The Goa State Environment Impact Assessment Authority (hereinafter referred to as 'the Authority', in short) on detailed perusal and in agreement with the Committee's recommendations and after referring to draft **'Sustainable Sand Mining – Management Guidelines'** published by the Ministry of Environment, Forests and Climate Change (MoEF & CC) in September 2015, has decided to grant prior environmental clearance (EC), as mandated in the EIA Notification, 2006 (*as amended till date*) and in terms of the directions contained in the Judgement of Hon'ble Supreme Court and National Green Tribunal for extraction of sand by manual traditional methods at following 14 stretches / clusters identified / proposed by the North Goa District Collector (NGDC), Panaji-Goa.

Proposed site-specific locations for traditional method of manual sand extraction (*estuarine clusters / stretches*) in North Goa.

Sr. no	Taluka (North/ South)	Cluster	Area in sqmts	Estimated Total minable reserve (cubic meters)	Latitude	Longitude	S.O.I Toposheet No.(s)on 1:25,000 scale	River
1	Bicholim/Tiswadi	MC-1	200000	1,20,00,00	15^0 32' 39.99"	73^{0}56' 30.14"	48E/14/6	Mandovi
2	Bicholim/Tiswadi	MC-2	200000	1,20,00,00	15^{0}32' 42.82"	73^{0}57' 22.93"	48E/14/6	Mandovi
3	Bicholi	MC-3	200000	1,20,00,00	15^{0}32'	73^{0}57'	48E/14/6	Mandovi

	m/Pond a				6.77"	59.17"		
4	Bicholi m/Pond a	MC-4	200000	1,20,00,00	15°31'27.19"	73°58' 27.00"	48E/14/6	Mandovi
5	Bicholi m/Pond a	MC-5	200000	1,20,00,00	15°31' 6.90"	73° 59'18.86"	48E/14/6	Mandovi
6	Bicholi m/Pond a	MC-6	200000	1,20,00,00	15°30' 5.09"	73°59' 59.45"	48E/14/6	Mandovi
7	Bicholi m/Pond a	MC-7	200000	1,20,00,00	15°29' 47.95"	74°01' 0.50"	48I/3/1	Mandovi
8	Bicholi m/Pond a	MC-8	200000	1,20,00,00	15°28' 47.60"	74°01' 33.76"	48I/3/1	Mandovi
9	Pernem	TC-1	200000	1,20,00,00	15°44' 8.41"	73° 44'41.74"	48E/14/1	Tiracol
10	Pernem	TC-2	200000	1,20,00,00	15°43' 32.12"	73°47' 7.79"	48E/14/1	Tiracol
11	Bardez/ Pernem	CC-1	200000	1,20,00,00	15°39' 9.77"	73°47' 0.50"	48E/14/2	Chapora
12	Bardez/ Pernem	CC-2	200000	1,20,00,00	15°39' 5.45"	73° 49'48.52"	48E/14/2	Chapora
13	Bardez/ Pernem	CC-3	200000	1,20,00,00	15°39' 10.98"	73°50' 26.92"	48E/14/2	Chapora
14	Bardez/ Pernem	CC-4	200000	1,20,00,00	15°40' 48.64"	73° 52'30.51"	48/E/14/4	Chapora
Total clusters: 14 nos.			Total Lease Area: 28,00,000 sq mts.	Total Extraction Capacity 16,80,00,00. M^3 per annum.				

Further, the Authority has decided to stipulate the conditions (*i.e. General and Specific*), as compliance to be mandated by Project Proponent not only during the sand-extraction activities but also during pre and post issuance of leases to prospective sand extractors. The details of these conditions are as under:

A. General conditions

1. The Project Proponent, while granting a lease / licences or permits for 'sand extraction', should ensure that sand extraction is strictly restricted within the prescribed lease boundary / cluster only. Accordingly, lease area should be properly surveyed and mapped with the help of GPS to assign geo-coordinates and accordingly display the same appropriately on the landward side of the proposed

cluster / lease so as to avoid unwarranted / unscientific and illegal extraction. Thus, the extraction of sand should be done only in area / stretches identified as indicated in table above.

2. The PP should erect a 'Display Board" on both river banks along either side of the proposed lease/cluster. This board should display name and contact details of nodal person concerned to enable timely redressal of sand-extraction related complaints received from general public.

3. The lease holder should adhere to only traditional method of manual extraction using wooden or FRP-boat without the use of any mechanical equipments, excavator, shovel, heavy-machinery, pump, dredgers, etc. No blasting shall be resorted in river/estuaries.

4. The EC holder / Permit/licence holder shall keep a correct account of quantity of mineral exported, dispatched from the site, mode of transport, registration number of vehicle, person-in-charge of vehicle and mine plan, details of Lessee / permit holder etc.

5. The lease/ licence/ permit holder should ensure proper access to enable transportation of extracted material from the lease to desired stacking at the site or elsewhere. Transportation of extracted material shall be done by covering the trucks with tarpaulin so that no spillage of material / dust pollution takes place on route. Vehicles only with fitness and PUC Certificate should be used.

6. The lease / licence / permit shall not create any impediments at the site of any extraction / stacking by way of erection of barricades, to enable any competent State Authority to inspect such sites for the purpose of effective monitoring and enforcement.

7. Number of vessels deployed in sand extraction / transport in the vicinity of an Island/ Protected Area, if any, be regulated to avoid disturbance to the residents and migratory bird fauna.

8. Number of vessels deployed in sand extraction / transport in the vicinity of river banks be regulated to avoid damage to coconut/palm fringes, as and where they exist in the riparian habitat along the river banks.

9. Safety gadgets and health-care facilities should be provided to workers engaged in the extraction, on and off-board vis-a-vis maintenance of hygiene surrounding the proposed lease boundary along the banks of river/estuary.

10. It shall be ensured that restoration of riparian and in-stream habitats, restoration of river-geometry causing degradation on upstream and downstream be taken care of by the lease / permit / licence holder at his own cost. Various lease holders operating in a given cluster / stretch may evolve appropriate mechanism for mitigation of likely impact caused by sand extraction.

11. Due care be taken to avoid discharge of fuel / engine oil either in the river water or banks sediments during any phase of sand extraction / transportation. Any accidental discharge of a significant scale must be immediately reported to the concerned State Agency for remediation.

12. Any change (*i.e. modification / expansion / alteration*) in proposed clusters / traditional method of extraction / extraction capacity / scope of working / environment management plan (EMP) shall require re-appraisal by this Authority as per the provisions of the EIA Notification, 2006 (*as amended*).

13. Considering the probability of ecological impacts due to sand extraction of riverine ecosystem the Authority mandates that the Goa State Biodiversity Board (GSBB) periodically monitors riverine and riparian biodiversity on a sampling mode.

14. This environmental clearance (EC) does not absolve the PP / lease holder to obtain other statutory and administrative clearances / NoCs'/ Permissions, as applicable, from other statutory and administrative authorities concerned.

15. An appropriate mechanism is evolved to ensure an assured back-flow of share of revenue generated, to a revenue village; in whose jurisdiction sand extraction is carried out.

16. This prior Environmental Clearance (EC) is valid for a period of five years (05), or lease validity whichever is later.

B. Specific Conditions

1. **"Patrolling-cum-Flying Squad" – a complaint / monitoring mechanism,** comprising of senior-level representatives from stakeholder departments and authorities to be constituted for effective implementation and monitoring of stipulated 'General' and 'Specific' conditions vis-a-vis redressal of complaints, preferably at district-level. A dedicated helpline number may be provided for effective redressal of complaints. The said squad / committee shall enforce the conditions of this clearance and be authorised to file FIR / criminal case in case of violations and also to stop the illegal sand extraction and to seize equipments, vehicles etc used in illegal sand extraction.

2. Capping of sand extraction *(i.e. permissible quantity of sand/ pebble extraction per year per cluster/stretch)* from these designated stretches / clusters be established in technical consultation with the Directorate of Mines and Geology (DMG), being a Nodal Department dealing with mineral resources.

3. There shall be voluntary moratorium on worked-out leases/stretches for a desired period in consultation with the Directorate of Mines and Geology (DMG) for effective sand replenishment of the extracted mineral.

4. The depth of the sand excavation within the designated cluster in estuarine regions should be restricted to a maximum depth of 3 mts. While, for dry river-beds, the depth of excavation should not exceed 2 mts.

5. The lease holder shall undertake adequate safeguard measures during sand extraction and such activities should be limited to timings between **06.00 a.m. to 06.00 p.m. only.** No sand extraction and allied activities are allowed during monsoon season (**1st June to 30th September**).

6. No removal/extraction be allowed/carried out within (a) the buffer zone of 25 mts. (at-least) from both the banks within the proposed riverine / estuarine cluster to control and avoid river-bank erosion, (b) safety zone (*i.e. 300 mts. upstream and downstream*) of any bridge or any cross-drainage structures, (c) No sand-extraction related activities be allowed within the peripheral limits of 50 mts. surrounding the island area within the estuarine region.

7. It shall be ensured that sand-extraction does not disturb the turbidity, velocity and flow-pattern of the river/estuary to the extent possible. Further, sand-extraction be avoided along the concave-portion of the meandering river/estuary to prevent bank erosion.

8. PP should ensure that riverine/estuarine bottom is always higher than the bed-depth of nearby water bodies (*i.e. well / lake / pond, etc.*,) so that the river/estuary is always a recharge source.

9. Further, the Authority mandates that above conditions be mandatorily transferred and be reflected in the **"Agreement"** between the State Nodal Agency (*i.e. the District Collectorate concerned or Directorate of Mines & Geology, as the case may be*) and the prospective Leasee / licence holder/permit holder and be legally binding on the latter.

10. The authority may alter / modify the conditions or stipulate any further condition in order to protect the local ecology and environment.

11. The directions given by the Hon'ble Supreme Court vide order dated 27/2/2012 in Deepak Kumar case [SLP(c) Nos. 19628-19629 of 2009], various orders passed by the Hon'ble National Green Tribunal and guidelines issued by the Ministry of Environment, Forests and Climate Change, Government of India time and again in the matter shall be strictly followed.

12. Any appeal against this prior environmental clearance shall be with the National Green Tribunal within a period of 30 days as prescribed under section 16 of the National Green Tribunal Act, 2010.

Yours faithfully,

(Srinet Kothwale)
Director/Ex-officio Jt. Secy. (Environment) &
Member Secretary, Goa-SEIAA

Copy for necessary action to:

1. **The Director, Directorate of Mines and Geology (DMG),** Udyog Bhavan, Panaji, Goa – 403 001.
2. **Assistant Engineer, Water Resources Department (WRD),** Panaji-Goa.
3. **The Member Secretary, Goa State Pollution Control Board,** 1st Floor, Dempo Towers, Patto, Panaji, Goa.
4. **The Captain, Captain of Ports Department**, Government of Goa, Dayanand Bandodkar Road, Panaji Goa.
5. **The Director, Department of Fisheries**, Government of Goa, D.B. Bandodkar Marg, Panaji Goa.
6. **The Member Secretary, Goa Coastal Zone Management Authority,** 3rd Floor, Dempo, Patto Panaji Goa.

7. **The Member Secretary, Goa State Biodiversity Board,** C/o. Department of Science, Technology & Environment, Opp. Saligao Seminary, Saligao Bardez Goa.

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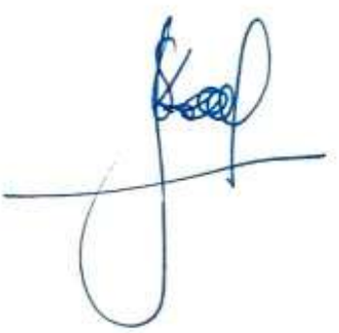
1. **P.A. to Principal Secretary (Environment), Government of Goa,** Secretariat, Alto-Porvorim, Goa.

2. **The Principal Chief Conservation of Forests, Forest Department, Government of Goa, Panaji-Goa.**

3. **The Director, (IA Division), Ministry of Environment, Forests and Climate Change (MoEF &CC),** Paryavaran Bhavan, C.G.O. Complex, Lodhi Road, New Delhi – 110510.

4. **Dr. Pramod V. Pathak, Chairman, Goa-SEIAA,** Satyam, Pundalik Nagar, Behind Sanjay School, Porvorim – 403521.

5. **Prof. Antonio Jaime Afonso, Chairman, Goa-SEAC,** Bairo Foro, St. Istevam, Tiswadi – 403 106.



PRE-FEASIBILITY REPORT

Extraction of sand from the river beds in Goa

Contents	Details
1. **Executive Summary**	The sand extraction was carried out traditionally using manual methods of extraction within the defined estuarine stretches at Colvale in Chapora prior to liberation. This activity of sand was extraction recognized by the Government after the liberation of the State as traditional activity. Post liberation, the activity was extended in river Tiracol in areas Devsu, Kiranpani, Korgao, Querim, Paliem, and in Pernem upto Torsem. This activity was also extended in river Mandovi in areas Amona, St. Estevem (Zuvem), Savoi Verem, Betqui-Khandola ,Akhada, Navelim, Narvoe, Piligaon, Surla and Kottombi. The methodology adopted for extraction at all areas was manual using divers for extraction of the sand from the estuarine bed with baskets using fiber glass canoes without board motors. The Captain of Ports only permits use of non-mechanized canoes for extraction of sand. In order to have some sort of control on the extraction of minor minerals (*i.e. sand*) in the State, the erstwhile Government framed the Rules as **"Goa, Daman & Diu Minor Mineral Extraction and Removal Rules, 1974"** wherein special privileges were given to the traditional extractors of sand such as concession in the payment of royalty. However, these Rules were repealed in 1985 and new Rules were introduced as the **"Goa, Daman & Diu Minor Mineral Concession Rules, 1985"** which are currently in force. Under the provisions of these Rules, permission was granted for extraction of sand for a period of one year along the river bed of river Terekhol, Chapora and Mandovi. The sand extractor had to pay royalty on sand on @ 600 m^3 for every quarter of the year. Every sand extractor was permitted to use two canoes registered with the Captain of Ports (CoP) for transportation of river sand. The sand was being collected in basket tied to long bamboos, which are immersed in the river bed and by dragging, sand is collected which is then brought to the surface and unloaded into the canoes. The grant of permission for the sand extraction was discontinued after implementation of the provisions of the Coastal Zone Regulation (CRZ) Notification in January 2011. Further, the Department of Mines and Geology (DMG) received complaints w.r.t. river-bank instability and its

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subsequent collapse at Querim and Poroscodem in Pernem Taluka within Terekhol river, due to overexploitation of sand. After carrying out site-inspection, the DMG has denotified these areas, along these banks, in village Querim in Pernem taluka within the Terekhol river.

The river Terekhol, Chapora and Mandovi are extensively used for navigation purpose and indirectly the sand extraction along certain stretches within this navigational channel has helped in maintaining the depth required for such navigational purposes. As per the records available with the Department of Mines & Geology, the details of permits granted in the estuarine stretches of Mandovi, Chapora and Tiracol are as under.

Year	No of permission granted	Quantity permitted per Person per financial years in Cubic Meter	Quantity of sand permitted for extraction in Cubic Meter
2008 – 09	88	2,400	2,11,200
2009 – 10	60	2,400	1,44,000
2010 - 2011	29	2,400	69,600

The size of present fiber-glass canoes have a capacity of 30 M^3 and are fitted without on-board motor.

2. Introduction of the project Background information

i. Identification of project and project proponent. In case of mining project, a copy of mining lease/letter of intent should be given

The present proposal is being submitted by Collector North Goa, who is the Chairman of **the North Goa District Committee notified vide notification No: 01/226/2012-Mines/2328 dated December 2012 issued by the Directorate of Mines and Geology and published in Official Gazette, Series II, No. 37, dated 13th December 2012 to comply with the provisions as stipulated in Goa Minor Mineral**

River	Area in sq.mts.	Max Width	Max Depth
Mandovi	8 stretches of 20hac each separated by 1.5 kms. Total area-160Hac	455mts	4mts
Terakhol	2 stretches of 20hac each separated by 1.5 kms. Total Area-40Hac	78mts	4mts
Chapora	4 stretches of 20hac each separated by 1.5 kms. Total Area- 80Hac	546mts	4mts
Total lease area in Hect.	280hac		

Concessions Rules, 1985. Accordingly, the proposal has been submitted seeking prior environmental clearance (EC) for extraction of sand in specific estuarine stretches of River Mandovi, Terekhol, Chapora as identified by the DMG, CoP and Department of Settlement and Land Records (DSLR). The identification has being carried out based on the historical data available with the DMG and permits granted earlier.

Senior Technical Assistant
Directorate of Mines & Geology
Government of Goa, Panaji-Goa

ii. Brief description of nature of the project	The sediments are river borne and have been formed as a result of weathering process of feldspethic rock of granitic composition. Running river is main agent responsible for weathering. It is significant during the season and generates a huge quantity of river sand which gets deposited at the bottom of the river. The size of the sediments decreases towards the end of the flow of river i.e. towards the river banks.
iii. Need for the project and its importance to the country and or region.	The basic objective of the Project is effective utilization of mineral in the region. With the development of infrastructure the demand of building material in last 10 to 15 years has increased manifold, mainly in infrastructure projects-like highways building township etc. which has raised the demand of river sand beside of the mineral. River sand mining not only provides the building material but also employment and economic growth of the State that will ultimately enhance the socio-economic status of the people of the region/area.
iv. Demand-Supply Gap	Sand is available in the State of Goa only in the estuarine stretches of the river below the water level in all seasons. There is a large demand for sand for construction activities in the State. This demand of sand will be fulfilled by this project to various end users in open market. The demand for sand which is an important component in construction activities of any kind, increases the demand as a whole. During the last three to four years sudden increase in the infrastructure projects of the State Government and need for housing in the State has further enhanced the high demand of the sand, which will be fulfilled by this project.
v. Imports, Indigenous production	Presently the sand is being imported from the neighboring State of Maharashtra. Indigenous production is proposed here. This will not be either exported or imported.
vi. Export Possibility	Not to be exported.
vii. Domestic / export Markets	The sand will be used within the State for Housing and Infrastructure Projects.
viii. Employment Generation (*Direct and Indirect*) due to the project	The proposed project will re-generate direct employment to traditional dwellers earlier involved in extraction of sand.

3. Project Description

i. Type of project including Interlinked and interdependent project, if any.	All development projects of the State Government and Housing are interlinked and interdependent on extraction of sand

Senior Geologist
Geology

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ii. Location (map showing general location, specific location, and project boundary & project site layout) with coordinates.	**Name of the project:** Traditional method of manual sand extraction within riverine / estuarine stretches in Revenue Villages of North Goa District. Village: As per **Plan Nos. 1, 2 and 3** Coordinates of ML area are as follows: Location Map: **Plan Nos. 1, 2 and 3**
iii. Details of alternate sites considered and the basis of selecting the proposed site, particularly the environmental considerations gone into should be highlighted.	The sites are identified using the historical data available with the DMG and bathymetric study carried out by COP.
iv. Size or magnitude operation.	12000cu.m/year/cluster
v. Project description with process details (a schematic diagram, flow chart showing the project layout, components of the project etc. should be given)	Extraction work will be started from village and mining activity will be regularly done in downstream the river. The area where significant quantity of water is present will be avoided. Extraction work shall be carried out upto 03 meters depth from surface level of river bed. The excavation will be inclined towards the periphery for safety. Water shall be sprinkled on river sand to suppress any dust that may be raised during digging and loading operations. Extraction and loading of mineral into trucks shall be carried out manually. Silt extracted if any shall also be loaded manually and stacked separately.
vi. Raw material required along with estimated quantity, likely source, marketing area of final products, Mode of transport of raw material and finished product.	No raw material required.. No mineral processing will be carried out at or near the site.
vii. Resource optimization / recycling and reuse envisaged in the project, if any, should be briefly outlined.	Excavation work will be carried out by manual method confined only to depth of 03 mts..
viii. Availability of water its source, Energy / power requirement and source should be given.	Not applicable
ix. Quantity of wastes to be generated (liquid and solid) and scheme for their Management / disposal.	There is no top soil and overburden/rejects waste in this lease area. So there is no requirement of any specific management plan.

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Directorate of Mines & Geology
Government of Goa, Panaji-Goa

x.	Schematic representations of the feasibility drawing which give information of EIA purpose.	Not applicable

4. Site Analysis

i. Connectivity	The proposed area is well connected to the public roads.
ii. Land Form, Land use and Land ownership.	The proposed lease area is Government land (*rivers and nallahs*). The land form is mostly river bed and non forest land. Moreover there will be no change in land use as the mining will be confined to river bed, which will get replenished naturally in the subsequent monsoon season. Project proponent: Collector of North Goa District, Panaji.
iii. Topography (*along with map*)	**Not applicable**
iv. Existing land use pattern (agriculture, non-agriculture, forest, water bodies (*including area under CRZ*), shortest distances from the periphery of the project to periphery of sanctuary, eco from the HFL industries area, be given.	Sand mining will be done in river bed. **Shortest distance from Sanctuary – 45Kms** No forest land
v. Existing Infrastructure	No existing infrastructure near the proposed lease area.
vi. Soil classification	Not applicable
vii.Climatic data from secondary sources.	Climatology (*Meteorological Data*) Source – Mining Plan

i	Average rainfall (Max in mm	:	3005mm
ii	Temperature (Max)	:	35°C (May-June)
iii	Temperature (Min)	:	20°C (January)
iv	Relative Humidity	:	Summer-65% Monsoon -90%
v	Wind direction	:	SWt o NE (March September) NW to SE (Winter)

Senior Technical Assistant
Directorate of Mines & Geology
Government of Goa, Panaji-Goa

viii. Social Infrastructure available	Proposed area is well connected with link road Nearest Railway Station is **Karmali**. Nearest Airport is **Dabolim** Airport. All the social infrastructural facilities like hospitals, schools, colleges, etc. are available in North Goa District.

5. Planning Brief

i. Planning concept (*type of industries, transportation etc*) Town and Planning / Development authority Classification.	The total optimum extractable sand from the proposed clusters are estimated as 12000cu.m./year/cluster Transportation: The sand produced from the mine is transported by trucks, tractors, trolleys and dumpers.
ii. Population Projection	All the people will be sourced from neighboring villages. Thus there will be no increase in population due to the project.
iii. Land use planning (*breakup along with*)	Not applicable
iv. Assessment of Infrastructure Demand (Physical & Social)	Not applicable
v. Amenities / Facilities	The following facilities/amenities will be extended by the mine management: Direct and indirect employment, of which most will be from nearby villages. Arrangements for safe and healthy working conditions. Provision of drinking water. Conducting medical camps for workers and nearby villagers at regular interval.

6. Proposed Infrastructure

i. Industrial Area (*Processing Area*)	The proposed project does not involve any processing.
ii. Residential Area (*Non Processing Area*)	Local persons will be employed; no residential area/housing is proposed.
iii. Green Belt	Necessary care will be taken to conserve Green Belt
iv. Social Infrastructure	Road facility (*existing roads will be maintained regularly*) Public transport system improvement Direct & Indirect employment opportunity Social awareness camps Increased revenue, sales tax, road tax to State Government Formation of Self Help Groups (SHGs') for the women in nearby villages.
v. Connectivity (*Traffic and Rail / Metro / Water Ways, etc*)	The proposed area is well connected with link road to North Goa District. Nearest railway station is Karmali, about 12km. from North Goa District Headquaretrs, Panaji. Nearest airport is Dabolim.

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vi. Drinking Water Management (*Source Water*)	Drinking water shall be made available at all times to the mine workers. This will be sourced from water tankers.
vii. Sewerage System	No sewerage system is proposed.
viii. Industrial Waste Management	Not applicable.
ix. Solid Waste Management	Not applicable.
x. Power Requirement & Supply / Source	No power requirement. All the activities will be carried out by manual method. There is no power requirement for the project as it will be done only from sun rise to sun set.

7. Rehabilitation and Resettlement (R&R) Plan

i. Policy to be adopted (Central/State) in respect of the project affected persons including home oustees, land oustees and landless laborers (*a brief outline to be given*)	It is entirely a Government land. No human settlements are existing in the ML area. The proposed project does not involve any rehabilitation and resettlement.

8. Project Schedule & Cost Estimates

i. Likely date of start of construction and likely date of completion (*Time schedule for the project to be given*).	No major constructions are required.
ii. Estimated project cost along with analysis in terms of economic viability of the project.	Not applicable

9. Analysis of proposal (*Final Recommendations*)

i. Financial and social benefits with special emphasis on the benefit to the local people including tribal population, if any, in the area.	The Project will bring economical benefits to the State by way of royalty on minerals. The sand extraction shall be providing employment to large number of persons directly involved in the excavation. Most of the local people are likely to be benefited. This project operation will provide livelihood to the poorest sections of the society. The activity is expected to have positive impact on socio-economic life of people living in nearby villages. Sand extraction will create the context for increased awareness about the need for education and general upliftment particularly in the women folk.

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PRE-FEASIBILITY REPORT

Extraction of sand from river beds in South Goa District

(As per Ministry of Environment and Forests Letter dated: 30-12-2010)

Contents	Details
1. Executive Summary	The sand extraction was carried out traditionally using manual methods of extraction within the defined estuarine stretches at Rivers Sal, Zuari, Galgibag and Talpona was going on prior to liberation. This activity of sand extraction was recognized by the Government after liberation of the State as traditional activities. Post-liberation, the activity was extended in the Rivers Zuari, Sal, Galgibag and Talpona as there is increase in demand in the areas and activities were also extended in River Dudhsagar, Khandepar, Ragada, Kushavati, Uguem, Sanguem, Galati, Sal and Zuari. The methodology adopted for extraction of all areas was manual using divers for extraction of the sand from the estuarine bed with baskets using wooden/fibre glass canoes without board motors. The Captain of Ports only permits use of non-mechanized canoes for extraction of sand. In order to have some sort of control on the extraction of Minor Minerals(*i.e. sand*) in the State, the erstwhile Government framed the Rules as **" Goa Daman & Diu Minor Minerals Extraction and Removal Rules 1974"** wherein special privileges were given to the traditional extractors of sand such as concession in the payment of royalty. However, these Rules were repealed in 1985 and new Rules were introduced as the **"Goa Daman & Diu Minor Minerals Concession Rules 1985"** which are currently in force. Under the provisions of these Rules, permission was granted for extraction of sand for the period of one year along the River bed of all the Rivers of Goa. The sand extractor had to pay royalty on sand on @ 600 m^3 for every quarter of the year. Every sand extractor was permitted to use two canoes registered with the Captain of Ports (CoP) for transportation of River sand. The sand was being collected in the basket tied to long bamboos, which are immersed in the River bed and by dragging, sand is collected which is then brought to the surface and unloaded on the Bank which was subsequently transported using trucks. The grant of permission for the sand extraction was discontinued after implementation of the provisions of the Coastal Zone Regulation (CRZ) Notification in January, 2011.

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	The River Zuari in South is extensively used for navigation purpose and indirectly the sand extraction along certain stretches within this navigational channel has helped in maintaining the depth required for such navigation purposes. Past records of sand extraction is as per Annexure "C"

2. Introduction of the project Background information

i. Identification of project and project proponent. In case of mining project, a copy of mining lease/letter of intent should be given	The present proposal is being submitted by Collector South Goa, who is the Chairman of the District Committee notified vide Notification No.01/226/2012-Mines/2328 dated 28/11/2012 for extraction of sand in specific estuarine stretches of River sal, Zuari, Talpona and Galgibag as identified by the DMG, CoP and Department of Settlement and Land Record(DSLR). The identification has been carried out based on the historical data available with the DMG and permits granted earlier **(As per Annexure-"C").**
ii. Brief description of nature of the project	The sediments are river borne and have been formed as a result of weathering process of feldspethic rock of granitic composition. Running river is main agent responsible for weathering it is significant at the time season and generates a huge quantity of river sand which deposited at the bottom of the river. The size sediments decrease towards the end of the flow of river i.e. towards the river mouth.
iii. Need for the project and its importance to the country and or region.	The basic objective of the Project is to effective utilization of mineral in the Country and/or region. With the development and infrastructure has enhanced the demand of building material in last 10 to 15 years. Mainly in infrastructure projects-like highways building township etc. which has raised the demand of river sand beside of the mineral. River sand mining not only provides the building material but also employment economic growth of the State that will ultimately enhance the socio-economic status of the people of the region/area.
iv. Demand-Supply Gap	Sand is available in the State of Goa only in the estuarine stretches of the River below the water level in all seasons and beyond tidal effect on the dry bed of Rivers during fair season. There is large demand of sand for construction activities in the State. Demand of sand is fulfilled by this project to various end users in open market. The sand which is an important component in the construction activities of any kind, increase the demand as a whole. During the last three to four years sudden increase in

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	the infrastructure projects of the State Government and need for housing in the State further enhance the high demand of the sand is fulfilled by this project.
v. Imports, Indigenous production	Presently, the sand is being imported from the neighbouring State Maharashtra and Karnataka.This is indigenous production. This will be neither exported nor imported.
vi. Export Possibility	Not exported
vii. Domestic / export Markets	The sand will be used within the State for housing and infrastructure projects.
viii. Employment Generation (*Direct and Indirect*) due to the project	The proposed project will re-generate direct employment to traditional dwellers earlier involved in extraction of sand.
3. **Project Description**	
i. Type of project including interlinked and interdependent project, if any.	All development projects of the State Government and housing are interlinked and interdependent on extraction of sand.
ii. Location (map showing general location, specific location, and project boundary & project site layout) with coordinates.	**Name of the project:** Traditional method of manual sand extraction within riverine/estuarine stretches in Revenue Villages of South Goa District. **Village: As per Annexure A & B** **Coordinates of ML area are as follows:** **Location Map is enclosed at Annexure "D" to "O"**
iii. Details of alternate sites considered and the basis of selecting the proposed site, particularly the environmental considerations gone into should be highlighted.	The sites identified using the historical data available with the DMG and bathymetric study carried out by CoP.
iv. Size or magnitude operation.	Proposed optimum sand extraction per annum (As per marked area) is 10,000 cubic metre per annum
v. Project description with process details (a schematic diagram, flow chart showing the project layout, components of the project etc. should be given)	Exraction work will be started from village and quarring activity will be regularly in downstream the river side direction. The area where significant quantity of water present mining activity will be avoided there. The extraction work shall be carried out upto 03 meters depth from surface level of river bed. Water shall be sprinkled on river sand to suppress any dust that may be raised during loading operations. Extraction and loading of mineral into trucks shall be carried out manually. Silt extracted if any shall

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	also be loaded manually and stacked separately.
vi. Raw material required along with estimated quantity, likely source, marketing area of final products, Mode of transport of raw material and finished product.	No raw material required.. No mineral processing will be carried out at or near the site.
vii. Resource optimization / recycling and reuse envisaged in the project, if any, should be briefly outlined.	Excavation work will be carried out by manual method for only depth of 03 mts.
viii. Availability of water its source, Energy / power requirement and source should be given.	Not applicable
ix. Quantity of wastes to be generated (liquid and solid) and scheme for their Management / disposal.	There is no top soil and overburden/rejects waste in this lease area. So there is no requirement of any specific management plan.
X. Schematic representations of the feasibility drawing which give information of EIA purpose.	Not applicable

4. Site Analysis

i. Connectivity	The proposed area is well connected to the public roads.
ii. Land Form, Land use and Land ownership.	The proposed lease area belongs to Government land (*river and nallahs*). The land form is mostly river bed and non forest land. Moreover there will be no change in land use as the mining will be confined to river bed, which will get replenished naturally in the subsequent monsoon season. Project proponement: Collector of South Goa District,Margao.
iii. Topography (*along with map*)	Topographical map is enclosed
iv. Existing land use pattern (agriculture, non-agriculture, forest, water bodies (*including area under CRZ*), shortest	Sand mining will be done in river bed.

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distances from the periphery of the project to periphery of sanctuary, eco from the HFL industries area, be given.	
v. Existing Infrastructure	No existing infrastructure near the proposed lease area.
vi. Soil classification	Not applicable
vii. Climatic data from secondary sources.	Climatology (Meteorological Data) Source – Mining Plan

i	Average rainfall (Max in mm)	:	3000 mm
ii	Temperature (Max)	:	36 (May-June)
iii	Temperature (Min)	:	23 (January)
iv	Relative Humidity	:	Summer 55 Monsoon 85
V	Wind direction	:	SW to NE (March to September) NW to SE (Winter)

viii. Social Infrastructure available	Proposed area is well connected with link road. Nearest Railway Station is Margao Nearest Airport: Dabolim Airport All the social infrastructural facilities like hospitals, schools, colleges, etc are available in South Goa District.
5. Planning Brief	
i. Planning concept (*type of industries, transportation etc*) Town and Planning / Development authority Classification.	**The total minable reserves from the mine are estimated as 10,000 cubic metre per annum per marked area** Transportation: The sand produced from the mine is transported by trucks.
ii. Population Projection	All the people will be sourced from neighboring villages, thus there will be no increase in population due to the project.
iii. Land use planning (*breakup along with*)	Not applicable.
iv. Assessment of Infrastructure Demand (Physical & Social)	Not applicable
v. Amenities / Facilities	The following facilities/amenities will be extended by the mine management: Direct and indirect employment, of which most will be from nearby villages. Arrangements for safe and healthy working conditions.

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	Provision of drinking water. Conducting medical camps for workers and nearby villagers at regular interval.
6.Proposed Infrastructure	
i. Industrial Area (*Processing Area*)	The proposed project does not involve any processing.
ii. Residential Area (*Non Processing Area*)	All the local persons will be employed, no residential area/housing is proposed.
iii. Green Belt	Necessary care will be taken to conserve Green Belt
iv. Social Infrastructure	Road facility (existing roads will be maintained regularly) Public transport system improvement Direct & Indirect employment opportunity Social awareness camps Increase revenue, sales tax, road tax to State Government Formation of self Help groups(SHGs') for the women in nearby villages.
v. Connectivity (*Traffic and Rail / Metro / Water Ways, etc*)	The proposed area is well connected with link road to South Goa District. Nearest Railway Station is Margao, about 3 kms. from South Goa District Headquarters, Margao. Nearest airport is Dabolim which is about 25 kms.
vi. Drinking Water Management (*Source Water*)	Drinking water shall be made available all the times to the mine workers. This will be sourced by water bottles.
vii. Sewerage System	No sewerage system is proposed
viii. Industrial Waste Management	Not applicable
ix. Solid Waste Management	Not applicable
x. Power Requirement & Supply / Source	No power requirement. All the activities will be carried out by manual method. There is no power requirement for the project as will be done only from sun rise to sun set.

7. Rehabilitation and Resettlement (R&R) Plan	
i. Policy to be adopted (Central/State) in respect of the project affected persons including home oustees, land oustees and landless laborers (*a brief outline to be given*)	It is entirely a Government traverse land, sanctioned the Mine lease to the project proponent. No human settlements are existing in the ML area. The proposed project does not involve any rehabilitation and resettlement.

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8. Project Schedule & Cost Estimates

i. Likely date of start of construction and likely date of completion (*Time schedule for the project to be given*).	No major constructions are required.
ii. Estimated project cost along with analysis in terms of economic viability of the project.	Not applicable

9. Analysis of proposal (*Final Recommendations*)

i. Financial and social benefits with special emphasis on the benefit to the local people including tribal population, if any, in the area.	The Project will bring economical benefits to the State by way of royalty for mineral. The mining operations shall be providing employment to large number of persons directly in the excavation. Most of the local people are likely to be benefited. This project operation will provide livelihood to the poorest section of the society. Mining is expected to have positive impact on socio-economic life of people living in nearby villages. Mining will create awareness amongst the people for education and general upliftment particularly in the women folk.

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Annexure B

PERMITS ISSUED IN SOUTH (2015-16 to 2016-17)			
Sr.No	**Cluster details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	S. P/Macazana/2016/569	Shri Mario Colaco	H.No. 01, Nr St Anthony Church, P.O Curchorem -Goa
2	S.P/Macazana/2016/492	Smt Sonali Mukund Parab	H.No.1461/A, Sonxem, Ullando ,Curtorim, Salcete Goa
3	S.P/Macazana/2016/580	Shri Johny Ivon Colaco	H.No. 1, Simer Panchwadi , Near, St. Anthony Church , Ponda Goa
4	S.P/Macazana/2016/583	Shri Joaquim Santan Luis	H.No. 1150/A, Muxivaddo, Curtorim , Salcete-Goa
5	S.P/Macazana/2016/584	Shri Agostin J Silveira	H.No. 2090, Bag Morrod Shiroda Ponda -Goa
6	S.P/Macazana/585	Shri Rama S Naik	H.No.1947, Barbhat Shiroda Ponda -Goa
7	S.Permit /Macazana/2016/578	Shri Clemente Fernandes	H.No. 464, Cantem , Macazana, Salcete Goa
8	SP/Macazana/2016/479	Shri Jose Menino Vaz	H.No 1162/D, Vetnem Vaddo , Curtorim ,Salcette-Goa
9	SP/Maacazana/2016/590	Shri John FilipeCosta	H. No. 206,Comprant, Panchwadi, Ponda Goa
10	Sand Permit/Macazana/2016/585	Shri Antonio Rodrigues	H.No. 1138, Muxivaddo Curtorim, Salcete Goa
11	Sand Permit/Xelvona/2016/589	Shri Diogo Pereira	H No.85, Nagvado, Betalbatim, Salcete Goa
12	S.P/RIVONA/2016/428	Shri James P Farias	H.No. 109/3, Zambaulim , Rivona, Sanguem Goa
13	S.P/RIVONA/2016/491	Shri Laurente J. Fernandes	H. No. 145/1, Fatimawado, Rivona, Saguem Goa
14	Talaulim/2016/480	Smt Lourenca Pinto	H.No. 1596, Culwaddo, Cuncolim , Salcete-Goa
15	S.Permit /Loutulim/2016/575	Shri Agnelo Luis	H.No. 1163, Vetnem ,Curtorim , Salcete-Goa
16	S.Permit/Collem/2016/568	Smt Cristina Natalia Abreu	H.No. 424, Methwaddo, Collem , Dharbandora ,Goa

SAND PERMITS ISSUED IN MANDOVI RIVER (2015-16 to 2016-17)			
MANDOVI CLUSTER 1			
Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C.I/2015/19	Smt Swati Amrut Volvoikar	H.No. 2/2, P.O Piedade,Vanxim,Tiswadi Goa
2	M.C-1/2016/0357	Shri Dil Bahadur Bogati	H.No. 429-4, Dulapi-Corlim, Ilhas, North Goa
3	M.C-1/2016/0389	Shri Shridhar H Naik	H.No.191,Surchem -Bhatt, Kumbharjua ,Tiswadi-Goa
4	M.C-1/2016/0536	Shri Molali Abdulaji Shaikh	H.No. 151, Ward No. 2, Indira Nagar, Chimbel Goa
5	M.C-1/2016/0577	Shri Nitin R Tari	H.No. 201, Surchem ,Bhatt, Kumbharjua, Tiswadi-Goa
6	M.C-1/2016/0579	Shri Manurai S Dulapkar	H.No. 410, Dhulapi, Corlim , Tiswadi-Goa
7	M.C-1/2016/0581	Shri Bhagwant G Phadte	H.No. 1356, St. Estevam ,Akhada -Goa
8	M.C-1/2016/183	Shri Shamsundar S Chodankar	H.No.682, Rambhuvan Wada, Cumbharjua,Tiswadi Goa
9	M.C-1/2016/223	Shri Shameer Abdul Kadar Tonse	H.No. B-37,St. Pedro,Old -Goa
10	M.C-1/2016/248	Premanand G Naik	H.No 110,Kumbharjua, Gaundalim Tiswadi -Goa
11	M.C-1/2016/249	Smt.Ranjana S Mandrekar	H.No. 392/2, Digi Wada Naroa , Bicholim -Goa
12	M.C-1/2016/336	Shri Mahendra D Gad	H.No.1157,Tonca, St. Estevem, Tiswadi Goa
13	M.C-1/2016/337	Shri Aditya Dushyant Vishwakarma	H.No. 200/7, Plot No. 29, Mollar, Corlim , Tiswadi Goa
14	M.C-1/2016/338	Smt Shama S Sawant	H.No. 1551, Akhada , St Estevam , Tiswadi Goa
15	M.C-1/2016/339	Smt Trupti A Narvekar	H.No. 228, Diggi wada, Naroa, Bicholim Goa
16	M.C-1/2016/340	Shri Ajit V Amonkar	H.No.275, Totem - Wada,Narva,Bicholim Goa
17	M.C-1/2016/341	Deepak Jaiwant Naik	H.No 393/3A ,Banastarim ,Ponda-Goa
18	M.C-1/2016/342	Shri Pranay P Phadte	H.No.1304, Akhada ,St Estevem,Tiswadi-Goa
19	M.C-1/2016/343	Shri Pundalik M Fadte	H.No. 631, Tari Wada ,Marcela, Ponda Goa
20	M.C-1/2016/344	Shri Laximan S Gaonkar	H.No.429, Dhulapi Corlim ,Tiswadi-Goa
21	M.C-1/2016/345	Shri Dattaram V Sawant	H.No. 1254, Akhada, St Estevam , Tiswadi Goa
22	M.C-1/2016/346	Shri Prakash R Tari	H.No. 215/54, Livrament, Sangolda, Bardez-Goa
23	M.C-1/2016/347	Shri Sadanand H Naik	H.No 108(Old) 189(New), Surchem Bhat , Kumbharjua, Tiswadi-Goa
24	M.C-1/2016/348	Shri Swapnil N Fadte	H.No. 181, Tarwada, Pilgao , Bicholim Goa
25	M.C-1/2016/359	Shri ShaIlesh V Chodankar	H.No. D-16, Gaundalim Road, Dhauji - Old-Goa Tiswadi Goa
26	M.C-1/2016/360	Shri Shamba R Madkaikar	H.No. 1315/1, Akhada, St Estevam ,Tiswadi -Goa
27	M.C-1/2016/361	Shri Shivanand B Bhosale	H.No. 38/2, P.O Piedade , Vanxim, Tiswadi Goa
28	M.C-1/2016/362	Supriya Sitaram Tari	H.No.29, Naroa Diwar Tiswadi -Goa
29	M.C-1/2016/363	Shri Tulsidas U Sawant	H.No. 1255,Akhada ,St. Estevam ,Tiswadi -Goa
30	M.C-1/2016/364	Shri Vishwar R Chodankar	H.No.16, P.O Piedade, Juney Tirth ,Naroa, Diwadi Goa

31	M.C-1/2016/365	Shri Vivekanand L Naik	H.No.76/1, Chal Bhat, Se-Old-Goa ,Tiswadi-Goa
32	M.C-1/2016/381	Shri Prashant G Volvoikar	H.No .D-50,Chal Bhat,Dhauji Road,Ella ,Old-Goa
33	M.C-1/2016/382	Shri Pratap D Fadte Gaonkar	H.No.269, Fadte, Wada, Adcona ,Banastarim-Goa
34	M.C-1/2016/383	Shri Prathamesh R. Tari	H.No.856, Rambhuvanwada , Cumbharjua, Tiswadi-Goa
35	M.C-1/2016/385	Shri Sadanand J Chodankar	H.No. 892, Village Jua, Tiswadi -Goa
36	M.C-1/2016/386	Shri Sanjay Tulsidas Bhonusle	H.No. 1302, Akhada St.Estevam ,Tiswadi-Goa
37	M.C-1/2016/387	Shri Santosh A Amonkar	H.No. 271/1, Tote Wada, Naroa , Bicholim-Goa
38	M.C-1/2016/390	Smt Siya S Sawant	H.No. 02, Marmawada Naroa , Bicholim Goa
39	M.C-1/2016/392	Shri Tukaram D Salgaonkar	H.No. 353, Tale Wada, Narva, Bicholim Goa
40	M.C-1/2016/393	Shri Tulshidas L Kavlekar	H.No. P-73, Sao Pedro , Panvelim , Se-Old -Goa, Tiswadi-Goa
41	M.C-1/2016/394	Shri Vallab U Fadte	H.No. 74/A, Halan Wada, Ecoshim , Bardez-Goa
42	M.C-1/2016/395	Shri Yogesh E Sawant	H.No. 340, Hindale Wada, Naroa, Bicholim -Goa
43	M.C-1/2016/396	Shri Anil S Tari	H.No 1303, Akhada, St Estevam ,Tiswadi -Goa
44	M.C-1/2016/397	Shri Chaitanya N Gaude	H.No. 367, St.Mathais , Muddi , Malar, Tiswadi Goa
45	M.C-1/2016/398	Shri Damodar S Naik	H.No.393, Banastarim ,Ponda-Goa
46	M.C-1/2016/401	Shri Dinesh G Parsekar	H.No .305, Desai Wada, Pirna ,Bardez-Goa
47	M.C-1/2016/406	Shri Madhusudan M Narvekar	H.No. 1260, Akhada, St.Estevam, Tiswadi Goa
48	M.C-1/2016/409	Shri Panchanan G Volvoikar	H.No D-50, Chal -Bhat, Dauji Road ,Ella, Old- Goa
49	M.C-1/2016/410	Shri Prasad D Halankar	H.No. 627/B, Tari-Wada, Marcela -Goa
50	M.C-1/2016/412	Shri Rajaram Nanda Tari	H.No. 1100, Tonca St. Estevam Tiswadi-Goa
51	M.C-1/2016/413	Shri Sanjay M Bandodkar	H.No.104, Kaity Bhat, Old Goa
52	M.C-1/2016/415	Smt Seema Rohidas Narvekar	H.No1362, Ahkada,St.Estevam ,Tiswadi Goa
53	M.C-1/2016/429	Shri Nanu M Tari	H.No. 1117, Tonca, St . Estevam , Tiswadi Goa
54	M.C-1/2016/430	Smt Neha N Madkaikar	H.No 1226, Akhada ,St Estevam ,Tiswadi Goa
55	M.C-1/2016/431	Smt Manik T Parab	H.No 974, (Old) ,1146 (New) ,Tonca , St -Estevam ,Tiswadi-Goa
56	M.C-1/2016/433	Shri Nagendra T Phadte	H.No.1309, Akhada, St.Estevam Tiswadi Goa
57	M.C-1/2016/434	Shri Govardhan B Phadte	H.No. 1164, Akhada ,St. Estevem, Tiswadi-Goa

58	M.C-1/2016/435	Shri Tanaya R Mandrekar	H.No. 391, Diggi Wada, Naroa, Bicholim Goa
59	M.C-1/2016/436	Shri Devidas S Phadte	H.No. 336, Golwada, Cumbharjua , Tiswadi Goa
60	M.C-1/2016/437	Shri Dayesh S Mandrekar	H.No 392, Diggi Wada, Naroa, Bicholim Goa
61	M.C-1/2016/438	Shri Gurudas D Parsekar	H.No.218, Gaonkar Wada, Naroa , Bicholim -Goa
62	M.C-1/2016/439	Shri Das D Fadte	H.No. 1334, Akhada ,St.Estevam , Tiswadi Goa
63	M.C-1/2016/440	Uday Rajaram Mandrekar	H.No.380, Diggi Wada, Naroa,Bicholim-Goa
64	M.C-1/2016/441	Shri Shramil S Fadte	H.No. 302, Devlay Khandola,Marcela-Goa
65	M.C-1/2016/442	Smt Rupali U Narvekar	H.No. 228, Tar Wada Naroa, Bicholim -Goa
66	M.C-1/2016/443	Shri Rajendra R Naik	H.No. 891, Surchebhat, Kumbharjua ,Tiswadi-Goa
67	M.C-1/2016/49	Shri Prasad R Bhonsle	H.No. 18, June Tirth , Naroa, Piedade, Tiswadi Goa
68	M.C-1/2016/530	Smt Rupa S Gad	H.No. 1141/1, Tonca, St. Estevam Juve, Tiswadi -Goa
69	M.C-1/2016/531	Vikas D Gad	H.No. 1141, Tonca, St Estevam, Juve, Tiswadi -Goa
70	M.C-1/2016/535	Shri Nur Shaikh	H.No. 429-5, Dulapi -Corlim -Goa
71	M.C-1/2016/558	Shri Rupesh K Naik	H.No. D-51, Dauji Road, Ella, Old Goa
72	M.C-1/2016/62	Shri Gokuldas J Chodankar	H.No. 1149,Tonca, St Estevam, Ilhas-Goa
73	M.C-1/2016/65	Shri Sushen Chandrakant Phadte	H.No.1131/1, Akhada ,St. Estevam Tiswadi-Goa 403106
74	M.C-1/2016/67	Shri Surya P Tari	H.No. 1288, Akhada St Estevam,Tiswadi-Goa
75	M.C-1/2016/68	Shailendra D Phadte	H.No. 1233, Akhada St. Estevam Tiswadi -Goa
76	M.C-1/2016/72	Deeptesh D Sawant	H.No.1273, Akhada, St. Estevam,Tiswadi Goa
77	M.C-1/2016/74	Shri Shrikrishna N. Tari	H.No.1100, Tonca Waddo, St-Estevam Tiswadi-Goa
78	M.C-1/2016/76	Smt Shashikala P Bhonsle	H.No. 38, Piedade , Vanxim , Ilhas Goa
79	M.C-1/2016/81	Shri Damodar G Volvoikar	H.No.49, Dhauji, Ela, Old -Goa
80	M.C-1/2016/85	Shri Sanjay Y Gaonkar	H.No. 105, Zuwarwada, Tivrem Marcela Goa
81	M.C-1/2016/403	Shri Glean Cabral	H. No. 122, Katye Bhat, Ella Old Go
82	M.C-1/2016/407	Shri Mahableshwar S. Tari	H. No. 427, Malawada Cumbharjua Tiswadi - Goa
83	M.C-1/2016/0185	Shri Vivek C. Tari	H.No. 213, Surchem Bhat,KumbharjuaGoa
84	M.C-1/2016/400	Shri Devanand Tari	H No.1258, Akhada St. Estevam, Tiswadi Goa
85	M.C-1/2016/75	Smt Suhasini Venkatesh Dhuri	H. No. 805, Devgim, Chodan, Tiswadi Goa
MANDOVI CLUSTER-II			
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C.II/2015/21	Shri Uday Uttam Sawant	H.No.444, Sawant Wada, Amona,Marcel ,Goa
MANDOVI CLUSTER-3			

Sr.No	Cluster Details	Name of the Permit Holder	Address Of Permit Holder
1	M.C-III/2015/38	Shri Vijesh Ashok Sawant	H.No.375,Sawant Wada,Amona ,Marcela Goa 403107
2	M.C.III/2015/31	Shri Navnath Anant Parab	H.No. 111,Pimpal Wada, Amona,Marcel -Goa 403107
3	M.C.III/2015/32	Shri Rupesh N Fadte	H.No.369, SawantWada,Amona,Marcela -Goa-403107
4	M.C.III/2015/33	Shri Ritesh N Fadte	H.No.369, SawantWada,Amona, Marcela -Goa-403107
5	M.C-3/2016/350	Shri Manoj R Gaonkar	H.No.116,Ganapati - Wada,Khandola,Ponda-Goa
6	M.C-3/2016/351	Shri Shriram M Phadte	H.No.619, Tari-Wada,Marcela ,Ponda Goa
7	M.C-3/2016/353	Shri Tulshidas G Gaonkar	H.No.276, Ganapati -Wada-Khandola,Marcela-Ponda-Goa
8	M.C-3/2016/354	Shri Jeevan R Parab	H.No.391, Kurduwada, Khandola,Ponda-Goa
9	M.C-3/2016/355	Shri Sagar D Haldankar	H.No. 109,HoldonWada, Khandola,Ponda-Goa
10	M.C-3/2016/356	Shri Vishwanath V Gaonkar	H.No.260/1, Ganapati Wada, Khandola ,Marcela, Ponda Goa
11	M.C-3/2016/358	Shri Soiru D Naik	H.No.356/3, Zaidwada,Khandola,MarcelaPonda-Goa
12	M.C-3/2016/379	Shri Sanjeet S Chodankar	H.No.370, Jaidwada, Khandola Marcela, Ponda Goa
13	M.C-3/2016/419	Shri Sandeep M Naik	H.No. 278, Nr Bus Stand Volvoi, Ponda -Goa
14	M.C-3/2016/420	Shri Sadanand Shamba Gaude	H.No. 103/2, Bag Wada Khandola,Marcela-Goa
15	M.C-3/2016/421	Shri Prasad P Phadte	H.No 683, Near Mayank Poultry Farm, Gaonkarwada, Betki, Marcela-Goa
16	M.C-3/2016/422	Shri Premanand S Naik	H.No.356/4, Jaidwada, Khandola, Ponda-Goa
17	M.C -3/2016/70	Suryakant B Naik	H.No 369, Jaidwada, ,Khandola ,Marcela,Ponda-Goa

MANDOVI CLUSTER-4			
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C-4/2016/100	Shri Ulhas K Parab	H.No. 428, Pimplawada, Amona ,Bicholim -Goa
2	M.C-4/2016/102	Shri Yeshwant K Sawant	H.No.395/2, Sawantwada, Amona, Bicholim-Goa
3	M.C-4/2016/105	Shri Gajanan N Naik	H.No. 153, Karekhazan ,Virdi Sanquelim Goa
4	M.C-4/2016/116	Shamkant J Mhato	H.No 477, Ghadiwada Amona ,Bicholim Goa
5	M.C-4/2016/145	Shri Bombdo S Parab	H.No.149/1, Pimpal Wada, Amona, Bicholim -Goa
6	M.C-4/2016/146	Shri Shrikant A Parab	H.No. 114/B, Pimmpalwada, Amona Bicholim -Goa
7	M.C-4/2016/147	Shri Manoj M Parab	H.No. 110, Pimpalwada, Amona Bicholim -Goa
8	M.C-4/2016/148	Shri Anant V Gawas	H.No. 76, Ambeshi Wada, Amona Goa
9	M.C-4/2016/149	Shri Sunil Srikant Gawas	H.No. 29/B, Amona ,Marcela-Goa
10	M.C-4/2016/150	Umesh K Gawas	H.No.133, Pimpalwada Amona-Goa
11	M.C-4/2016/154	Shri Jagannath Tato Sinari	H.No. 463, Kalam-Wada, Amona ,Bicholim-Goa
12	M.C-4/2016/155	Shri Rupesh R Kamat	H.No.2009,Karekhazan ,Virdi ,Sanquelim-Goa
13	M.C-4/2016/156	Shri Ramesh Shablo Parab	H.No.149/1, Kalam -Wada, Amona, Bicholim -Goa
14	M.C-4/2016/157	Shri Prajyot M Sinari	H.No. 435, Kalam ,-Wada ,Amona ,Bicholim -Goa
15	M.C-4/2016/158	Prakash Bhikaro Tari	H.No 574 , Timsawada Amona Bicholim -Goa
16	M.C-4/2016/160	Mrs Manjusha A Gawas	H.No 48, Ambeshiwada , Amona, Bicholim -Goa
17	M.C-4/2016/162	Anuradha A Sinari	H.No.143/1,Pimpalwada,Amona - Bicholim Goa
18	M.C-4/2016/163	Shri Narayan R Sinari	H.No.556, Kalam -Wada,Amona, Bicholim -Goa
19	MC-4/2016/164	Sapana S Naik	H.No 658, Virdi, Kharekhajan Wada ,Sanquelim -Goa
20	M.C-4/2016/167	Shri Mahesh V Sawant	H.No 395/1, Sawant -Wada, Amona ,Bicholim -Goa
21	M.C-4/2016/170	Shri Dattaram A Avkhale	H.No. 571, Karekhajan Virdi, Sankhali Goa
22	M.C-4/2016/171	Shri Somnath K Sinari	H.No. 580, Pimpalwada, Amona, Bicholim Goa
23	M.C-4/2016/172	Shri Arjun V Dhavaskar	H.No. 2106, Karekhazan , Virdi ,Sanquelim -Goa
24	M.C-4/2016/173	Ashok J Parab	H.No 492, ,Virdi , ParabwadaSanquelim -Goa
25	M.C-4/2016/184	Shri Krishna M Gawas	H.No.421, Ambeshi -Wada, Amona Bicholim -Goa
26	M.C-4/2016/186	Shri Mukund V Gawas	H.No.66/2, Ambeshi Wada, Amona, Bicholim -Goa
27	M.C-4/2016/188	Shri Anand N Fadte	H.No.1378, Karekhajan Virdi -Sankhali , Bicholim -Goa
28	M.C-4/2016/190	Shri Bhanudas V Parab	H.No.82/2, Ambeshiwada, Amona,Bicholim-Goa
29	M.C-4/2016/192	Dasharath Prabhakar Jalmi	H.No 1542,Virdi Gaonkarwada,Sanquelim Goa
30	M.C-4/2016/195	Shri Dayanand C Mhato	H.No.306/2, Bandorwada,Amona,Marcela -Goa
31	M.C-4/2016/196	Deepak Y Avkhale	H.No 572, Virdi Karekhajan Wada, Sanquelim Bicholim Goa

32	M.C-4/2016/197	Shri Devanand D Sawant	H.No.367, Sawant Wada,Amona,Marcela-Goa
33	M.C-4/2016/198	Shri Dinesh J Kamat	H.No.2429,Dhat Wada,Virdi,Sanquelim -Goa
34	M.C-4/2016/199	Dnyaneshwar S Kamat	H.NO .H.NO 957, Gaonkarwada, Virdi ,Sanquelim ,Bicholim -Goa
35	M.C-4/2016/200	Dinesh A Gawas	H.No.172, Kalam Wada Amona Bicholim Goa
36	M.C-4/2016/226	Shri Sunil Subhash Sinari	H.No 163/A, Kalam Wada, Amona Bicholim Goa
37	M.C-4/2016/227	Shri Nilgo H Gawas	H.No. 28, Ambeshiwada, Amona, Bicholim Goa
38	M.C-4/2016/228	Shri Suryakant N Naik	H.No 1565, Karekhajan ,Virdi ,Sanquelim -Goa
39	M.C-4/2016/230	Maddu D Tari	H.No. 360, Sawant Wada, Amona,Bicholim Goa
40	M.C-4/2016/232	Shri Mahadev V Fadte	H.No. 223, Fadte Wada, Amona, PO-Marcela, Bicholim -Goa
41	M.C-4/2016/234	Shri Ramnath S Tari	H.No.355, Sawant Wada, Amona, Bicholim-Goa
42	M.C-4/2016/235	Prasad A Avkhale	H.No.572,Karekhajan Wada ,Virdi,Sanquelim-Goa
43	M.C-4/2016/236	Rupesh S Naik	H.No.290,Bhandarwada,Amona, Marcela -Goa
44	M.C-4/2016/237	Shri Sameer H Amonkar	H.No. 337/2, Sawant Wada, Amona, Bicholim -Goa
45	M.C-4/2016/240	Shri Sanjay C Parab	H.No. 1266, Parab Wada, Virdi, Sankhali -Goa
46	M.C-4/2016/241	Smt Sarla S Sinari	H.No.127, Pimple Wada, Amona ,Bicholim Goa
47	M.C-4/2016/242	Mrs. Sonali S Sawant	H.No. 543, Sawantwada, Amona Marcela -Goa
48	M.C-4/2016/243	Shri Sonu Sagun Gawas	H.No. 67/1 B, Ambeshi Wada , Amona, Bicholim -Goa
49	M.C-4/2016/244	Shri Suryakant V Sinari	H.No. 528, Kalam Wada, Amona ,Bicholim Goa
50	M.C-4/2016/245	Ramita R Sawant Amonkar	H.No.185, Betalwada,Amona Bicholim -Goa
51	M.C-4/2016/246	Shri Sushant M Volvoikar	H.No.1155, Akhada, St. Estevam, Tiswadi Goa
52	M.C-4/2016/247	Shri Raoji S Avkhale	H.No.573, Karekhajan ,Virdi-Sanquelim ,Bicholim -Goa
53	M.C-4/2016/251	Kum Shilpa M Naik	H.No. 225, Surchem Bhat , Kumbharjua-Goa
54	M.C-4/2016/337	Shri Khemlo S Sawant	H.No. 181/1, Betal Wada, Amona, Bicholim Goa
55	M.C-4/2016/416	Shri Vasudev R Sinari	H.No.175, Kalam Wada, Amona Bicholim Goa
56	M.C-4/2016/417	Shri Viren M Dhawaskar	H.No.563, Virdi, Karekhazan ,Sanquelim -Goa
57	M.C-4/2016/418	Jaiwant A Parab	H.No.114-A,Pimpal -Wada,Amona Marcela -Goa
58	M.C-4/2016/425	Shri Pradeep G Kamat	H.No.1592, Gaonkarwada, Virdi ,Bicholim Goa
59	M.C-4/2016/43	Shri Sachin Devidas Naik	H.No.449, Bhandar Wada, Amona P.O Marcela-Goa
60	M.C-4/2016/457	Shri Sushant L Kamat	H.No. 568, Karekhajan , Virdi Sankhali Bicholim Goa
61	M.C-4/2016/458	Smt Siya S Gauns	H.No. 69, Ambeshiwada, Amona, Bicholim -Goa
62	M.C-4/2016/465	Shri Prakash B Kolambkar	H.No. 308, karapur Tisk , Sankhali , Bicholim Goa
63	M.C-4/2016/469	Shri Sonu M Ghadi	H.No. 61/A, Manmolemwada, Betqui, P.O Marcela, Ponda -Goa
64	M.C-4/2016/58	Shri Ramesh U Akhadkar	H.No.1155, Akhada , St. Estevam, Tiswadi -Goa

65	M.C-4/2016/64	Shri Surendra M Tari Volvoikar	H.No.1194, Akhada , St Estevam,Tiswadi-Goa
66	M.C-4/2016/231	Shri Mahadev C. Kamat	H.No 1495, Gaonkarwada ,Virdi, Sankhali-Goa
67	SP/M.C.4/2016/193	Shri Datta Narayan Ghadi	H. No. 590, Timsawada, Amona BicholIM Goa
68	M.C.4/2016/191	Shri Chidambar Pandurang Naik	Virdi, Kharakhajan vada, SanquelimGoa
MANDOVI CLUSTER-5			
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C.V/2015/39	Shri Bhikaro V Naik	H.No.516,Near Gram Panchayat Adpoi , Ponda-Goa
2	M.C-5/2016/349	Shri Vishwanath V Naik	H.No. 516, Adpoi, Ponda Goa
3	M.C-5/2016/352	Shri Shriram S Shetye	H.No.603,Savoi-Verem-Ponda-Goa
4	M.C-5/2016/423	Smt Shaila K Velkaskar	H.No.218, Velkas,SavoiVerem,Ponda-Goa
5	M.C-5/2016/424	Satish Madhukar Naik	H.No172, ,Kulkerni -Wada ,Betki Marcela,Ponda Goa
6	M.C-5/2016/445	Shri Laxman Nagesh Naik Gaonkar	H.No. 273, Ganapatiwada, Candola , Marcela -Goa
7	M.C-5/2016/446	Shri Prakash P.N Amonkar	H.No. B-91,Gharkul Co-Op HSG Society Bainguinim ,Old Goa
8	M.C-5/2016/447	Shri Mohan S Naik	H.No.311, Devlay ,Khandola,Marcela-Goa
9	M.C-5/2016/448	Shri Gonsalo J Menezes	H.No 329, Golwada, Cumbharjua, Tiswadi Goa
10	M.C-5/2016/449	Shri Deepak D Gaunekar	H.No 626,Ghano-Savoi ,Verem Ponda Goa
11	M.C-5/2016/450	Shri Arvind R Gaonkar	H.No. 145/1, Gaonkarwada, Khandola,Marcela,Ponda-Goa
12	M.C-5/2016/454	Smt Shanti S Parab	H.No 663/3, Tari Wada ,Marcela Ponda Goa
13	M.C-5/2016/455	Smt Sheela S Wadkar	H.No. 219/2, Wadiwada, Betki, Khandola, Ponda-Goa
14	M.C-5/2016/456	Shri Tukaram P Ghadi	H.No.56/3, Manmollem,Betqui, Ponda Goa
15	M.C-5/2016/533	Shri Nilkanth R Sawant	H.No 810, ChristianWada, Near Church Marcela Ponda Goa
16	M.C-5/2016/72	Shri Deepak Surya Sawant	H.No 402, Tari Wada, Marcela -Goa
17	M.C-5/2016/86	Shri Vaman V Naik	H.No. 402/A, Talaulim , Ponda -Goa
MANDOVI CLUSTER-VI			
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C.VI/2015/01	Shri Prashant Namdev Joshi	H.No. 928, Khadapwada, Kumbharjua, Tiswadi Goa
2	M.C.VI/2015/04	Shri Gangaram Matkar	H.No . 25/3, Gadachawada ,Keri , Pernem Goa
MANDOVI CLUSTER-7			
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C-7/2016/79	Shri Ajay M Sawant	H.No. 1, Nr Satyanarayan Temple, Metwada, Volvoi, Ponda Goa
MANDOVI CLUSTER-8			
Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	M.C.VIII/2015/37	Shri Vishal Vishnu Shet	H.No. 4/A,Met Wada, Volvoi,Ponda Goa
2	M.C-8/2016/168	Shri Jayesh Gurudas Tari	H.No. 46, Rumad ,Surla,Bicholim-Goa

3	M.C-8/2016/174	Shri Vinayak V Shet	H.No.4/A, Meta Wada,Volvoi, Post Savio -Verem,Ponda Goa
4	M.C-8/2016/175	Shri Vinayak A Vengurlekar	H.No.119, Deulwada,Volvoi,Ponda - Goa
5	M.C-8/2016/176	Shri Sudesh A Naik	H.No. 528, Shilwada, Savoi-Verem, Ponda Goa
6	M.C-8/2016/178	Shri Rajendra V Naik	H.No. 436, Bidruk, Savoi-Verem,Ponda-Goa
7	M.C-8/2016/179	Shri Vilson Dias	H.No. 554, Sonar Bag, Usgao,Ponda - Goa
8	M.C-8/2016/181	Shri Priyank S Volvoiker	H.No.119, Deulwada ,Volvoi,Ponda - Goa
9	M.C-8/2016/182	Shri Pratish Namdev Naik	H.No 69/A, Bhamai Pali,Bicholim-Goa
10	M.C-8/2016/271	Shri Dinesh N. Bhonsle	H.No. 91/B, Volvoi, Ponda Goa
11	M.C-8/2016/272	Shri Dattaram T Naik	H.No. 36/A, Met Wada , Volvoi, Ponda Goa
12	M.C-8/2016/273	Shri Dattaram S Navelkar	H.No 338, Madhala Wada, Maina ,Navelim -Goa
13	M.C-8/2016/274	Shri Datta S Volvoikar	H.No. 38 B, Rumad Wada, Pale,Bicholim -Goa
14	M.C-8/2016/275	Shri Datta M Sawant	H.No.24, Rumad Wada, Pale, Bicholim Goa
15	M.C-8/2016/276	Shir Benjamin E Rodrigues	H.No. 497, Sonarbag, Usgao,Ponda-Goa
16	M.C-8/2016/277	Shri Balkrishna R S Savoikar	H.No.634, ,Ghano, Savoi-Verem ,Ponda -Goa
17	M.C-8/2016/278	Shri Digambar A Naik	H.No.346, Madhlawada, Maina Navelim ,Bicholim-Goa
18	M.C-8/2016/279	Shri Anant V Tari	H.No. 307, Metwada, Volvoi, Savoi-Verem,Ponda Goa
19	M.C-8/2016/280	Shri Girish Narayan Naik	H.No.374, Fonchebhat,Volvoi,Savoi Verem,Ponda Goa
20	M.C-8/2016/281	Shri Babu B Gaude	H.No.606/At Savoi,Savoi-Verem ,Ponda Goa
21	M.C-8/2016/282	Shri Anil M Naik	H.No.233, Fonchebhat ,Volvoi,Savoi-Verem,Ponda -Goa
22	M.C-8/2016/283	Amit R Tari	H.No 115, DeulWada ,Volvoi, Ponda-Goa
23	M.C-8/2016/40	Shri Jeevan S Phadte	H.No. 31, Metwada, Volvoi, Ponda Goa
24	M.C-8/2016/42	Shri Dayanand G Phadte	H.No.4, Ximitim ,Bandora ,Ponda-Goa
25	M.C-8/2016/451	Shri Krishna V Shet	H.No. 4-A, Metwada, Volvoi, Ponda - Goa
26	M.C-8/2016/452	Shri Govind G Gaunekar	H.No. 639, Ghano , Savoi-Verem , Ponda -Goa
27	M.C-8/2016/453	Shri Gopal R Shet Narvekar	H.No. 06, Vagurme ,Savoi -Verem ,Ponda Goa
28	M.C-8/2016/460	Shri Prathamesh M Tari	H.No. 30, Rumodwada, Surla,Bicholim-Goa
29	M.C-8/2016/461	Shri Ramkrishna Vasant Fadte	H.No.108, Deulwada,Volvoi , P.O Savoi Verem,Ponda-Goa
30	M.C-8/2016/462	Shri Ramdas B Kolwalkar	H.No. C-7,IIIrd Floor,Taj Co-Operative Housing Society Ltd, Marcel -Goa
31	M.C-8/2016/463	Shri Rajesh S Gaonkar	H.No. 57-C,Halli Wada, Volvoi, Ponda Goa
32	M.C-8/2016/464	Shri Prasad S Sawant	H.No 51, Rumadwada,Surla,Pale,Bicholim -Goa
33	M.C-8/2016/466	Shri Narcinha G Naik	H.No. 262/1-A, Fonchebhat ,Volvoi , Ponda -Goa
34	M.C-8/2016/467	Shri Mukund Vithal Tari	H.No 129, Deulwada,Volvoi,Ponda-Goa
35	M.C-8/2016/468	Shri Mahesh V Tari	H.No 107, Deulwada,Volvoi,Ponda-Goa

36	M.C-8/2016/470	Shri Somanath N Bhonsle	H.No. 91, Deul wada ,Volvoi, Ponda - Goa
37	M.C-8/2016/471	Shri Shashikant S Gaude E Jalmi	H.No.08, Murdi , Khandepar, Ponda - Goa
38	M.C-8/2016/472	Shri Sharadkumar Piso Sawant	H.No 375, Metwada , Volvoi , Ponda Goa
39	M.C-8/2016/473	Shri Shankar B Naik	H.No.59, Nanus ,Usgao, Ponda Goa
40	M.C-8/2016/474	Shri Shamba B Prabhu	H.No. 38, Gaonkar Wada, Vagurme ,Savoi -Verem,Ponda-Goa
41	M.C-8/2016/475	Shri Shailesh M Phadte	H.No. 292, Near Bus Stand , Volvoi , Ponda -Goa
42	M.C-8/2016/476	Shri Santosh Ganesh Volvoikar	H.No.25,Rumad-Pali,Surla,Bicholim Goa
43	M.C-8/2016/477	Shri Sahil D Sawant	H.No 1, Metwada, Volvoi , Ponda Goa
44	M.C-8/2016/478	Shri Sadanand B Bhosale	H.No. 404, Bayem -Surla, Sankhalim , Bicholim -Goa
45	M.C-8/2016/582	Shri Mahesh B Naik	H.No. 209, Gauthan, Khandepar , Ponda -Goa
46	M.C-8/2016/90	Janardhan M. Shet	H.No. 9-B/Metwada, Volvoi, Ponda - Goa
47	M.C-8/2016/91	Shri Dattaram M Shet	H.No. 9/B, Metwada, Volvoi ,Ponda - Goa
48	M.C-8/2016/41	Milan B Shet	H.No 26,Metwada, Volvoi,Savoi Verem Ponda -Goa
49	M.C -8/2016/180	Shri Khemraj C Naik	H.No.213,Fonchebhat, Volvoi, Ponda-Goa

SAND PERMITS ISSUED IN CHAPORA RIVER (2015-16 to 2016-17)			
CHAPORA CLUSTER 1			
Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	C.C-1/2016/120	Shri Uday G Naik	H.No 325, Poracha Wada, Camurlim , Bardez-Goa
2	C.C-1/2016/121	Shri Vinayak D. Volvoikar	H.No.197, Bharwan Wado, Camurlim ,Bardez-Goa
3	C.C-1/2016/122	Shri Vivek Vaman Bhosle	H.No 253,Poreshwar Wada, Camurlim, Bardez -Goa
4	C.C-1/2016/123	Shri Vivekanand Kumar M Khorjuvenkar	H.No 239,Molli Wada , Camurlim ,Bardez-Goa
5	C.C-1/2016/125	Shri Janardan V Khorjuvekar	H.No.325, Porcha Wado, Camurlim ,Bardez -Goa
6	C.C-1/2016/126	Shri Steven M Lobo	H.No.229, Molli Wado, Camurlim, Bardez-Goa
7	C.C-1/2016/127	Smt Suraksha S Volvoikar	H.No. 237, Molli Wada, Camurlim , Bardez-Goa
8	C.C-1/2016/132	Shri Tarkeshwar P Bhosle	H.No. 262, Poracha Wado, Camurlim ,Bardez-Goa
9	C.C-1/2016/306	Shri Anand R Khorjuvekar	H.No.240,Molli, Wada, Camurlim,Bardez-Goa
10	C.C-1/2016/307	Shri Avinash M Halankar	H.No.569,Bharwanwada ,Camurlim Bardez-Goa
11	C.C-1/2016/309	Shri Eknath A Khorjuvekar	H.No. 261, Tarwada , Melwado, Camurlim , Bardez-Goa
12	C.C-1/2016/310	Shri Gopaldas Anant Arlekar	H.No. 149, Naner Wado, Camurlim Bardez Goa
13	C.C-1/2016/312	Shri Gurudas B Khorjuvenkar	H.No.147, Poracha Wado, Camurlim - Bardez-Goa
14	C.C-1/2016/314	Shri Kalidas K Khorjuvekar	H.No. 95, Bharwan Wado, Camurlim , Bardez-Goa
15	C.C-1/2016/315	Smt Likhita L Volvoikar	H.No.235, Molli, Wado, Camurlim ,Bardez-Goa
16	C.C-1/2016/316	Shri Loknath A. Khorjuvekar	H.No. 261, Poracha Wado, Camurlim , Bardez-Goa
17	C.C-1/2016/317	Shri Mangaldas A Khorjuvekar	H.No. 259, Poracha Wado, Camurlim , Bardez-Goa
18	C.C-1/2016/318	Shri Manik M Halankar	H.No.569, Bharwan Wado, Camurlim ,Bardez-Goa
19	C.C-1/2016/319	Smt Medha Machindranath Bhosle	H.No.261, Poracha Wado, Camurlim Bardez -Goa
20	C.C-1/2016/320	Shri Nabesh N Khorjuvenkar	H.No. 259, Porcha Wado, Camurlim, Bardez-Goa
21	C.C-1/2016/322	Shri Navnath R Bhosle	H.No.240, Moli Wada, Camurlim , Bardez-Goa
22	C.C-1/2016/323	Shri Prathamesh N Naik	H.No. 285, Darbar Wada, Camurlim,Bardez -Goa
23	C.C-1/2016/325	Shri Rohit P Khorjuvenkar	H.No.258/A, Poracha Wado, Camurlim, Bardez-Goa
24	C.C-1/2016/326	Shri Satish L Bhosle	H.No.264, Poracha Wado, Camurlim ,Bardez-Goa
25	C.C-1/2016/327	Shri Shankar N Khorjuvenkar	H.No. 333,Molli Wada, Camurlim , Bardez -Goa
26	C.C-1/2016/328	Shyamsunder K Khorjuvenkar	H.No 241, Poreshwar Wada, Camurlim Bardez-Goa

27	C.C-1/2016/329	Smt Sunita G Volvoikar	H.No. 266/1, Poracha Wado, Camurlim , Bardez Goa
28	C.C-1/2016/331	Shri Suresh K. Khorjuvenkar	H.No 95,Bharwan Wada ,Camurlim,Bardez-Goa
29	C.C-1/2016/332	Shri Sushant P Volvoikar	H.No 237/A, Molli Wado,Camurlim ,Bardez-Goa
30	C.C-1/2016/333	Shri Suryakant G Dhargalkar	H.No 503,Vaidongar, Parsem, Pernem-Goa
31	C.C-1/2016/334	Smt Suvarna T Khorjuvekar	H.No. 241, Poryacha Wada , Camurlim , Bardez-Goa
32	C.C-1/2016/481	Shri Rama Y Halankar	H.No. 123/A, Bharvanwada, Camurlim Bardez-Goa
33	C.C-1/2016/574	Shri Sudhakar Y Halankar	H.No. 123, Bharwan Wado, Camurlim , Bardez-Goa
34	C.C-1/2016/324	Shri Rajesh N. Chari	H. No. 337/A, Mulloi waddo, Camurlim, Bardez Goa.
35	C.C-1/2016/321	Smt Vimal Mahableshwar Khorjuvekar	H. No. 248(A), Poracha wado, Camurlim Bardez Goa

CHAPORA CLUSTER-2

Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	C.C.II/2015/05	Shri Kedar Raghunath Dhavjekar	H.No.114/6, Tarwada, Colvale, Bardez-Goa
2	C.C.II/2015/08	Shri Prakash Fakirappa Pujari	H.No. 301, Khajanwada, Colvale Bardez-Goa
3	C.C.II/2015/12	Shri Dharma C Chodankar	H.No.113, Manshiwada, Revora, Bardez-Goa
4	C.C.II/2015/13	Shri Satish Vishnu Chodankar	H.No.273/39, Ramnagar Colvale , Bardez-Goa
5	C.C.II/2015/14	Shri Sharad Harmalkar	H.No. 163/01, Karkecho Vall, Revora Bardez-Goa
6	C.C.II/2015/15	Shri Sagar Rohidas Khorjuvekar	H.No. 340, Tar Wada, Colvale ,Bardez-Goa
7	C.C.II/2015/16	Shri Yeshwant S Chodankar	H.No.359, Tar Wada , Colvale ,Bardez-Goa
8	C.C.II/2015/17	Shri Prakash Vithal Naik	H.No. 375, "Bhavani Niwas" Tar Wada , Colvale, Bardez-Goa
9	C.C.II/2015/18	Shri Babani Maddu Salgaonkar	H.No 112, Tar Wada, Colvale ,Bardez Goa
10	C.C.II/2015/25	Shri Girish Govind Alornekar	H.No. 710/40, Chon Wada, Dhargal, Pernem-Goa
11	C.C.II/2015/36	Shri Purushotam D Kauthankar	H.No.194, Revora,Manshi Wada, Bardez-Goa
12	C.C-2/2016/103	Shri Anand B Halarnkar	H.No.308/6,Tarwada,Colvale ,Bardez - Goa
13	C.C-2/2016/135	Shri Kamu G Halarnkar	H.No.286/1, Tar Wadda, Colvale,Bardez-Goa
14	C.C-2/2016/136	Shri Peter A Dsouza	H.No.313 Tar Wadda, Colvale , Bardez Goa
15	C.C-2/2016/138	Shri Prashant V Mandrekar	H.No. 188, Kundoi , Revora , Bardez-Goa
16	C.C-2/2016/139	Shri Premanand R Korgaonkar	H.No. 233, Zilla Bhat, Revora , Bardez-Goa
17	C.C-2/2016/140	Shri Rama N Sadekar	H.No .125/B ,Khajin Waddo, Colvale, Bardez-Goa

18	C.C-2/2016/141	Shri Rohidas D Halarnkar	H.No.342, Tarwado Colvale , Bardez-Goa
19	C.C-2/2016/142	Kum Roshan R Bhosle	H.No. 122/6, Khazin Wadda, Colvale , Bardez-Goa
20	C.C-2/2016/203	Sadanand T Bagkar	H.No 129, Hali Wada , Revora Bardez - Goa
21	C.C-2/2016/205	Shri Shrikant Govind Alornekar	H.No. 350, Colvale , Bardez-Goa
22	C.C-2/2016/206	Smt Suchita Ulhas Mandrekar	H.No. 181/E, Kundai Waddo,Revora, Bardez-Goa
23	C.C-2/2016/208	Shri Suryakant N Khorjuvekar	H.No. 156/6, Tar Wada, Colvale , Bardez-Goa
24	C.C-2/2016/209	Smt Usha J Naik	H.No.451, Tar Wada, Colvale, Bardez-Goa
25	C.C-2/2016/217	Shri Jayeshwar R Budgo	H.No.587, Camurlim, Darbar Wada, Bardez-Goa
26	C.C-2/2016/47	Shri Subhash G Alornekar	H.No. 350, Colvale, Bardez-Goa
27	C.C-2/2016/77	Shri Gajanand D Naik	H.No. 451,Tarwada,Colvale,Bardez-Goa
28	CC-2/2016/133	Shri Dashrath Y. Halarnekar	H. No. 123/6, Khajin Waddo, Colvale, Bardez Goa
29	CC-2/2016/129	Shri Baburao P. Sawant	Rambhuwan Wadda, Colvale, Bardez Goa
30	CC-2/2015/10	Shri Tukaram Pednekar	H. No. 59/5, Tarchegalu, Bardez Goa
CHAPORA CLUSTER 3			
Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	C.C-3/2016/130	Shri Sudesh Datta Chodankar	H.No. 239,Tankvado , Revora, Bardez-Goa
2	C.C-3/2016/131	Shri Naresh D Desai	H.No. 184, Nadora Wadi, Nadora Bardez-Goa
3	C.C-3/2016/201	Shri Carmino D souza	H.No. 47, Codxel ,Nadora ,Bardez -Goa
4	C.C-3/2016/202	Shri Anant P Naik Salgaonkar	H.No. 300,Wadi Waddo, Nadora,Bardez-Goa
5	C.C-3/2016/211	Shri Uday N Parab	H.No. 357, At Revora Tank , Post Colvale, Bardez-Goa
6	C.C-3/2016/213	Shri Kishor S Gaonkar	H.No. 370, Revora-Tank, Revora, Bardez-Goa
7	C.C.-3/2016/214	Shri Sadashiv A Chodankar	H.No. 376/A, Revora, Tank, Revora, Bardez-Goa
8	C.C-3/2016/219	Shri Pundalik C Gawas	H.No.221, Nadora -Waddi , Nadora , Bardez-Goa
9	C.C-3/2016/221	Shri Kamlakar Laximan Gawas	H.No. 137/A, Gawant Waddo, Nadora, Bardez-Goa
10	C.C-3/2016/252	Anthony C Noronha	H.No. 136, Nadora ,Bardez-Goa 403513
11	C.C-3/2016/222	Shri Devesh M. Naik Redkar	H. No. 73, Madant, Nadora, Bardez Goa
12	C.C-3/2016/220	Shri Pramod T. Bagkar	H. No.129, Revora, Manshiwaddo, Bardez Goa
CHAPORA CLUSTER-4			
Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**

1	C.C.IV/2015/06	Shri Dharma Laxman Kubal	H.No.325, Sangavwada, Ozari , Pernem Goa
2	C.C.IV/2015/07	Shri Chandrakant R Gawande	H.No.69, Thorli Chandai , Pirna Bardez-Goa
3	C.C.IV/2015/09	Shri Sushant D Chodankar	H.No.339,Revora Tank, Bardez-Goa
4	C.C.IV/2015/11	Shri. Pundalik M. Chodankar	H.No.375, Tankwada, Revora, Bardez-Goa
5	C.C.IV/2015/20	Shri Narliso M Lobo	H.No. 173/B, Modlo Wada, Pirna,Bardez-Goa
6	C.C.IV/2015/26	Smt. Sanjana Sunil Naik	H.No. 110(2) , Madla Wada, Mencurem Colvale ,Bardez-Goa
7	C.C.IV/2015/30	Shri Mahadev Gaonkar	H.No. 348, Revora Tank, Bardez -Goa
8	C.C-4./2016/255	Shri Dinesh V Mayekar	H.No 283, Kashimbhat ,Ozarim,Pernem - Goa
9	C.C-4./2016/259	Shri Sakharam N Pandit	H.No.51, Moryawada,Talarna,Pernem-Goa
10	C.C-4./2016/261	Shri Satyawan Vasu Gad	H.No. 65, Khalcha Wada, Mencurem , Bicholim -Goa
11	C.C-4./2016/263	Smt Sneha S Mishal	H.No. 50/1, Khalcha Wada, Mencurem,Bicholim -Goa
12	C.C-4./2016/89	Shri Chatur M Sawant	H.No. 80, Thorli ,Chandai ,Pirna ,Bardez Goa
13	C.C-4/2016/117	Shri Prakash K Chodankar	H.No.28/A, Dhakh Chandai, Pirna,Bardez-Goa
14	C.C-4/2016/254	Shri Digambar G Naik	H.No. 312, Sangavwada, Ozarim, Pernem Goa
15	C.C-4/2016/256	Smt Mahima M Lamgaonkar	H.No. 111, Madhala Wada, Mencurem , Bicholim -Goa
16	C.C-4/2016/258	Shri Ravindra A Kubal	H.No.327, Sangavwada, Ozarim,Pernem-Goa
17	C.C-4/2016/264	Shri Sudam J Parab	H.No 160, Ozarim ,Kasim Bhat ,Pernem - Goa
18	C.C-4/2016/265	Shri Suresh P Desai	H.No.181,DesaiWada, Pirna ,Bardez-Goa
19	C.C-4/2016/266	Shri Ulhas B Satardekar	H.No. 203, Talap Vaddo, Pirna, Bardez-Goa
20	C.C-4/2016/288	Kum Arti A Halarnkar	H.No.31, Throli ,Chandai ,Pirna ,Bardez-Goa
21	C.C-4/2016/46	Shri Gopal Keshav Naik	H.No. 63, Mankurem, Bicholim -Goa
22	C.C-4/2016/51	Shri Nilesh D Kubal	H.No.329,Sangavwada,Ozarim ,Pernem-Goa
23	C.C-4/2016/54	Shri Gajanan N Naik	H.No. 153, Karekhazan ,Virdi Sanquelim Goa
24	C.C-4/2016/57	Shri Fati Rohidas Revodkar	H.No. 67, Thorli Chandai Pirna ,Bardez-Goa
25	C.C-4/2016/59	Shri Ravindranath B Naik	H.No. 12(2), Khalchawada, Menkure, Bicholim-Goa
26	C.C-4/2016/88	Shri Vishnu D Parab	H.No.165, Kashimbhat, Ozarim ,Pernem-Goa
27	C.C-4/2016/96	Shri Jitendra R Parab	H.No.155/3(A), Kashimbhat Ozari,Pernem -Goa
28	C.C-4/2016/98	Shri Sanjay T Parab	H.No. 151,Kashimbhat Wada, Ozarim ,Pernem-Goa
29	C.C -4/2016/286	Shri Shailesh Yeshwant Desai	H.No 294, Desai Waddo Pirna Bardez-Goa
30	CC-4/2016/270	Shri Krishna V. Chodankar	H. No. 100, Talap Vaddo, Pirna,Bardez Goa

31	CC-4/2016/284	Shri Surendra R. Halarnkar	H. No. 31, Thorli Chandai Pirna Bardez Goa
32	CC-4/2016/285	Shri Shekhar P. Dessai	H. No. 181, Talapwada, Pirna Bardez Goa

SAND PERMITS ISSUED IN TEREKHOL RIVER (2015-16 to 2016-17)			
TERECOL CLUSTER -1			
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	T.C-1/2016/368	Shri Albert Fernandes	H.No 401/C , Porascadem , Pernem -Goa
2	T.C-1/2016/374	Shri Samil N Bhatlekar	H.No.359, Bhalkhajan Korgao , Pernem -Goa
3	T.C-1/2016/377	Shri Vikas V Gawade	H.No.355, Bhalkhajan ,Korgao,Pernem-Goa
4	T.C-1/2016/532	Shri Rupesh D Gawade	H.No. 326 ' B ', Bhalkhajan , Korgao , Pernem-Goa
5	T.C-1/2016/93	Shri Inas F Dias	H.No. 103, Devsu, Korgao, Pernem-Goa
6	T.C.1/2016/587	Smt Pallavi V. Gawade	H No. 360. Bhalkhajan Korgao Pernem - Goa
7	T.C.1/2016/586	Shri Abhay E. Gawade	H. No. 58, Bhalkhajan Korgao, Pernem-Goa
8	T.C.1/2016/591	Smt Swarupa Santosh Gawade	H. No. 336/B, Bhalkhajan, Korgao, Pernem Goa.
TERECOL CLUSTER-2			
Sr. No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	T.C.II/2015/23	Shri Jaidev D Arolkar	H.No. 607, Tuem Pernem Goa
2	T.C.II/2015/27	Shri Ramesh Shridhar Tari	H.No. 351, Kiranpani, Palyem Pernem Goa
3	T.C.II/2015/35	Shri Andrew Fernandes	H.No 90, Torxem, Pernem Goa
4	T.C.II/2015/02	Shri Eknath Shamba Teli	H.No. 141/B ,Anale , Naibag,Pernem Goa
5	T.C.II/2015/03	Shri Uttam Shamba Teli	H.No.141,Bhatpavni Poroscodem ,Pernem-Goa
6	T.C-2/2016/250	Shri Nilesh R Naik	H.No.222/A, Corte -Real ,Santa Cruz-Goa
7	T.C-2/2016/290	Shir Dattaprasad R Naik	H.No26,Naikwada ,Pernem-Goa
8	T.C-2/2016/294	Meghashyam G Harmalkar	H.No. 23A, Paraste, Pernem-Goa
9	T.C-2/2016/295	Shri Menin Kistu D Souza	H.No.2/6, Bagayat, Paraste, Pernem Goa
10	T.C-2/2016/296	Shri Raj M Palyekar	H.No. 2/99, Bagayat ,Paraste ,Pernem-Goa
11	T.C-2/2016/297	Shri Ravikant Y Arolkar	H.No. 2/20, Bagayat Wada, Pernem -Goa
12	T.C-2/2016/299	Shri Surendra A Arolkar	H.No.156, Bagayat Wada,Pernem-Goa
13	T.C-2/2016/303	Vishnu B. Chinchkar	H.No.1/28, Parastem , Pernem-Goa
14	T.C-2/2016/304	Shri Anil D Gawade	H.No.375, Bhalkhajan, Korgao, Pernem,Goa
15	T.C-2/2016/335	Shri Vishnu S Kambli	H.No. 76, Paraste, Pernem-Goa
16	T.C-2/2016/369	Shri Suhas V Khadpe	H.No. 1/8/ILL, Cunchalim , Bardez-Goa
17	T.C-2/2016/48	Shri Ramnath S Bhonsle	H.No.1/21,Paraste, Pernem Goa

18	T.C-2/2016/53	Shri Francisco P Fernandes	H.No. 1/8, Paraste ,Pernem-Goa
19	T.C-2/2016/552	Shri Sitaram Y Mandrekar	H.No.25,Rumad-Pali,Surla,Bicholim Goa
20	T.C-2/2016/576	Smt Priya R Bhandari	H.No. E-3, 1st Floor, St. Francis Xavier Colony , Santa Cruz ,Goa
21	T.C-2/2016/66	Shri Chandrakant S Tandel	H.No. 257, Naikwada ,Torse, Pernem Goa
22	T.C-2/2016/69	Shri Keshav Kashinath Tandel	Rajwelwada, Torxem,Pernem-Goa
23	T.C-2/2016/71	Shri Santosh T. Talawanekar	H.No.32, Naibag,Pernem Goa
24	T.C-2/2016/83	Shri Deepak B. Mandrekar	Parastem , Pernem Goa
25	T.C -2/2016/44	Shri Yeshwant V Dicholkar	H.No. 1/1, Bedgewada Pernem -Goa
26	T.C-2/2016/87	Shri Jairam R Pirankar	H.No.76/A ,Naibag, Poroscodem , Pernem-Goa
		TERECOL CLUSTER-3	
Sr.No	**Cluster Details**	**Name of the Permit Holder**	**Address Of Permit Holder**
1	T.C.III/2015/22	Shri Prasad H Kerkar	H.No 194/F, Naik Wada, Verla Para ,Bardez Goa
2	T.C.III/2015/24	Shri Gajendra Shiva Kaskar	H.No.172, Talwada ,Keri, Pernem Goa
3	T.C.III/2015/28	Shri Venkatesh Sonu Tarkar	H.No .17, Tal Wada, Keri Pernem -Goa
4	T.C.III/2015/29	Shri Vishram A Palyekar	H.No. 378, Kiranpani ,Palyem Pernem Goa
5	T.C.III/2015/34	Shri Pramod Yeshwant Sawal	H.No. 384/3-A, Kiranapani ,Palyem ,Pernem -Goa
6	T.C-3/2016/110	Shri Vishal E Sawant Bandekar	H.No 526,Dhaktebag Keri ,Pernem Goa
7	T.C-3/2016/111	Shri Santosh D Sawant	H.No.9, Varnawada, Morjim, Pernem -Goa
8	T.C-3/2016/499	Shri Rohan A Kerkar	H.No. 21, Madhalawada, Keri, Pernem-Goa
9	T.C-3/2016/50	Shri Dilip K Maulankar	H.No 537,Lima Wada, Porvorim ,Bardez Goa
10	T.C-3/2016/501	Sachin P Vengurlekar	H.No 86 , Pawanwada , Keri , Pernem Goa
11	T.C-3/2016/502	Shri Sagar M Nhanji	H.No. 57A, Palyem Bhandar -Wada, Pernem Goa
12	T.C-3/2016/503	Shri Sainath S Gawade	H.No. 328/A, Balkhajan ,Korgao, Pernem Goa
13	T.C-3/2016/505	Shri Shankar N Sawal	H.No. 384/3-B, Kiranpani, Palyem, Pernem-Goa
14	T.C-3/2016/507	Shiva N Kerkar	H.No 62, Pawanwada,Keri, Pernem- Goa
15	T.C-3/2016/508	Shri Satyawan J Gadekar	H.No 373/D, Kiranpani , Palye, Pernem-Goa
16	T.C-3/2016/510	Uday B Gawandi	H.No.68, Bhandarwada,Paliem,Pernem-Goa
17	T.C-3/2016/511	Shri Prakash M Gawade	H.No.481, Gawade Wada Korgao , Pernem Goa
18	T.C-3/2016/512	Shri Prakash V Dajji	H.No. 88, Powan Wada, Keri ,Pernem-Goa

19	T.C-3/2016/513	Smt Pratibha V Tandel	H.No 68, Naik Wada , Torse ,Pernem-Goa
20	T.C-3/2016/514	Smt Priyanka P Talawanekar	H.No. 354, Bhalkhajan , Korgao ,Pernem-Goa
21	T.C-3/2016/515	Shri Rajan N Parab	H.No 242-A Manshiwada , Korgao , Pernem -Goa
22	T.C-3/2016/516	Smt Rashmi R Parab	H.No.243, Manshiwada, Korgao,Pernem Goa
23	T.C-3/2016/517	Smt Laxmi J Gadekar	H.No. 373, Kiranpani , Paliem , Pernem -Goa
24	T.C-3/2016/518	Shri Raghoba N Pednekar	H.No 529, Dhaktebag, Keri, Pernem-Goa
25	T.C-3/2016/519	Shri Peter Romal Fernandes	H.No. 55/A, Pawanwada, Querim , Pernem -Goa
26	T.C-3/2016/520	Shri Sadguru Mahadev Redkar	H.No.379, Almeida Waddo, Parra, Bardez-Goa
27	T.C-3/2016/524	Shri Tulshidas V Gawade	H.No 345/C , Bhalkhajan , Corgao , Pernem -Goa
28	T.C-3/2016/527	Shri Uttam S Arolkar	H.No.340/3, Kiranpani , Paliem Corgao, Pernem-Goa
29	T.C-3/2016/528	Shri Vithal Nhanu Arolkar	H.No. 343, Kiranpani Paliem Pernem Goa
30	T.C-3/2016/537	Philip Pasku Pereira	H.No.36, Bhandarwada, Paliem -Goa
31	T.C-3/2016/539	Shri Shashikant J Gadekar	H.No.373/C, KiranPani Palyem Pernem Goa
32	T.C-3/2016/542	Shri Tulshidas V Gawandi	H.No 63/1-C, Bhandarwada, Palyem , Pernem-Goa
33	T.C-3/2016/543	Smt Sunila T Gadekar	H.No.373/A, Kiranpani ,Palyem Pernem-Goa
34	T.C-3/2016/55	Shri Ravindra V Sawal	H.No.384/2, Kiranpani , Palyem,Pernem-Goa
35	T.C-3/2016/554	Shri Madan C Sawal	H.No.24, Thorlebag , Keri Pernem Goa
36	T.C-3/2016/555	Shri Manohar U Korkhankar	H.No.80, Pawanwada, Keri ,Pernem Goa
37	T.C-3/2016/556	Shri Madhu S Naik	H.No. 10, Konadi Korgao , Pernem -Goa
38	T.C-3/2016/558	Shri Amol D Gawade	H.No.326/A,Gawade Vas Temple Balkhajan Corgao Pernem -Goa
39	T.C-3/2016/559	Shri Amrose Coelho	Tumwada Korgao, Pernem-Goa
40	T.C-3/2016/560	Shri Anil Manohar Asolkar	H.No. 286 Dandoswada , Mandre , Pernem -Goa
41	T.C-3/2016/561	Shri Babani Laxman Arolkar	H.No.340, Kiranpani Palyem, Pernem -Goa
42	T.C-3/2016/562	Shri Dasharath K Pokhare	H.No.219, Thorle bag Keri, Pernem -Goa
43	T.C-3/2016/563	Shri Dattaram G Naik	H.No. 519, Dhaktebag, Keri, Pernem-Goa
44	T.C-3/2016/564	Shri Dnyaneshwar D Arolkar	H.No.45/B, Bhandarwada Paliem Pernem Goa
45	T.C-3/2016/565	Shri Gajanan R Morajkar	H.No. 383, Kiranpani Palyem Pernem Goa
46	T.C-3/2016/567	Shri Lopriya Rama Gawade	H.No.349/C, Bhalkhajan Korgao Pernem Goa
47	T.C-3/2016/573	Dinesh S Narvekar	HNo. 92/A, Pawanwada ,Kerim , Pernem -Goa
48	T.C-3/2016/618	Shri Anton K Trindade	H.No. 224, Manshiwada, Korgao, Pernem-Goa
49	T.C-3/2016/619	Smt Catarina Trindade	H.No 229, Manshi Wada, Corgao Pernem-Goa

50	T.C-3/2016/620	Shri Savio Trindade	H.No. 239, Manshi Wada, Korgao, Pernem - Goa
51	T.C-3/2016/63	Shri Premanand Y Chodankar	H.No 528, Dhakte Bag , Keri ,Pernem Goa
52	T.C-3/2016/78	Shri Shailendra B Parab	H.No.68,Virnoda ,Madhlawada,Pernem-Goa
53	T.C-3/2016/521	Shri Kustan S Coelho	H.No.249-B-1, Tumwada,Corgao, Pernem-Goa
54	T.C -3/2016/56	Shri Chatur S Palyekar	H.No.369/A, Kiranpani ,Palyem ,Pernem-Goa
55	T.C -3/2016/61	Smt. Siddhi B Tandel	H.No.58, Naikwada, Torxem , Pernem-Goa
56	T.C -3/2016/144	Shri Giridhar G. Gawde	No. 322/B. Maina, Korgao, Pernem, Goa
57	T.C -3/2016/504	Shri Sandeep M. Bhatlekar	H. No. 386/3, Bhalkhajan, Korgao, Pernem, Goa
58	T.C -3/2016/522	Shri Xavier Francis Fernandes	H.No.298, Tumwada, Corgao, Pernem-Goa
59	T.C -3/2016/566	Shri Laxman G. Shetgaokar	H. No. 870,Kattewada, Morjim, Pernem Goa

Suchitra

IN THE HIGH COURT OF BOMBAY AT GOA

PIL WRIT PETITION NO. 14 OF 2018

Federation of Rainbow Warriors,
A Society registered under the
Societies Registration Act, 1860,
under Registration No.190/Goa/2014),
with its address at CSH-1, Block C-2,
Leandra Heritage , Madel, Margao, Goa,
through its members,
Mr. Arun V. Madgavkar,
Phone No.9226857379
Fax No.Nil. PAN Number: AGGPM8225,
National Unique Identity Number: Nil
Email: ameetmadgavkar@gmail.com
Annual Income: Rs.5 lakhs

and

Mr. Viraj V. Bakre
Phone No.9423058923
Fax: Nil, PAN ACIPB2323D,
National Unique Identity Number: Nil
Email: viraj_bakre@rediffmail.com
Annual Income: Rs.9 lakhs. .... Petitioners

Versus

1. Directorate of Mines and Geology
   Government of Goa, through its
   Director, Udyog Bhavan,
   Panaji-Goa.

2. The Goa Coastal Zone Management
Authority, through its Member Secretary,
Pt. Deendayal Upadhyay Bhavan,
Porvorim, Bardez, Goa.

3. The Captain of Ports,
Captain of Ports Department,
Government of Goa,
Dayanand Bandodkar Road,
Panaji, Goa – 403001.

4. State of Goa
through the Chief Secretary of Goa,
Government of Goa, The Secretariat,
Porvorim, Bardez Goa.

5. The Goa State Environment Impact
Assessment Authority, through its
Chairperson, Dempo Towers,
Patto, Panaji, Goa.

6. The Goa State Biodiversity Board,
Through its Member Secretary,
Saligao, Bardez, Goa. .... Respondents

Mr. Nigel Da Costa Frias, Advocate for the Petitioners.
Ms. Maria Collasso, Advocate for the Intervenors.
Mr. D. Pangam, Advocate General along with Mr. P. Faldessai, Additional Government Advocate for the State.

Coram:- M.S. SONAK &
SMT. M. S. JAWALKAR, JJ.

Reserved on:- 12th December, 2019

Pronounced on:- 18th December, 2019

ORAL JUDGMENT (Per M. S. Sonak, J.)

Heard Mr. Nigel Da Costa Frias for the petitioners and Ms. Maria Collasso for the intervenors vide Miscellaneous Civil Application No.995/2019. Mr. D. Pangam, learned Advocate General along with Mr. P. Faldessai, learned Additional Government Advocate appear for the respondents.

2. We issue Rule and with the consent and at the request of learned counsel for the parties, we proceed to dispose of this petition finally. Mr. P. Faldessai, learned Additional Government Advocate waives service on behalf of the respondents.

3. In this petition, instituted in public interest, the petitioners basically seek reliefs with regard to the following two aspects:-

A) Remedial measures to be adopted by the State and its agencies to prevent and control illegal sand mining in the State of Goa;

B) Directions to the Goa State Environment Impact Assessment Authority (GSEIAA) – respondent no.5 to withdraw the environment clearance dated 01.10.2015 for undertaking sand mining in certain specified areas and, if necessary, to issue fresh environment clearance after compliance with sustainable Sand Mining Management

Guidelines, 2016 issued by the Ministry of Environment, Forest and Climate Change, Union of India.

4. In so far as relief in terms of prayer clause (B) above (the prayer clause in the petition is BB) is concerned, according to us, it may not be appropriate to consider the same in the present petition, particularly since such issue would involve hearing not only the Ministry of Environment, Forest and Climate Change but also at least some of the beneficiaries of this environment clearance upon representative basis. We felt that there was no point in delaying consideration of relief in terms of (A) above, by linking the two issues together, though, we agree, that the two issues are not entirely unconnected.

5. Accordingly, we made it clear that in this petition, we will not be considering any relief in terms of prayer clause (BB) of the petition but we will grant liberty to the petitioners to institute a fresh petition, in relation to such relief. We also made it clear that the interim orders dated 31.10.2018, as modified on 28.01.2019, in the present petition, which have a bearing on the consideration of relief in terms of prayer clause (BB) shall continue to operate for a period of six weeks from the date of disposal of this petition so as to enable the petitioners to seek either continuance or fresh interim relief, in the fresh petition, which the petitioners propose to institute in relation to relief in terms of

prayer clause (BB) of this petition. To such a petition, we assume, the petitioners will implead at least some of the beneficiaries of the environment clearance which they propose to challenge, in representative capacity. We order and grant liberty, accordingly.

6. In so far as relief in terms of (A) above is concerned, it is necessary to note that there is really no dispute raised even by the respondents that there is illegal sand mining going on in the State of Goa and that effective measures need to be taken to curb and control the same. Upon this undisputed premise, we have, from time to time, been making orders in this petition, so that, there is some mechanism in place to deal with the issue of prevention and control of illegal sand mining in the State of Goa.

7. We are happy to note that both the parties have not treated this petition as some adversarial litigation and approach of both the parties has been to endeavor to put in place some workable mechanism to prevent illegal sand mining and to take remedial measures, where such illegal sand mining is taking place.

8. On 03.07.2018, we made the following order:

> *" Heard Mr. Nigel Da Costa Frias, learned counsel for the Petitioners and Mr. Pravin Faldessai, learned Additional Government Advocate for the Respondents.*

2. Reply on behalf of Respondent no.3 is tendered. The learned Additional Government Advocate states that the reply on behalf of the Director (Mines) would be filed.

3. The Petitioners have raised certain issues at Para 60 of the Petition. Therefore, a response would be needed on these points raised.

4. To crystalise the issues, the State response is needed on the following points:

(a) Whether a preparation of plan with a study showing the annual replenishment of sand in mining lease area is required under the Memorandum dated 24 December 2013 and if so, within how much time this plan would be prepared? If it is not required, whether the State is ready to prepare one?

(b) Whether any study is mandated to determine the depth of the river beds and the impact of sand mining activities on the river beds, the buffer zones, proximity to bridges, embankment, bunds and river banks and stream, is mandated under the Memorandum dated 24 December 2013 and even if it is not so mandated, whether the State is ready to undertake such study and if so, within how much time?

(c) Whether periodical monitoring by the Goa State Bio-Diversity Board as regarding to ecological impacts of sand extraction on the riverine ecosystem is being carried out. If so, whether there are any reports prepared of the said monitoring and which is the Authority which enforces the compliances?

(d) Whether there is any Authority is entrusted with the compliance of the conditions environment clearance in respect of the sand mining or the general activity of sand mining, and whether any progress reports are maintained by such Authority?

(e) Whether any patrolling is being carried out to oversee

the activity of the sand mining?
(f) *Whether any registration and inspection of of boats involved in sand mining, methods used for extraction and monitoring of personnel involvement of boats used for sand mining is being carried out, if so, details thereof?*

5. *The response of the State on the above points by way of an affidavit of an responsible Officer be placed on record by 31 July2018.*
6. *Stand over to 31 July 2018."*

9. In response to the aforesaid order the Director of Mines has filed an affidavit, in which, he referred to five instances of illegal sand mining in the Mandovi river. Out of the five instances, penalty was imposed in one of the cases and the others were mostly compounded. Accordingly, we were constrained to observe that the trend of compounding such cases can hardly have any deterrent effect and there must be serious action if violations are found and proved. We observe that mere compounding will simply embolden further violations.

10. Thereafter, in our order dated 31.07.2018, we issued following interim reliefs:-

6. *The environmental clearances granted to the Collector and District Magistrate by the Goa State Environment Impact Assessment Authority contain various stipulations. It is emphasized that there should be a proper survey and there should be scientific extraction. It is also stated that there should be a Patrolling-cum-Flying squad and complaint/monitoring*

mechanism, comprising of senior level representatives from stakeholder Departments and Authorities to be constituted for effective implementation. There should also be a mechanism for redressal of complaints at District level and a dedicated helpline number. The Goa State Biodiversity Board should periodically monitor riverine and riparian biodiversity on a sampling mode. These are the conditions on which the Collector has been authorized to give further licenses and therefore they will have to be strictly complied with.

7. *As regard the flying squad, the affidavit of the Director does not disclose that it has been constituted. Learned Counsel for the petitioner on instructions states that flying squad does not have a functional Boat.*

8. *The permits which have been granted to the individuals also lay down various conditions. The permit holder is under obligation not to interfere or damage any riverbanks or not to carry out excavation below maximum depth specified. So that the permit holder carries out the obligation under the permission, a regular monitoring is required. It is for the very reason that the establishment of the flying squad is necessary and must be made effective.*

9. *In both, implementation of the conditions and preparation of plan and conducting an In-Depth study more efforts on the part of the State are necessary. The conditions in the EC and the permits will have to be enforced.*

10. *Accordingly, as a first step, we direct that a flying squad, if not already set up, be set up within a period of six weeks from today. A flying squad should have a functional boat for its effective monitoring.*

11. *The learned Counsel for the petitioner has also drawn our attention to the memorandum issued by the Ministry of Environment and Forest on 24 December 2013 more particularly clause 2(1)(iii)(e) in respect of the study for annual replenishment of sand. It is pointed out that for carrying out this*

study, the monsoon period, when the sand mining activity is suspended, could be most ideal.

12. *The Captain of Ports along with the Goa State Environment Impact Assessment Authority and a Biodiversity Board will consider carrying out a preliminary study as contemplated in the Office Memorandum dated 24 December 2013. Since it will be a preliminary study, the same can be conducted as early as possible preferably within a period of four weeks from today, unless of course it is not possible due to some cogent reason or that scientifically it is not the correct time period.*

13. *As already contemplated in the Environment Clearances, the State will constitute a committee comprising of senior level representative from stake holders department for effective implementation and monitoring of the general and specific conditions of the environment clearance vis-a-vis complaints at the district level, within a period of eight weeks.*

14. *The State will set up a dedicated helpline number, if not already set up, for effective redressal of the complaint and will give adequate wide publicity of the dedicated helpline number.*

15. *The State will set up a study group of expert on the subject to prepare In-Depth study of the aspect of sustainable sand mining and map as contemplated under the sustainable sand mining guidelines and environmental clearances granted by the Goa State Environment Impact Assessment Authority. The composition of the study group shall be identified within a period of six weeks from today and the composition of the same shall be placed before us before it is so finally constituted.*

16. *To report the compliance of the above directions and to ascertain further progress in the matter, we defer the hearing of this petition by six weeks from today."*

11. In our subsequent order of 10.07.2018, we noted that there were various instances of illegal sand mining which were acknowledged by

the State and its agencies. We also noted the stance of the State and its agencies that efforts were being made to control such violations. However, we were constrained to note that there was complete lack of any sort of effective regulatory mechanism to prevent such violations or at least to control them.

12. Accordingly, in our order dated 10.09.2018, we made following interim directions:-

> ***4.*** *To control the illegal sand mining, there must be an effective enforcement mechanism in place. Instead we see a complete lack of any sort of effective regulatory mechanism. The Petition was heard in the morning session and was kept in the afternoon session for the learned Additional Govt. Advocate to take instructions as we were given the standard explanation of movement of files from table to table. Now the Director Mines is present in the Court along with the Deputy Captain of Ports. We are informed by the learned Additional Govt. Advocate, on instructions, that the enforcement squad was created for Pernem, Bardez, Tiswadi, Bicholim, Sattari and Ponda Talukas on 22 August 2013, but it is non-functional. There is no functional boat. It is obvious that the State will not be able to curb the illegal sand mining if it does not have an enforcement mechanism in the form of Patrolling Squad. The State also has not set any help line or a complaint platform to receive any information regarding illegal sand mining. In such a state of affairs, how it will deter illegal sand mining is difficult to discern.*
>
> ***5.*** *It is absolutely necessary that the State must put in place a regulatory mechanism to curb the illegal sand mining. In our earlier order ,reproduced above with underlined emphasis, we*

have referred to various conditions and stipulations imposed by the authorities themselves. The conditions seems to have remained on paper.

6. *The learned Additional Govt. Advocate states that the Director of Mines & Geology is in process of creating the enforcement squads. He states that squads with same compositions as in communication dated 22 August 2013 will be set up. He states that a communication to that effect will be issued by tomorrow. Learned Additional Govt. Advocate states that the Director of Mines and Geology has requested the Captain of Ports and the Coastal Security Police, to provide services of functional boats. This letter is sent today, even though we had granted six weeks time. The Captain of Ports and the Coastal Security Police shall accordingly provide the functional boats as requested by the Director of Mines and Geology. All the three Authorities will report compliance by next date. We are informed that the sand mining season would commence from 1 October 2018. We expect that the regulatory mechanism in the form of enforcement squad with functional boats and complaint forum is established forthwith, to avoid any restraint order.*

7. *S.O. to 12 September 2018. To be listed under the caption "For Directions". On the next date, the Respondents will apprise the Court of the status of the progress in respect of the other directions issued."*

13. In our order dated 12.09.2018, we noted the compliances which were reported to us, particularly in relation to the constitution of flying squads and their operations. Our order dated 12.09.2018, reads thus:-

" Heard learned Counsel for the parties.

2. *The learned Advocate General states that in compliance*

with the order dated 10 September 2018, flying squad has been constituted. The flying squads which were constituted for Pernem, Bardez, Tiswadi, Bicholim, Sattari and Ponda Taluka vide order dated 22 August 2013 have been revived and letter has been issued on 10 September 2018. He states that the copy of the letter dated 10 September 2018 along with the composition of such flying squads is already placed before this Hon'ble Court. The learned Advocate General states that request is made to the Captain of Ports and the Superintendent of Police, Coastal security to provide services of functional boards by letter dated 10 September 2018. He states that the Captain of Ports has communicated that his department will provide services of functional boat in river Mandovi which can also be used in river Zuari. He has given the details of the boat and the contact person has also been given. As regards to the compliance by the SP, Coastal Security, the learned Advocate General states that the boats will be provided as and when required. A letter to that effect will be issued to the Director of Mines giving details of such boars and the operators/contact persons. Learned Advocate General states that such letter will be issued latest by Monday i.e. on 17 September 2018 after the formal approval of Director General of Police.

3. *Learned Advocate General further states that in addition to the flying squads earlier mentioned, vide order issued yesterday the Director of Mines and Geology has constituted similar flying squads for Salcete, Sanguem, Quepem, Dhar-Bandora, Canacona and Mormugao Taluka. Learned Advocate General states that yesterday the Deputy Director, Mines and Geology has designated the officials from the Directorate of Mines and Geology on the Taluka wise flying squads and the list of such officers along with their telephone numbers is issued.*

4. *The learned Advocate General states that preliminary impact study, has been carried out and the report is submitted. He states that constitution of a committee for implementation*

and monitoring and dedicated helpline number, the Government has approved the issue of dedicated helpline number and a letter is issued yesterday requesting to notify such helpline number. He assures that other issues of expert committees, a high level meeting will be held. The meeting will be held at the Chief Secretary level and the action taken will be appraised. We expect that the Helpline Number is set up and Committee meeting takes place at the earliest.

5. *The learned Counsel for the petitioners has drawn our attention to the Environment Clearance, which is annexed to the petition and more particularly to the general and specific conditions specified therein. We note that since these are the conditions upon which power to issue licenses is given to the Authorities, the response of the State to each of these conditions as to when they will be complied, is necessary.*

6. *To enable the State to file an additional affidavit and to inform the status as above stand over to 19 September 2018."*

14. On 27.09.2018, 03.10.2018, 16.10.2018, 23.10.2018 and 31.10.2018, we made some orders which are relevant in the context of relief relating to the issue of environment clearance. Since, we are not addressing the said issue in this petition, we make no further reference to the said orders.

15. Finally, on 25.09.2019, the learned counsel for the parties assured this court that the parties, their advocates and government officials who are concerned with the issue relating to sand mining, whether legal or otherwise will meet on 4th October, 2019 at 5.00

p.m. in the office of the learned Advocate General, in an attempt to either sort out the issues or to at least to come out with some mechanism to prevent illegal sand mining or take remedial action, in the matter of illegal sand mining.

16. We were informed that more than two meetings took place in which, the parties attempted to formulate some agreed minutes, on the basis of which, the issue of prevention of illegal sand mining and remedial measures could perhaps be worked out. Drafts of minutes of the order were exchanged between the parties. Though there was broad agreement on most of the issues, there were differences in the modalities suggested. As such, the parties, were not in a position to present to this Court agreed minutes of the order. However, we are happy to note that at least on some broad aspects, there was consensus and therefore, we too, propose to take into consideration such minutes, in making our final order. On aspects where there was no consensus however, we propose to issue our own directions.

17. Before we do so, we would like to refer to the decision of the Hon'ble Supreme Court in the case of ***State (NCT of Delhi) vs. Sanjay – (2014) 9 SCC 772***, in which, the Hon'ble Supreme Court, has considered the issue as to whether the provisions contained in the Mines and Minerals (Development and Regulation) Act, 1957

(MMDR Act) operate as a bar against prosecution of a person who has been charged with allegation which constituted offence under Section 379 and other provisions of the Indian Penal Code, 1860 (IPC). In other words, the issue which arose for consideration in the said case was whether the provisions of MMDR Act explicitly or impliedly exclude provisions of IPC when an act of the accused is an offence both under MMDR Act as well as the IPC. This judgment is relevant because the same arose in the context of rampant illegal mining of sand from river beds, which is, the issue with which we are concerned in the present public interest litigation.

18. In the context of illegal sand mining, the Hon'ble Supreme Court has made following relevant observations:-

> *" **32.** The policy and object of Mines and Minerals Act and Rules have a long history and are the result of an increasing awareness of the compelling need to restore the serious ecological imbalance and to stop the damages being caused to the nature. The Court cannot lose sight of the fact that adverse and destructive environmental impact of sand mining has been discussed in the UNEP Global Environmental Alert Service report. As per the contents of the report, lack of proper scientific methodology for river sand mining has led to indiscriminate sand mining, while weak governance and corruption have led to widespread illegal mining. While referring to the proposition in India, it was stated that Sand trading is a lucrative business, and there is evidence of illegal trading such as the case of the influential mafias in our Country.*

33. *The mining of aggregates in rivers has led to severe damage to river, including pollution and changes in levels of pH. Removing sediment from rivers causes the river to cut its channel through the bed of the valley floor, or channel incision, both upstream and downstream of the extraction site. This leads to coarsening of bed material and lateral channel instability. It can change the riverbed itself. The removal of more than 12 million tonnes of sand a year from the Vembanad Lake catchment in India has led to the lowering of the riverbed by 7 to 15 centimetres a year. Incision can also cause the alluvial aquifer to drain to a lower level, resulting in a loss of aquifer storage. It can also increase flood frequency and intensity by reducing flood regulation capacity. However, lowering the water table is most threatening to water supply exacerbating drought occurrence and severity as tributaries of major rivers dry up when sand mining reaches certain thresholds. Illegal sand mining also causes erosion. Damming and mining have reduced sediment delivery from rivers to many coastal areas, leading to accelerated beach erosion.*

34. *The report also dealt with the astonishing impact of sand mining on the economy. It states that the tourism may be affected through beach erosion. Fishing, both traditional and commercial – can be affected through destruction of benthic fauna. Agriculture could be affected through loss of agricultural land from river erosion and the lowering of the water table. The insurance sector is affected through exacerbation of the impact of extreme events such as floods, droughts and storm surges through decreased protection of beach fronts. The erosion of coastal areas and beaches affects houses and infrastructure. A decrease in bed load or channel shortening can cause downstream erosion including bank erosion and the undercutting or undermining of engineering structures such as bridges, side protection walls and structures for water supply.*

> ***35.*** *Sand is often removed from beaches to build hotels, roads and other tourism-related infrastructure. In some locations, continued construction is likely to lead to an unsustainable situation and destruction of the main natural attraction for visitors – beaches themselves. Mining from, wit*hin or near a riverbed has a direct impact on the stream's physical characteristics, such as channel geometry, bed elevation, substratum composition and stability, instream roughness of the bed, flow velocity, discharge capacity, sediment transportation 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 instream biota and riparian habitats. This disturbance may also cause changes in channel configuration and flow-paths."

19. The Hon'ble Supreme Court, has in paragraph 36 of *State vs. Sanjay (supra)*, has referred to the decision of the division bench of the Madras High Court, in the case of ***M. Palanisamy v. The State of Tamil Nadu, (2012 (4) CTC 1)***, in which, Eqbal J., as His Lordship then was, was also the member of the Bench. In the said case, there was elaborate discussion on the object of restrictions put on illegal mining, transportation and storage of minerals including sand after consideration of various reports. The relevant paragraphs from the said judgment, which are quoted by the Hon'ble Apex Court read as follows:-

> *" **21.** In order to appreciate the issue involved in these Writ Petitions, we may have to look at the larger picture - the impact*

of indiscriminate, uninterrupted sand quarrying on the already brittle ecological set up of ours. According to expert reports, for thousands of years, sand and gravel have been used in the construction of roads and buildings. Today, demand for sand and gravel continues to increase. Mining operators, instead of working in conjunction with cognizant resource agencies to ensure that sand mining is conducted in a responsible manner, are engaged in full-time profiteering. Excessive in-stream sand-and-gravel mining from river beds and like resources causes the degradation of rivers. In-stream mining lowers the stream bottom, which leads to bank erosion. Depletion of sand in the stream-bed and along coastal areas causes the deepening of rivers and estuaries and enlargement of river mouths and coastal inlets. It also leads to saline-water intrusion from the nearby sea. The effect of mining is compounded by the effect of sea level rise. Any volume of sand exported from stream-beds and coastal areas is a loss to the system. Excessive in- stream sand mining is a threat to bridges, river banks and nearby structures. Sand mining also affects the adjoining groundwater system and the uses that local people make of the river. Further, according to researches, in-stream sand mining results in the destruction of aquatic and riparian habitat through wholesale changes in the channel morphology. The ill effects include bed degradation, bed coarsening, lowered water tables near the stream-bed, and channel instability. These physical impacts cause degradation of riparian and aquatic biota and may lead to the undermining of bridges and other structures. Continued extraction of sand from river beds may also cause the entire stream-bed to degrade to the depth of excavation.

23. *The most important effects of in-stream sand mining on aquatic habitats are bed degradation and sedimentation, which can have substantial negative effects on aquatic life. The stability of sand-bed and gravel-bed streams depends on a delicate balance between stream flow, the sediments supplied from the*

watershed and the channel form. Mining-induced changes in sediment supply and channel form disrupt the channel and the habitat development processes. Furthermore, movement of unstable substrates results in downstream sedimentation of habitats. The affected distance depends on the intensity of mining, particles sizes, stream flows, and channel morphology.

24. *Apart from threatening bridges, sand mining transforms the riverbeds into large and deep pits; as a result, the groundwater table drops leaving the drinking water wells on the embankments of these rivers dry. Bed degradation from in-stream mining lowers the elevation of stream flow and the floodplain water table, which in turn, can eliminate water table-dependent woody vegetation in riparian areas and decrease wetted periods in riparian wetlands. So far as locations close to the sea are concerned, saline water may intrude into the fresh waterbody."*

20. The Hon'ble Apex Court after detailed analysis of the provisions of MMDR Act and IPC, finally came to the conclusion that initiation of proceedings for commission of an offence under MMDR Act does not debar the police from taking action against persons for committing theft of sand and minerals under the provisions of the IPC and that of the Code of Criminal Procedure (Cr.P.C.). The Hon'ble Apex Court has observed that in a situation where a person without any lease or license or any authority enters into river and extracts sand, gravel and other minerals and remove or transport those minerals in a clandestine manner with an intent to remove dishonestly those minerals from the possession of the State, is liable to be punished for committing such

offence under Sections 378 and 379 IPC. The Hon'ble Apex Court has held that from a close reading of the provisions of MMDR Act and the offence defined under Section 378 IPC, it is manifest that the ingredients constituting the offence are different. The contravention of terms and conditions of mining lease or doing mining activity in violation of Section 4 of the MMDR Act is an offence punishable under Section 21 of the MMDR Act, whereas dishonestly removing sand, gravel and other minerals from the river, which is the property of the State, out of the State's possession without the consent, constitute an offence of theft. Hence, merely because initiation of proceeding for commission of an offence under the MMDR Act on the basis of complaint cannot and shall not debar the police from taking action against persons for committing theft of sand and minerals by exercising power under the Cr.P.C. And submit a report before the Magistrate for taking cognizance against such persons. In other words, in a case where there is a theft of sand and gravel from the government land, the police can register a case, investigate the same and submit a final report under Section 173 Cr.P.C. before Magistrate having jurisdiction for the purpose of taking cognizance as provided in Section 190(1)(d) Cr.P.C. The Hon'ble Supreme Court, has, in paragraph 73, finally held that after giving thoughtful consideration in the matter, in the light of the relevant provisions of the MMDR Act vis-a-vis the IPC or Cr.P.C., the Hon'ble Supreme Court was of the definite opinion that

the ingredients constituting the offence under the MMDR Act and the ingredients constituting the offence under the MMDR Act and the ingredients of dishonestly removing sand and gravel from the riverbeds without consent, which is the property of the State, is a distinct offence under the IPC. Hence, for the commission of offence under Section 378 IPC, on receipt of the police report, the Magistrate having jurisdiction can take cognizance of the said offence without awaiting the receipt of complaint that may be filed by the authorized officer for taking cognizance in respect of violation of various provisions of the MMDR Act. The contrary view taken by different High Courts was held to be unsustainable and the Magistrates were directed to proceed accordingly.

21. The aforesaid authoritative pronouncement of the Hon'ble Apex Court makes it quite clear that the State is the owner of minor minerals like sand, gravel, etc. found in the riverbeds or on the banks of the rivers and if any person without any lease or license or any authority enters into the river and extracts sand, gravel and other minerals and removes or transports these minerals in a clandestine manner without any permission or authorisation, with an intent to remove dishonestly those minerals from the possession of the State, such person is liable to be punished for committing such offence under Sections 378 and 379 IPC.

22. When we say that the State is the owner of the minor minerals like sand, gravel and other minerals in the riverbeds or on the banks of the rivers, we wish to clarify that the ownership of the State is to be construed in a special sense. This is because sand, gravel and other minerals found in the riverbeds or on the river banks are natural resources and in that sense, they are public property or national assets.

23. The State, as was observed in the case of ***Centre for Public Interest Litigation vs. Union of India – (2012) 3 SCC 1***, *is empowered to distribute* natural resources. However, as they constitute public property/national asset, while distributing natural resources the State is bound to act in consonance with the principles of equality and public trust and ensure that no action is taken which may be detrimental to public interest. Like any other State action, constitutionalism must be reflected at every stage of the distribution of natural resources. In Article 39(b) of the Constitution it has been provided that the ownership and control of the material resources of the community should be so distributed so as to best subserve the common good, but no comprehensive legislation has been enacted to generally define natural resources and a framework for their protection. Of course, environment laws enacted by Parliament and State Legislatures deal with specific natural resources i.e. forest, air, water, coastal zones, etc.

24. In such matters, the Doctrine of Public Trust clearly applies as was explained by the Hon'ble Supreme Court in the case of ***M.C. Mehta vs. Kamal Nath and others (1997) 1 SCC 388***. In this decision, the Hon'ble Apex Court records that this doctrine perhaps developed in the ancient Roman Empire. This doctrine was founded on the ideas that certain common properties such as rivers, seashore, forests and the air were held by Government in trusteeship for the free and unimpeded use of the general public.

25. The Hon'ble Supreme Court in *M.C. Mehta vs. Kamal Nath (supra)*, has explained that the public trust doctrine primarily rests on the principle that certain resources like air, sea, waters and the forests have such a great importance to the people as a whole that it would be wholly unjustified to make them a subject of private ownership. The said resources being a gift of nature, they should be made freely available to everyone irrespective of the status in life. The doctrine enjoins upon the Government to protect the resources for the enjoyment of the general public rather than to permit their use for private ownership or commercial purposes.

26. Finally, the Hon'ble Supreme Court made it clear that our legal system – based on English common law – includes the public trust doctrine as part of its jurisprudence. The State is the trustee of all

natural resources which are by nature meant for public use and enjoyment. Public at large is the beneficiary of the sea-shore, running waters, airs, forests and ecologically fragile lands. The State as a trustee is under a legal duty to protect the natural resources. These resources meant for public use cannot be converted into private ownership.

27. The aforesaid principle was reiterated in ***Intellectuals Forum, Tirupathi vs State of A.P. & Ors – (2006) 3 SCC 549***, wherein the Hon'ble Supreme Court held that the responsibility of the State to protect the environment is now a well-accepted notion in all countries. It is this notion that, in international law, gave rise to the principle of "state responsibility" for pollution emanating within one's own territories. This responsibility is clearly enunciated in the United Nations Conference on the Human Environment, Stockholm 1972 (Stockholm Convention), to which India was a party. The relevant Clause of this Declaration in the present context is Paragraph 2, which states that the natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.

28. The reference to this Doctrine of Public Trust is necessary for two reasons in the context of large scale illegal mining of sand from the

riverbeds and river banks in the State of Goa. Firstly, such reference is necessary so that the State realizes that it is not some literal or absolute owner of all these natural resources like sand, gravel, etc. found in the riverbeds and banks of the rivers. The State, is a trustee in respect of these natural resources and therefore, it is the responsibility of the State to ensure that such natural resources are protected, inter alia, from theft and even robbery. It is the responsibility of the State to ensure that such natural resources are not in any illegal and unauthorized manner converted into private ownership and exploited for commerce. The second reason is that these natural resources like sand, gravel, etc. found in the riverbeds and banks of the rivers are to be found in ecologically sensitive and at times even fragile areas. Doctrine of Public Trust requires the State to undertake the responsibility to protect the environment as well. The protection of environment is now accepted as one of the necessary facets of Article 21 of the Constitution of India, which guarantees the right to life and not merely livelihood. Therefore, when there is rampant illegal and unauthorized sand mining for commercial purpose and there is no proportionate will to initiate action, if necessary, criminal action against the exploiters of these natural resources, clearly, there is infringement of the constitutional guarantees enshrined in Articles 14 and 21 of the Constitution of India. In such a situation, there is clearly a breach of the Public Trust Doctrine, which is now recognized

as a part of our Constitution through the dynamic interpretation of the provisions of Article 21 of the Constitution of India.

29. Just as the State, prosecutes thieves and robbers who steal and rob from private parties or their private properties, so also, the State must be equally, if not more, vigilant, when it comes to stealing or robbing of natural resources held in trust by the State. The attitude that something which belongs to all, belongs to none in particular, is required to be shunned and strict action is required to be taken against those who, with impunity, indulge in illegal mining of sand and gravel from the riverbeds and river banks, regardless of the damage which they cause to the environment and regardless of the financial loss which they cause to the State.

30. In the case of ***Chenchu Rami Reddy and another v. Government of Andhra Pradesh and others- (1986) 3 SCC 391***, the Hon'ble Supreme Court was constrained to observe as follows:

> *"More often than not detriment to what belongs to 'many', collectively, does not cause pangs to 'any', for no one is personally hurt directly. That is why public officials and public-minded citizens entrusted with the case of 'public property' have to show exemplary vigilance. ....."*

31. The aforesaid attitude, has unfortunately percolated in the State, when it comes to dealing with those, who, with impunity indulge in mining of sand and gravel from the riverbeds and river banks, solely for commercial exploitation. Therefore, it is high time, that serious criminal prosecutions are launched against those found in extracting, transporting and appropriating sand and gravel from the riverbeds and river banks, without valid permissions, leases and clearances as prescribed under the relevant legislations dealing with such matters.

32. From the material placed before us, we find that some action is indeed being taken against those who are indulging in illegal and unauthorized extraction of sand and gravel from the riverbeds and river banks. The action is mainly in the form of confiscation of canoes or trucks as well as the extracted sand and gravel. However, in the course of these proceedings, we were quite disturbed to note that in most cases, the trucks and canoes were released after imposing paltry fines. There were occasions where even the illegally extracted sand and gravel was being released to the exploiters, after imposition of some paltry fines. All this according to us, is quite illegal and will only further encourage illegal extraction of sand and gravel from the riverbeds and river banks. Such persons, only, factor the fines and penalties into the final price and continue to profit in the illegal business of extraction of sand and gravel from the riverbeds and river banks.

33. Learned counsel for the petitioners have pointed out that the illegal sand mining mainly takes place in the following areas:

PONDA TALUKA (Mandovi River)
1. Candola
2. Savoi Verem
3. Volvoi

TISWADI TALUKA (Mandovi River and Cumbhajua Canal)
1. Cumbhajua
2. St Estevam
3. Corlim

BICHOLIM TALUKA (Mandovi River)
1. Amona
2. Navelim

PERNEM TALUKA (Tiracol and Chapora Rivers)

1. Tiracol
2. Querim
3. Paliem
4. Corgao
5. Porscodem
6. Pernem
7. Torxem

BARDEZ TALUKA (Mandovi and Chapora Rivers)

1. Chapora
2. Querim
3. Paliem
4. Corgao
5. Porscodem

6. Pernem
7. Torxem



BARDEZ TALUKA (Mandovi and Chapora Rivers)

1. Chapora
2. Colvale
3. Camurlim
4. Nadora
5. Pirna
6. Ozrim

SALCETE TALUKA (Zuari and Kushawati Rivers)

1. Loutolim
2. Curtorim
3. Guirdolim (Rivulet)
4. Chandor (Kushawati River)
5. Assolda

SANGUEM/QUEPEM TALUKAS (River Zuari)

1. Panchwadi
2. Sanvordem
3. Xelvona
4. Curchorem

34. Learned counsel for the petitioners have also pointed out that there are certain routes from where the illegally mined sand and gravel is transported. The same are as follows:

S. No.	Roads from where sand is transported	River	Taluka
1	Volvoi via Keri – Ponda Road	Mandovi	Ponda
2	Volvoi via Savoi Verem Marcela Road	Mandovi	Ponda

3	Betqui to Marcela Road	Mandovi	Ponda
4	Candola side under Amona Bridge to Marcela Road	Mandovi	Ponda
5	Amona side under Amona Bridge to Marcela Road and also Sakhali Road	Mandovi	Ponda
6	Virdi Bridge to Sakhali Road and also Marcela Road	Mandovi	Ponda
7	Govt College Candola – Gaundhali Bridge Junction	Kumbharjuva canal, Mandovi at Aakhada	Ponda
8	Kundaim Industrial Estate Junction	Mandovi	Ponda
9	Borim Bridge Circle before bridge	Mandovi	Ponda
10	Bridge – Candepar	Mhadai	Ponda
11	Banastarim Bridge (Corlim – Dhulape side)	Mandovi, Kumbharjuva canal	Tiswadi
12	Old Goa Church circle	Mandovi	Tiswadi
13	Junction of Mapusa – Bicholim – Pernem	Mandovi	Bardez
14	Bridge – Colvale – Dhargal	Chapora	Pernem
15	Bridge – Satarda	Terekhol	Pernem
16	Maina – Kudnem Junction	Mandovi	Bicholim
17	Ponda – Margao Road, Circle at Loutolim, near Old Borim Bridge	Zuari	Salcete
18	Ponda – Margao Road, Circle at Loutolim, near Old Borim Bridge	Zuari	Ponda
19	Sanvordem Circle, near Sanvordem – Curchorem bridge	Zuari	Sanguem
20	Ambedkar Chowk, Curchorem and	Zuari	Quepem

	Junction 220 m to the east on the road towards Assolda/ Chandor		
21	Assolda – Chandor – Tilamol junction at Assolda, near Kushawati Bridge from Assolda to Chandor	Zuari	Quepem
22	Margao – Curtorim – Macazana Road, Maina Market Junction, Near St Rita's Church, Maina	Zuari	Salcete
23	Margao – Curtorim – Macazana Road, junction 100 m to the east from St Anthony Chapel, Curtorim	Zuari	Salcete
24	Ramnagar Junction, Margao Housing Board to Chandor road	Zuari	Salcete

35. Learned counsel for the petitioners and intervenors submit that if there are directions to intensely patrol the aforesaid areas and routes, then, it is possible that there is some check to these rampant illegal sand mining and transportation.

36. Mr. Nigel da Costa Frias and Ms. Collasso are perhaps right in suggesting that such illegalities continue either with the active connivance of the authorities or at least on account of inaction on the part of the authorities despite knowledge of the magnitude of such illegal sand mining. Although, it would not be appropriate for us to make any sweeping observations on such issues, if, the position, as it stands, continues any further, some inferences, from proven

circumstances, will have to be drawn. For the present, we say no more on this subject.

37. After this matter was reserved for orders, Mr. Nigel Da Costa Frias placed on record order dated 12.12.2019 made by the National Green Tribunal (NGT) on the issue of illegal sand mining in river Chapora. He pointed out that certain directions have been issued by the NGT in relation to the illegal sand mining in river Chapora. The directions which we propose to issue relate to the issue of illegal sand mining in the entire State of Goa. Obviously therefore, the directions which we propose to issue will be in addition to the directions issued by the NGT in relation to the illegal sand mining in river Chapora.

38. For all the aforesaid reasons, we dispose of this petition by making the following order:-

a) We direct the State and its various departments to undertake regular patrolling through flying squads at all stretches of rivers. Such patrolling shall not be at any fixed time of the day but randomly during the day and during the night, so as to genuinely surprise those indulging in illegal sand mining and ensure the stoppage of such illegal sand mining.

b) The canoes and boats used for illegal extraction of the sand shall be seized by the flying squads and thereafter confiscated. The registration of such canoes/boats used for illegal sand mining shall be cancelled by the Captain of Ports. The canoes/boats operating without registration shall be dealt with as per notification dated 29.03.2016 issued by the Director of Mines and Geology and the circular dated 25.02.2019 issued by the Captain of Ports.

c) The State and its authorities, in the first instance, shall ensure that the illegally mined sand stacked on the river banks or on plots close to the river banks is put back into the river or used for the purpose of replenishment of the areas, where erosion has taken place on account of indiscriminate sand mining or other natural causes. The expenses for this will have to be initially borne by the State and its agencies. However, the State and its agencies, should invariably recover such expenses from those found involved in illegal sand mining at the site.

d) If, for some reason such restoration or replenishment as aforesaid is not feasible, the State, may use the confiscated sand, gravel and other material for public projects, after maintaining proper records and following due procedures. The maintenance of such records is absolutely necessary, as otherwise, there is a tendency for such

confiscated material to find its way into unauthorized markets, looking to the demand for this material, particularly from the real estate or construction industry.

e) The State should launch prosecution against those, found to be illegally extracting sand and other natural resources. For this purpose, the First Information Reports should be filed by invoking the appropriate provisions of the IPC and such prosecution should be pursued with all seriousness and taken to their logical conclusions. The State, must not, rest only with prosecution under the MMDR Act or the Goa Minor Mineral Concessions Rules, 1985, since, we find that most of these prosecutions, end up with levy of paltry penalties and fines upon those indulging in illegal extraction of sand and gravel from the riverbeds and river banks.

f) The areas which are quite notorious for illegal sand mining have been identified by the Director of Mines and Captain of Ports, who are the main agencies of the government involved in the detection of illegal mining and charged with the responsibility of preventing such illegal mining or taking remedial action in that regard. Such areas are referred to in paragraph 33 of this Judgment and Order. The State and its agencies must ensure that there is intensive patrolling in these areas, both by road as well as in the rivers themselves. We direct that

patrolling must be done at least thrice each day in these areas and police must make entries in this regard in the station diary in their respective police stations. The vigil at these areas will have to be kept mainly by the police authorities, who, upon detection of illegal sand mining must take immediate action, including by way of summoning flying squads constituted for the purpose of taking action in such matters.

g) The helpline numbers already constituted by the State and its agencies, in terms of our interim orders, must continue to remain operational, so that, any members of the public can report/complain about illegal sand mining. In addition, we direct that in the talukas of Ponda, Pernem and Bicholim where, there is rampant illegal sand mining the complaints regards illegal sand mining be entertained by the police with promptitude. No sooner such complaint is received, the police authorities will be duty bound to visit the site in question and if, there is any illegal sand mining in progress, the same, will have to be immediately halted and the flying squad will also have to be alerted of taking immediate action in the matter. The police authorities in these talukas to coordinate with the flying squads and other agencies which are enjoined in the task of taking action against illegal sand mining.

h) We direct that in addition to these helplines, members of the public be informed by appropriate publications through the Directorate of Information that complaints may be lodged by calling the emergency number 100. Upon receipt of such complaints, the police authorities of the concerned police station to immediately visit the site and alert the flying squad if any illegal sand mining is going on at the site.

i) We direct the State to provide the flying squads with dedicated boats for patrolling and site inspection with adequate staff. We also direct the Marine/Coastal Police to assist the flying squads to carry out regular patrolling and raids along the rivers whenever reports are received in the matter of illegal sand mining. We direct the State Government to make adequate arrangements in this regard. In particular, we direct that some dedicated boats be made available for patrolling the sensitive areas referred to in paragraph 33 of this Judgment and Order. All this exercise must be completed within three months from today.

j) The petitioners have pointed out certain routes on which illegal transportation of sand and gravel, again illegally mined, is carried out. These routes are referred to in paragraph 34 of this Judgment and Order. Accordingly, we direct the State, through its police machinery

as well as transport department to regularly patrol these areas and check the transport vehicles carrying sand to verify whether the same is backed by valid permissions and authorizations. If the transporters are unable to indicate the source from where such sand or gravel is mined and to produce necessary permissions/ authorizations for transportation, the police and transport authorities to take stern action, including but not restricted to confiscation of trucks and material therein. The police should also consider, in such cases, to launch prosecution under the relevant sections of the IPC as well as MMDR Act.

k) The State, through its Directorate of Information, is directed to publish in the local newspapers the helpline numbers, so that, the members of the public, are made aware of the same and there is prompt action, once, the helpline is accessed.

l) We direct the Director of Mines and Geology to forward the copy of this Order to the Village Panchayats, Mamlatdars and police stations for the purpose of effective implementation and enforcement.

m) We make absolute the interim orders made by us from time to time in the course of this petition in so far as they relate to the issue of illegal sand mining.

39. As indicated earlier, in this Judgment and Order we are not dealing with the aspect (B) as indicated in paragraph 3 of this Judgment and Order or relief in terms of prayer clause (BB) of the petition. Accordingly, we grant liberty to the petitioners to institute a fresh petition in respect of the said aspect or in respect of relief in terms of prayer clause (BB) of this petition. We however extend the operation of interim order regards this aspect, including in particular, the interim order dated 31.10.2018, as modified on 28.01.2019, for a period of six weeks from today.

40. The Rule is made absolute in the aforesaid terms. There shall be no order as to costs.

SMT. M. S. JAWALKAR, J. ***M. S. SONAK, J.***

ss

Annexure D

Report on [redacted]

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 to 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 costal 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° 42' 42.3" and 15° 35' 53.1" N) and longitudes (73° 51' 31.5" and 73° 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.

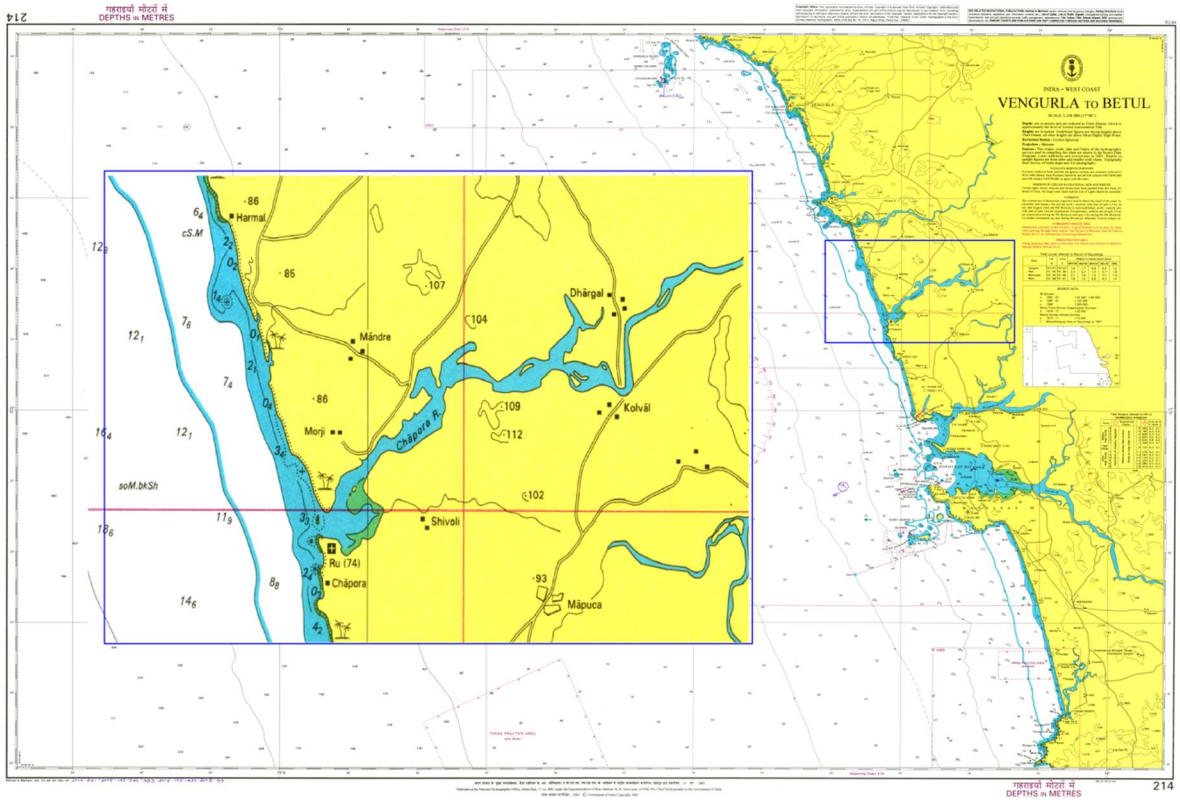


Figure 1.1 Hydrographic Map of Goa. Insight zoom area of Chapora Estuary

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, Noth 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).

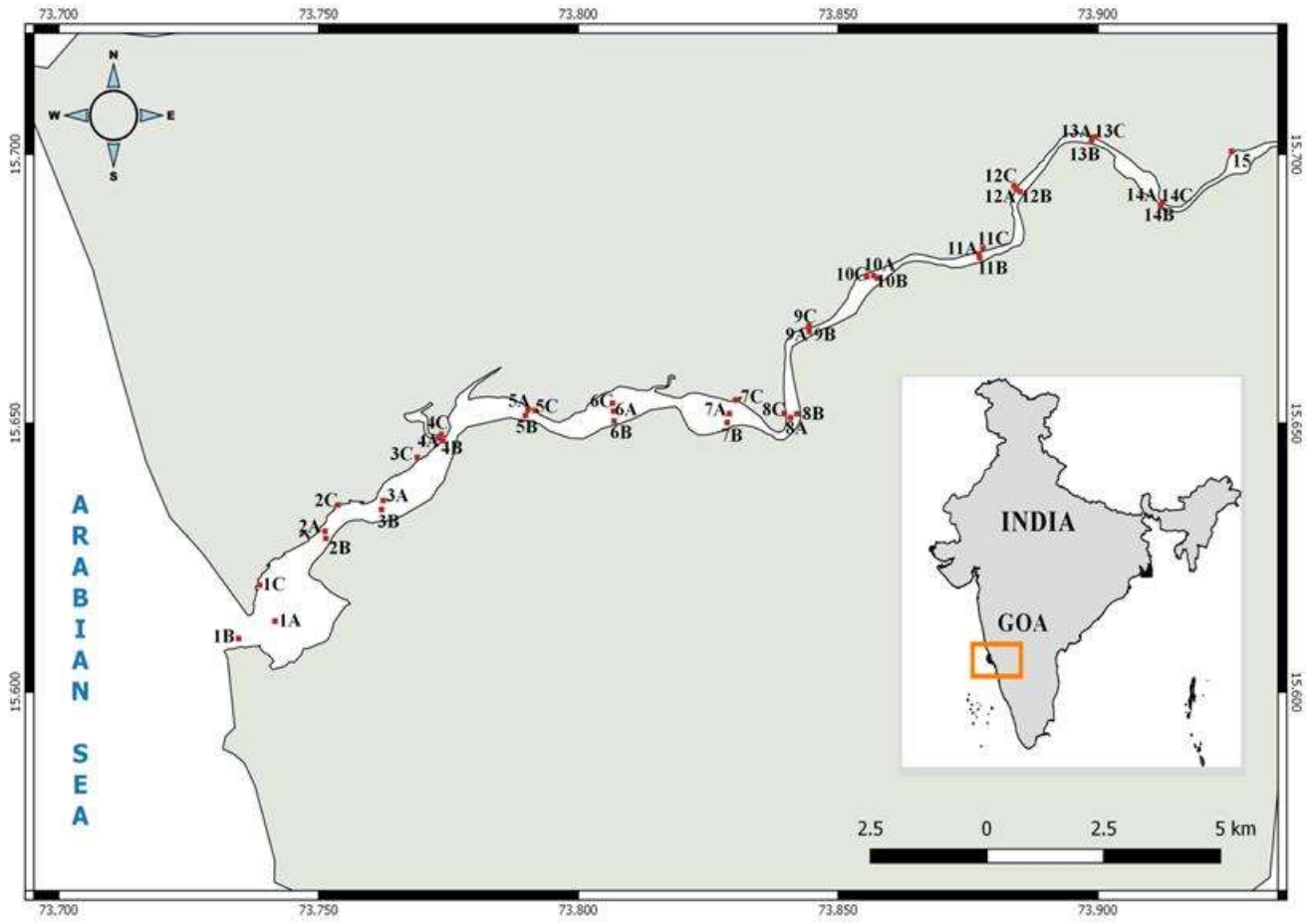


Figure 2.1: Map showing sampling stations of Chapora Estuary

Table 2.1: Coordinates, depth and sediment texture 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

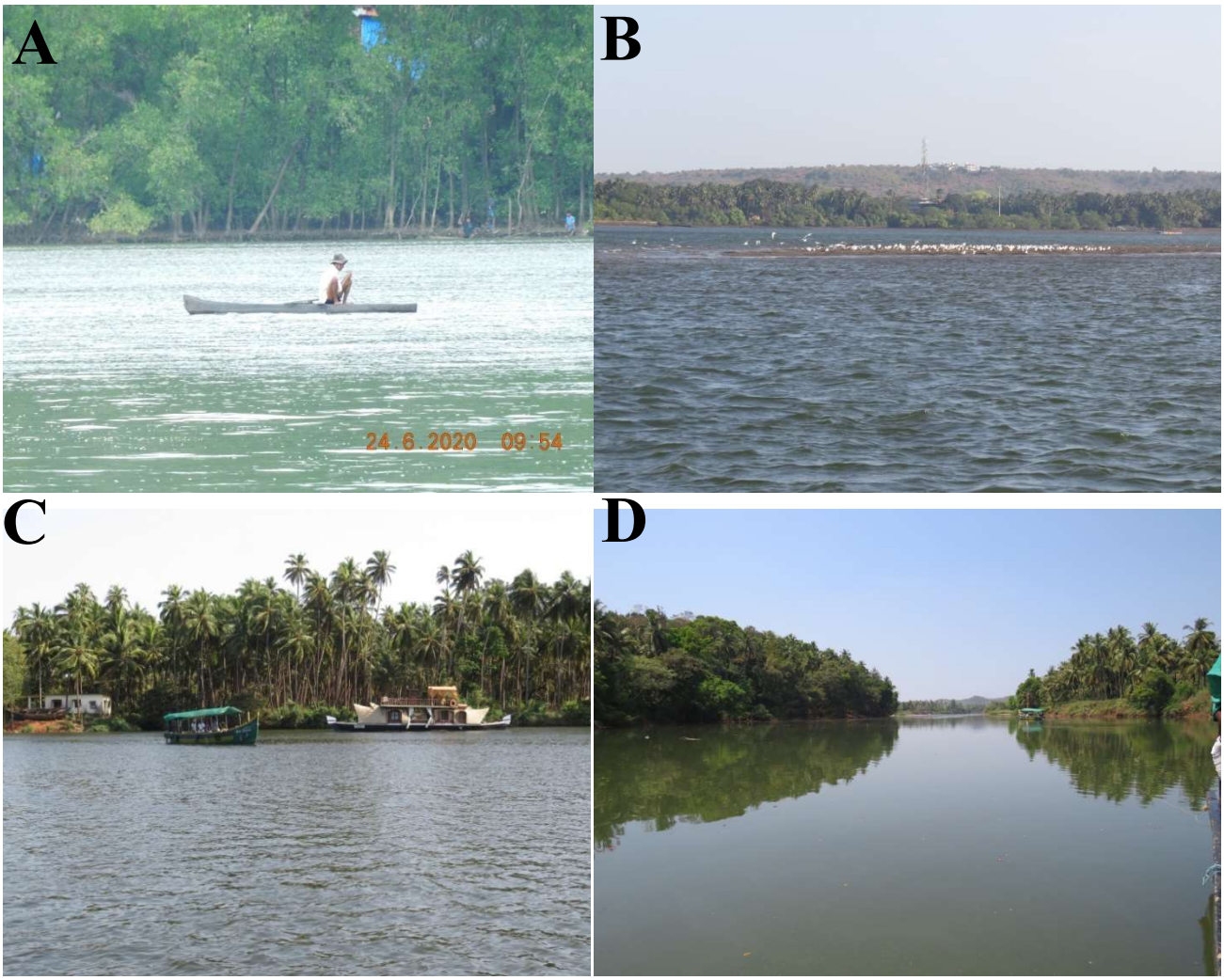


Plate 1: Study area - Chapora Estuary (A- Artisanal fishing in Chapora estuary; B- Mouth region showing exposed sand flat in the estuary; C- Tourism activity in middle stretches of the estuary; D- Upstream region of the estuary.)

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).

3.1Phytoplankton:

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 0.7µm) 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 m^2 and mesh size 200µm 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.

3.4Meiobenthos:

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 (0.0418m^2) for the central stations and metal Quadrant (0.0625 m^2) 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/ m^2. 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/m^2.



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.

Table 3.1: Threshold limits used for ecological status of AMBI and M-AMBI index

	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 (Band4, 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 where 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).

Table 4.1: Chemical parameters of Chapora Estuary

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

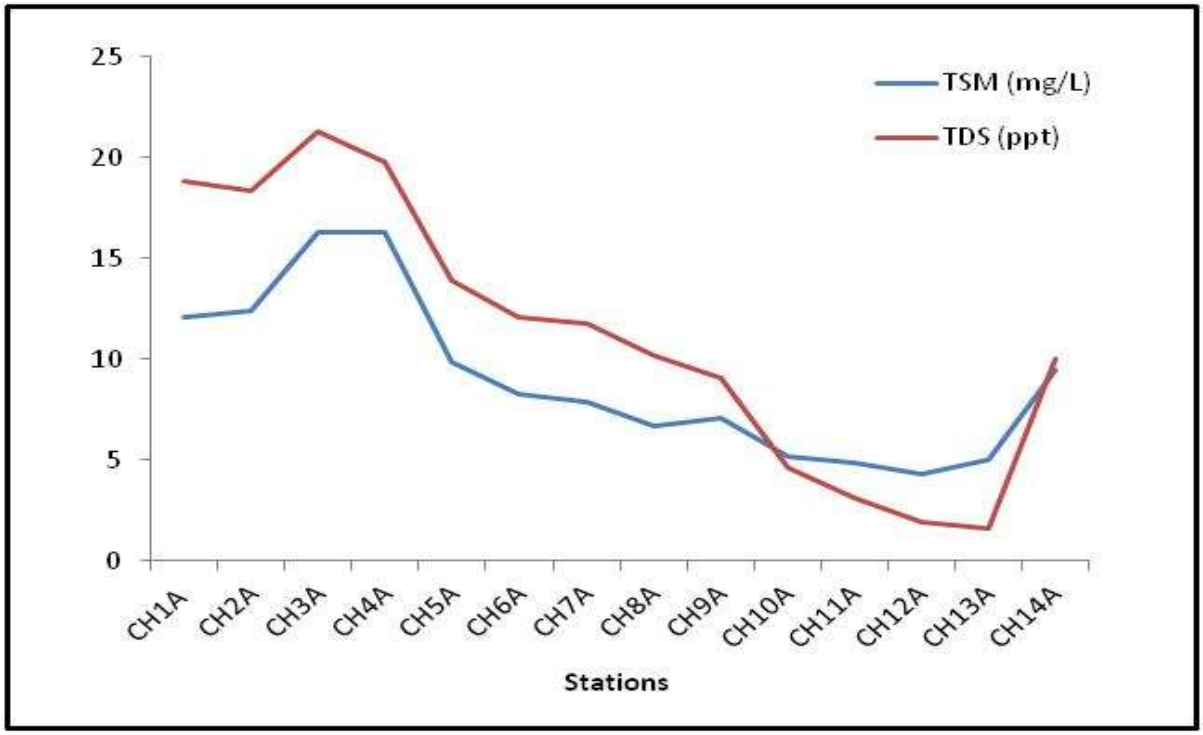


Figure 4.1: Graph depicting TSM and TDS of Chapora Estuary

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^{o}C- 29.5^{o}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)

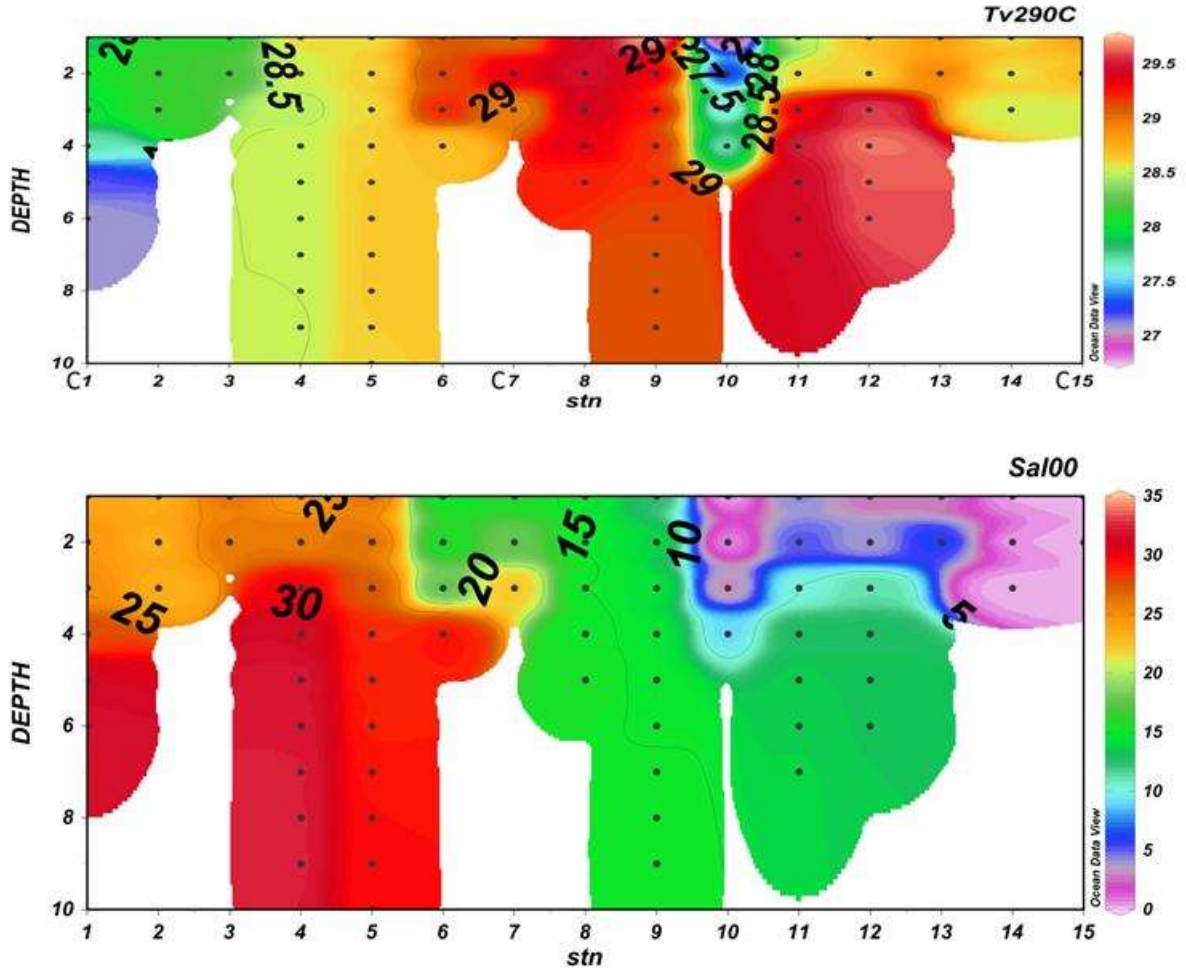


Figure 4.2: Spatial variations in (a) temperature (°C), b salinity (psu) in the Chapora Estuary.(C1-river mouth and C15-upstream region)

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 (~2ml/L) observed at stn C12 has significant implications for nitrogen and carbon mediated by microbial processes (Fig. 4.3).

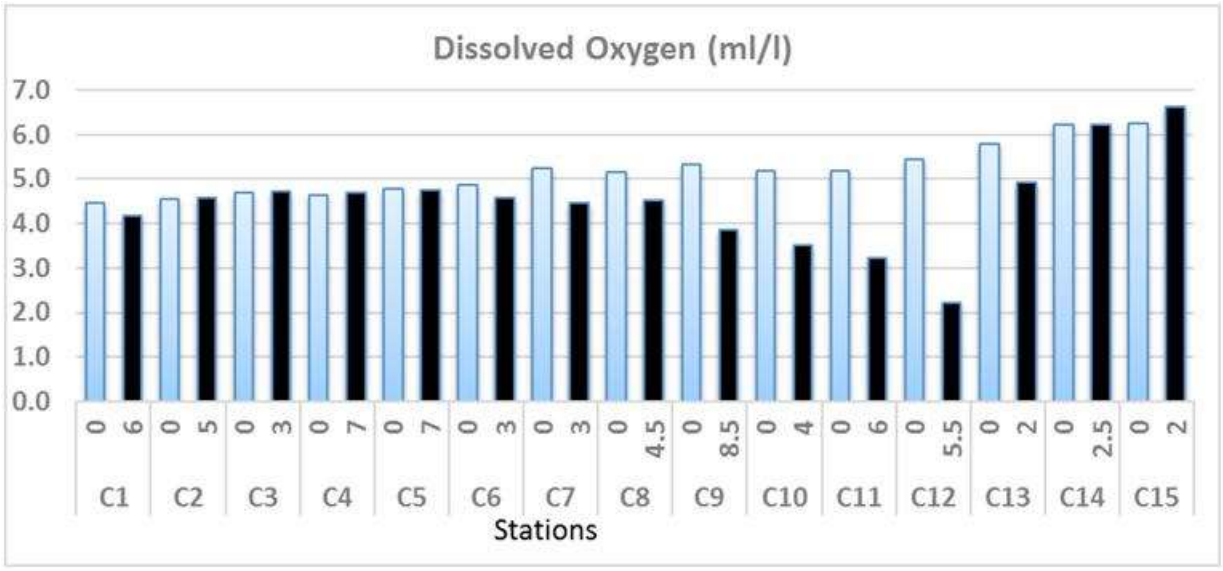


Figure 4.3: Spatial variations (surface and bottom) in dissolved oxygen in the Chapora Estuary.(C1-river mouth and C15-upstream region)

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 (NO3-) was found to be very low (0.03-0.5µM) from mouth to mid-stream region and increased substantially further upstream to be the highest (Stn C15: 5.8µM). Similarly, nitrite (NO2-) was very low (0.02-0.23µM) between the mouth and mid-stream region. But it attained maxima (1.97-2.81µM) just after stn C10 and then decreased further to 0.07µM near stn, C15. Contrary, phosphate ($PO_4$3-) showed the opposite trend to nitrate. Highest $PO_4$3- (0.9µM) was observed at the mouth region, which progressively decreased to 0.26µM in the mid-stream region and further to 0.06µM in the upstream region. Silicate (SiO_4^{4-}) showed a similar trend to NO3-. It increased from 27µM at the mouth region to 76µM in the mid-stream region and further to 112µM 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 PO43- and SiO44- 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 (~2ml/L) observed at stn C12 has significant implications for nitrogen and carbon mediated by microbial processes.

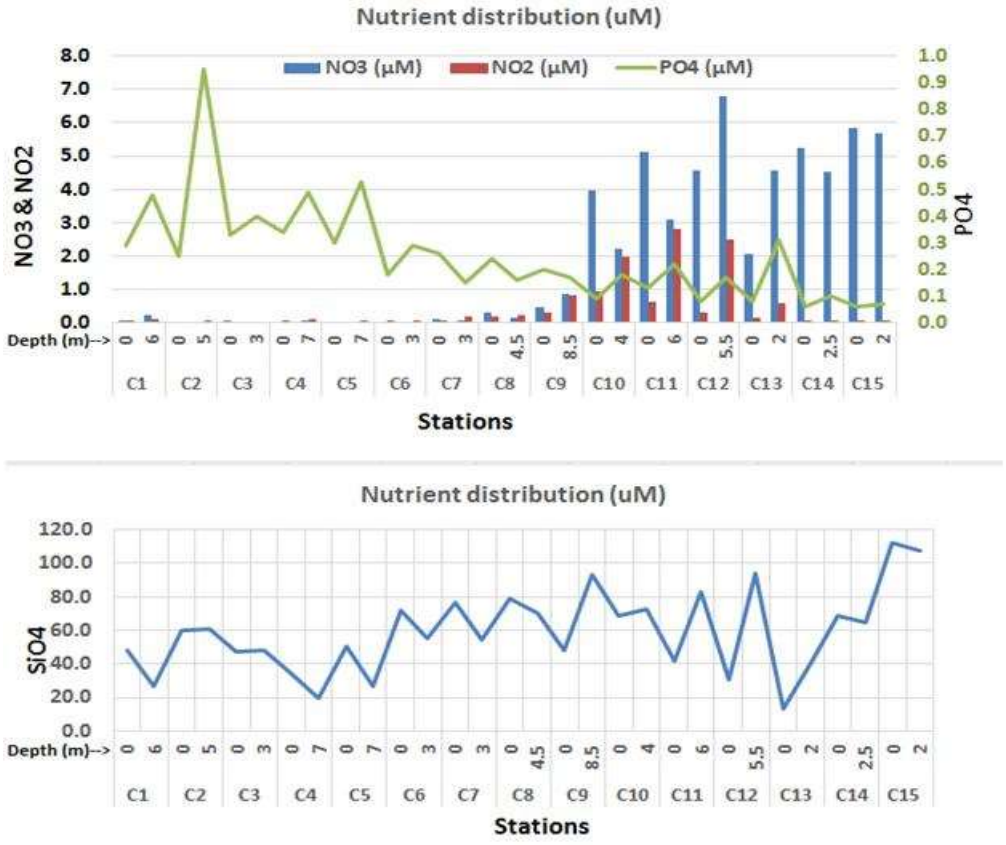


Figure 4.4: Spatial variations in (a) nitrate (NO_3) , nitrite (NO_2) and phosphate (PO_4) and (b) silicate (SiO_4) in the Chapora Estuary.(C1-river mouth and C15-upstream region)

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 CO_2. 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).

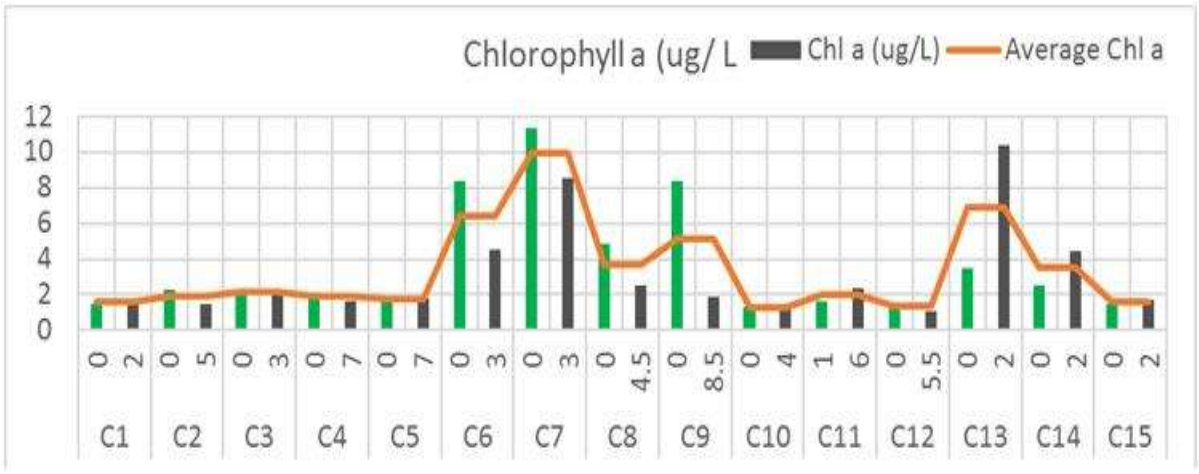


Figure 4.5:Spatial variations in Chlorophyll a (ug/L) in the Chapora Estuary.(C1-river mouth and C15-upstream region)

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).

Table 4.1: Depth wise and spatial variation of phytoplankton abundance, composition in the Chapora Estuary.

	Phytoplankton composition and abundance (Nos./L) [Surface (S) and Bottom (B)]																											
Stations	C1		C2		C3		C4		C5		C6		C7		C8		C9		C10		C11		C12		C13		C14		C15	
Depth	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B
DIATOM (Centric)																														
Agmenellum spp.																												0.60		
Aulacoseira spp.																			10.21	3.64	39.53	16.80	84.20	10.08	73.08	114.9	131.6	134.1	215.3	82.88
Bacteriastrum spp.								0.18							0.78														0.31	
Bellerochea spp.	2.24	1.46	1.88	1.92	2.70	3.40			1.62	1.04	0.43	0.65																		
Cerataulina bicornis								0.54														6.56		8.16						
Cerataulina pelagica				0.48														0.48												
Cerataulina spp.			0.56				0.60	2.16	1.28	1.92	2.88	16.63	0.72	9.33						0.78		1.28								
Chaetoceros danicus	2.06	0.21		0.72					0.35	0.30	0.86	0.22						0.48												
Chaetoceros compressus							5.00	1.26																						
Chaetoceros decipiens	0.34	0.83		5.52	1.26	3.40		2.34	2.32	0.15										0.26		1.60								
Chaetoceros laevis						1.20		0.36	0.23	0.44	0.58	1.51				2.24	1.82					0.32								
Chaetoceros peruvianus				0.72								0.22																		
Chaetoceros subtillis		0.83	8.46	7.92	5.04	11.40			7.08	1.18	22.32	39.96	21.60	23.53	9.10	14.00	6.50	0.96	1.86	10.14	2.16	8.00								
Chaetoceros spp.	4.64	0.42	4.32					8.28			1.15																			
Corethron spp.					0.36						0.14																			
Cosmarium spp.																					1.30		7.00	0.72	1.80	2.08	6.72	3.90	8.74	9.24
Coscinodiscus spp.				0.48	0.54	0.60		3.96	3.25	3.26		0.22		0.21	0.26	0.28				0.78										
Closterium spp														0.42					1.86	0.26	0.22	4.48		0.24						
Cyclotella spp.	4.64		5.45	0.96	1.62	0.80	0.20	2.34	0.81		0.14	1.08	0.24	0.85	1.04	2.80		0.24	0.70	3.90	0.65	5.92	2.00	4.32	0.72	1.04	0.56	0.90		
Dactyliosolen analarcticus											0.29																			
Dinobryon spp.																							0.80			0.52		1.20	0.31	
Ditylum spp.		0.21	1.13		0.18				0.35	0.59										0.26		0.32								
Euglena spp.																							0.40			0.26				
Gossleriella tropica	0.52																													
Guinardia delicatula																														
Guinardia flaccida						0.40			0.23			2.59					0.26													
Guinardia spp.			4.14	0.24		1.40	0.40	0.36	1.62	0.89				0.42	1.04	3.64	0.26			1.30										
Guinardia striata					0.18	1.40		0.72			1.15	6.05		0.42																
Hemiaulus spp.			0.75	1.92	0.36				0.23	1.04	0.29	0.43																		
Leptocylindrus spp.			1.88		2.16	2.00	11.80	15.66	4.06	0.44	6.62	33.48		19.50	1.82	4.20	5.20	2.16	0.70	2.08										
Melosera granulata									10.09	3.40																				
melosera spp.				0.48				0.18																						
Odontella mobiliensis			1.32																											
Odontella sinensis					0.18																									
Odontella spp.	0.86			0.72	0.54	0.20		0.36		0.44	0.14					2.80														
Oocystis spp.																							0.20					0.30		0.28
Oscillatoria																							0.20							
paralia Sulcata																				0.26										
Pediastrum spp.																													0.94	0.28
Pseudoguinardia spp.						0.80		0.36																						
Rhizosolenia imbricata								0.18																						
Rhizosolenia pungens			4.70	1.92	6.66	0.80		0.36																						
Rhizosolania setigera		1.66	5.64	9.60	8.10	6.20	1.00	0.90	2.55	1.48	5.04	7.99		7.42	1.56	7.84	6.50	0.72		4.42										
Rhizosolenia spp.																			0.23			3.68				0.26				
Scenedesmus spp.																			0.46				0.20	0.96		0.26	1.12			0.28
Skeletonema spp.	9.98	1.66	9.78	20.40	1.80	6.00			3.25	3.40		11.88		3.39		5.60	5.46			2.34		2.08		1.20						
Staurastrum parastrum																			0.23											
Staurastrum Diacanthum																			1.16		0.22									
Staurastrum spp.													0.24						0.70		3.46	0.48	7.00		3.96	6.50	23.80	7.50	21.84	13.44
Stigonema spp.																														0.28
Surirella busta												1.51																		
Surirella spp.				0.24	0.18				0.58	0.44		0.22		0.21	0.26	0.84	0.26					0.16		0.24						
Tetraedron spp.																										0.52		0.90	0.62	0.56
Thalassiosira spp.	6.02	1.87	2.82	9.60	4.14	7.40	1.00	2.16	11.72	1.63	7.20	5.18	1.68	5.09	2.60	7.00	3.38	2.88		3.64	0.65					0.52				

DIATOM (pennate)																												
Actinastrum spp.																		0.70						9.54	4.94	22.68	4.80	9.05	2.24
Achnanthus spp.																										0.28			
Amphora spp.	3.96	3.33	1.69	3.12		1.60	0.20	3.96	1.97	1.48	0.14	0.86	0.48	0.21	1.82	0.84		2.40	0.23			0.32	0.60	0.72	0.36	0.78	0.28	0.30	
Ankistrodesmus																		3.94		6.91	1.44	7.00	1.68	3.06	1.82	11.20	4.80	3.12	0.28
Aphiprora alata	7.57																							0.72					
Asterionella japonica									0.12																				
Asterionella spp.																							0.48			0.56			
Attyeya spp.	0.69		0.19																										
Bacillaria spp,									1.16																				
Caloneis spp.																					0.16	0.40							
Calothrix spp.																							0.72						0.28
Ceratoneis closterium						0.60																							
Ceratoneis spp							4.20	10.26																					
Cymbella spp.								0.36	0.23	0.30		0.22	0.24	0.64	0.26	0.84					1.08	3.36	2.40	1.68	2.70	3.38	4.20	1.50	0.62	
Cylindrothica closterium	0.34																												
Cylindrothica spp.										5.92	26.21	4.32	9.60	35.40	9.88	36.40	20.28	1.68	1.62	28.60		12.32	1.00	11.52					
Diploneis spp.			0.75		0.36				0.23	1.33				0.21						0.26				0.24					
Entomoneis spp.	7.05	1.66	8.65	4.80	3.96	6.60		3.06	7.89	5.18		3.24		0.85	0.52	3.64		0.24			0.65	2.56		1.92	0.54	1.82	1.96	3.30		
Euastrum spp.														0.64												1.56	1.96	0.90	1.87	1.12
Fragillaria spp.																								1.92						
Frustulia vulgaris																					0.86								
Frustulia spp.																					0.22								
Glocotrichia spp.																							0.40						
Gomphonema Spp.																								0.24	0.54	0.26			
Gyrosigma balticum																													
Gyrosigma spp.	0.17				0.54		0.40	1.80		1.78	0.58		0.24	0.21		1.40								0.24		0.26				
Licmophora spp.								0.18				0.65	0.72	1.70	0.78	0.56	0.52	3.12	0.46		0.22			1.20		0.78	1.96	0.30	0.62	0.28
Micrasterias spp.																									0.18			33.30		
Meuniera Membranancea					0.36				0.35									0.96												
Navicula directa			0.56	1.68	1.44	0.80			0.23	0.30																			
Navicula distans	0.17																												
Navicula transistance	1.20	2.08	1.50	2.40	0.72	3.40		0.36		0.59	1.01	0.43		0.85															
Navicula granii	1.72																												
Navicula spp.	1.20	6.86	8.84	7.68	2.34	1.40	0.40	5.76	2.90	3.26	2.45	3.89		2.12	0.26	1.68	0.26		0.70	1.30	0.22	3.36	3.40	1.68	1.44	1.30	8.12	4.20	1.25	1.68
Neodenticula seminae						0.60							0.24																
nitzschia longissima	0.86							6.66		2.22	7.78		0.24		2.08	1.40	16.90												
Nitzschia distans					0.18																								
Nitzschia spp.	39.39	32.24	54.90	88.56	31.50	28.40		6.48	24.36	8.88	0.14	20.74		15.26	10.40	11.20				6.76	1.30	2.40	1.80			0.78				
pinnularia spp																						0.48		0.24	1.44		0.28	0.30		
pleurosigma elongatum			0.19																											
Pleurosigma clevei								0.18																						
Pleurosigma directum			1.32	3.12	2.70	1.60																								
pleurosigma normanii			0.75	0.72	0.54	0.40			0.12																					
Pleurosigma spp.	1.03	1.46	1.32	0.72		0.20		3.96	1.28	2.52	1.44	1.94		5.94	1.30	2.80	0.26					1.28		0.72		0.26				
Pseudo-nitzschia spp.	9.46	2.08	10.34	4.08	2.16	3.40	5.40	18.54	6.61	1.48		3.67	6.00	10.81	1.82	2.80	0.78		0.23	2.60		4.80		0.24						
Rhopalodia spp.				0.96	0.36																									
Synedra spp.					0.54	0.20		0.18													0.22	0.48	0.60	0.72	1.80	0.78	1.96			
Striatella spp.			0.19																											
Tabellaria spp.																							0.40							
Thalassionema frauenfeld							0.80	3.24																						
Thalassionema nitzschoid		2.08	5.08	7.92	8.46	5.40	0.60	2.70	1.16		5.33	4.75		9.75	2.08	5.04														
Thalassionema spp.	4.99	0.42	0.38	1.20			0.20		5.80	2.22	2.74		2.88							1.56		0.48		0.48						0.28
Tribonema spp.																											5.04	3.30	13.42	6.72

DINOFLAGELLATES																													
Alexandrium spp.	0.34	0.42		0.24	0.18	1.00					7.49	7.34	1.92	2.12	0.78							0.40							
Amphidinium poecilochro												0.65																	
Amphidinium spp.											0.43	10.37	0.72	0.42	0.78	2.80		0.48											
Adenoides eludens														0.42		0.28													
Balechina coerulea								0.18																					
Ceratium furca			0.19			0.40																							
Ceratium fusus				0.24					0.23																				
Ceratium synmetricum					0.18																								
Chatonella spp.	2.06	0.21	1.50			0.40	0.40	0.54	0.23		1.01	0.43																	
Dinophysis acuta													0.72																
Dinophysis fortii											0.43																		
Dinophysis caudata			0.19								0.43		0.72	0.21															
Dinophysis spp.				0.24																									
Gonyaulax polygramma												0.65																	
Gonyaulax polyndra												0.22																	
Gonyaulax spinifera		0.42																											
Gonyaulax spp.	2.92		4.70	3.12	3.24	2.80	0.20		2.55	1.18	2.45	10.37	0.96	2.97	2.34	3.36	0.78	0.72		1.82									
Gymnodinium spp.			0.19	0.48	0.18	1.40	0.40	1.80	2.32	2.22	2.74	12.53	27.60	4.24	20.80	7.00		22.32	5.34	0.78	3.02	0.48							
Gyrodinium spirale									1.74		1.87	2.81																	
Gyrodinium instriatum									0.12					0.42															
Gyrodinium lachryma											0.14																		
Gyrodinium spp.	0.34		1.13	1.68	0.36	2.20		0.36	1.86	1.18	10.80	53.57	9.60	16.96	0.78	3.64		3.60	3.02	7.80	1.30	0.16	3.60	0.24		0.26	0.28		
Heterocapsa triquatra												0.22																	
Heterocapsa spp.	1.20	0.42	0.56	0.96																									
Noctiluca spp.	0.17					0.40		0.54	0.12		1.30	0.22	0.24	0.42	0.52	0.28	0.26												
Oxytoxum parvum											0.14																		
Oxytoxum spp.	1.72	0.21	0.19	0.24		0.20	0.20	1.44	0.12	0.30		3.67				0.28			0.46	0.26									
Oxyrrhis marrina											27.07	11.66	33.60	22.26	41.34	16.52		42.72											
Podolampas spp.		0.83																											
Podolampas palmipes						0.60																							
Prorocentrum enarginatu															0.26														
prorocentrum gracile		0.42	0.75							0.44			0.24																
Prorocentrum lima												1.08																	
prorocentrum spp.	0.17		0.19			0.20		1.44	0.12			0.22																	
protoceratium spinulosum						0.20																							
protoperidinium depressu										0.15																			
Protoperidinium spp.								0.18	0.23		0.58	1.94	0.96	0.85	0.52	1.40	0.52												
peridinium spp. FW																									3.96	182.0	0.84	3.30	0.62
Pyrophacus spp.				0.96					0.35	0.30	0.29	2.59	4.80		0.78	0.56		0.48						0.72		0.26			
Rhodomonas spp.																						2.00							
Scrippsiella trichodea											2.88	4.10	1.92			1.96													
Scrippsiella spp.	7.05	0.21	1.50	0.72	0.18	1.40	0.60	0.90	6.61	0.30	6.48	7.56	1.92	3.18	4.94	6.16	0.26	6.00	0.70	0.26	1.94	0.16		0.24	0.72	0.78		0.30	1.25
Warnowia polyphemus					0.36							0.22																	
Warnowia spp.									0.35																				
Total phytoplankton	254.2	129.0	321.1	399.4	193.7	226.4	68.0	235.4	245.9	131.1	327.2	613.9	262.1	419.8	247.0	328.2	140.9	185.3	71.0	172.1	132.2	171.8	252.0	108.0	213.1	657.8	450.8	419.4	559.7

Average phytoplankton abundance (x 10^3/L) that varied within the water column from 61-235 (avg. 137± 61.9) showed spatial variation along the length of the estuary with higher population chiefly at the mid-stream region (Zone 2) and a few upstream locations of Zone-3 (stn. C13-C15) (Figure 8). Likewise, depth variation in its abundance was also noticed with higher abundances at the near bottom depth at most sampling sites. Amongst, diatoms were predominant forms of the phytoplankton community contributing >50% to its abundance compared to the dinoflagellates, which were relatively higher at the mid-stream region (Zone -2) (Figure 4.6).

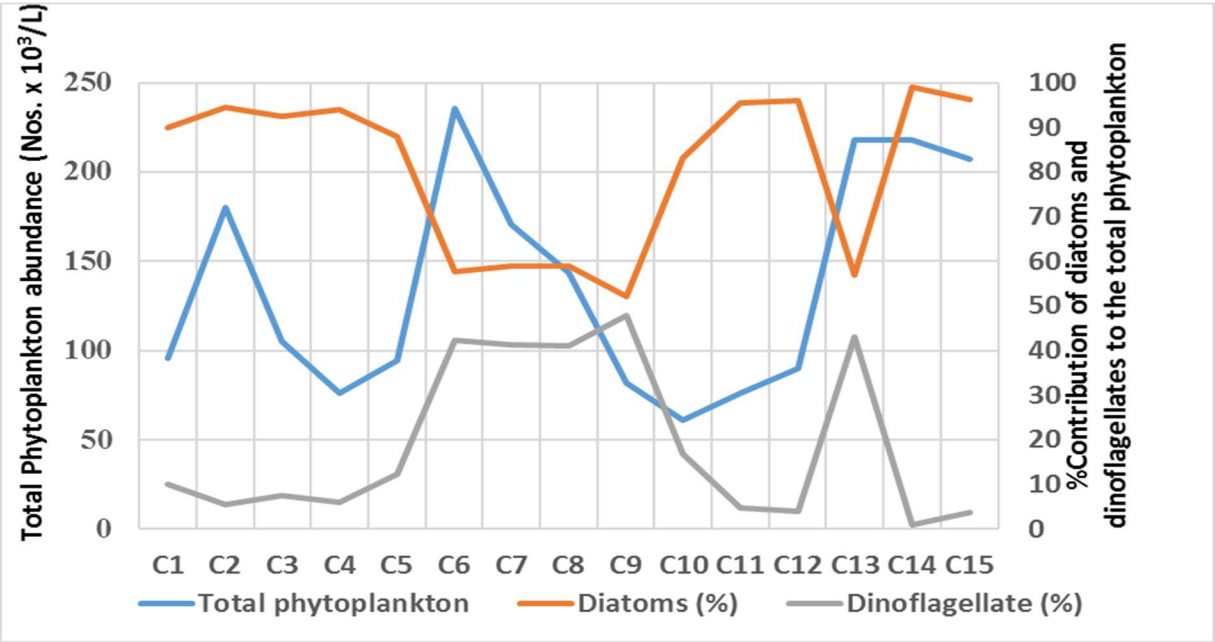


Figure 4.6: Spatial variations in total phytoplankton (Nos./L) and % contribution of diatoms and dinoflagellates in the Chapora Estuary.(C1-river mouth and C15-upstream region)

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

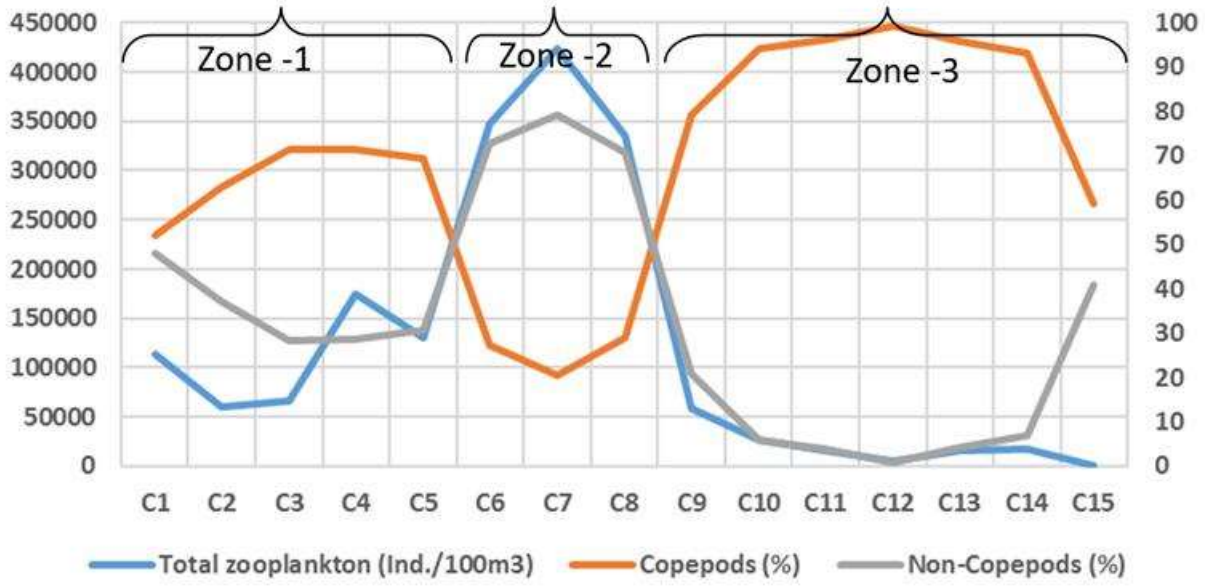


Figure 4.7: Spatial variations in Meso-zooplankton abundance along middle portion of the in the Chapora Estuary.(C1-river mouth and C15-upstream region)

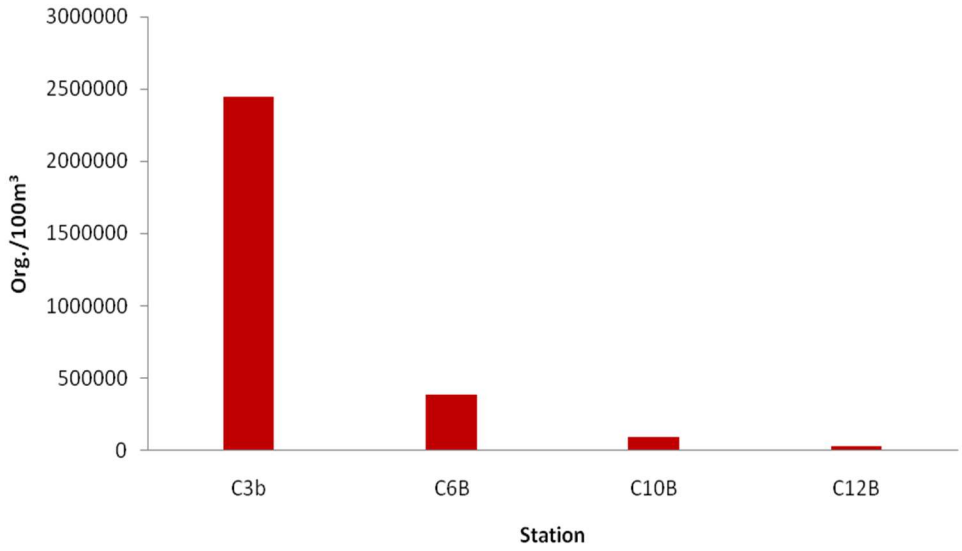


Figure 4.8: Spatial variations in zooplankton abundance along the southern (right side of the river) bank of Chapora Estuary.(C3-near river mouth and C12-upstream region)

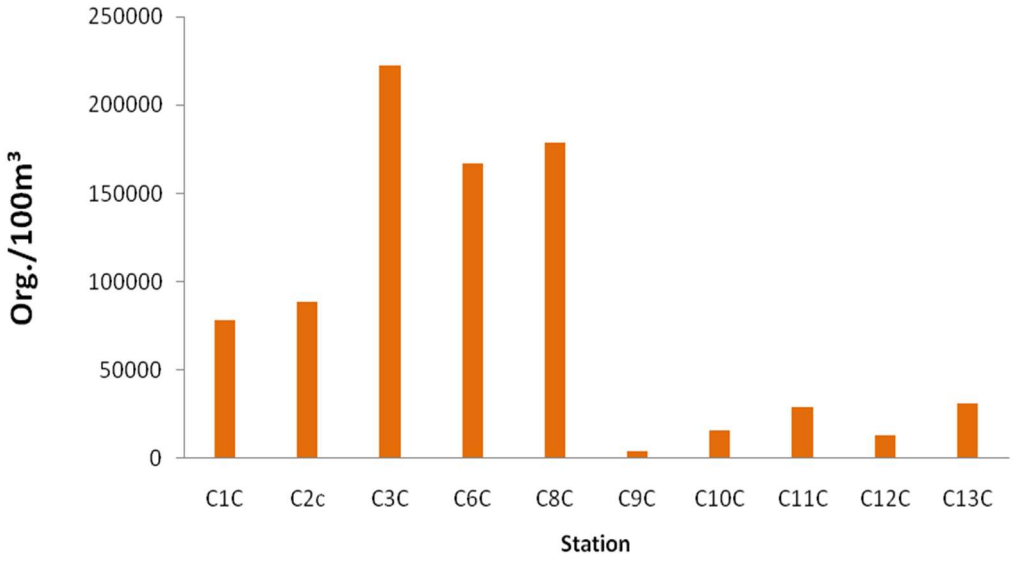


Figure 4.9: Spatial variations in zooplankton abundance along the northern (left side of the river) bank of Chapora Estuary.(C1-river mouth and C15-upstream region)

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
Zooplantkon Composition															
Calanoida															
Paracalanidae															
Acrocalanus sp.	18177	10805	11802	24276	10459		701					52	10787		
Acrocalanus gibber	3231														
Paracalanus sp.	13329	14903	6910	31487	39924	28063	10859	2606	1658	16552	10658	5344	417	731	53
Acartiidae															
Acartia sp.	3635	4844	16616	9254	8660	67150	75663	94895	43928	9037	5018	262	2813	7312	
Pontellidae															
Labidocera spp.		466													
Clausocalanidae															
clausocalanus sp.		93													
Centropagidae															
Centropages furcatus			311	2764	1912										
Centropages sp.															
Calanidae															
Canthocalanus pauper			155	1442	1125				36						
Nanocalanus minor	808		78										35		
Eucalanidae															
Subeucalanus sp.		186	1242	4567	1799										
Temoridae															
Temora discaudata	404			721	562										
Temora turbinata				481	112										
Tortanidae															
Tortanus sp.			155	481	112										
Pseudodiaptomidae															
Pseudodiaptomus sp.	404			481	1125								35	5703	
calanoid unknown												52		292	
Cyclopoida															
Oithonidae															
Oithona sp.	6059	1211	4503	10335	7198		350		108					1316	160
Sapphirinidae															
Sapphirina sp.		93													
copilia sp.															
Harpacticoida															
Ectinosomidae															
Microsettela sp.		93	78	120	112									146	
Macrosetellidae															
Macrosettela gracilis															
Tachidiidae															
Euterpina acutifrons	1212		466	1803	675				36						
Clytemnstridae															
Clytemnestra sp.				120											
Miracia sp.		279		120									12		
harpacticoid unknown										32					107
Poicelostomatoida															
Oncedae															
Onceae spp.	1212	186	2019	5408	3036				108				12		
Corycaecidae															
corycaeus sp.	8482	4844	2562	23074	12258				432				12		
Copepod naupli	2424	93	621	5889	1687								12	146	
Calanoid copepodite				1682									648	146	
calanoid(damaged)															373
Other Groups															
Barnacle nauplii		2888	699	2884	2137	68152	5955	869	2090	95	41				
Bivalve	4039	2608	621	3125	1462	802		434	324	63					
Bryozoan larva	404	186	155	481					36						
calcarious shell													12		
Chaetognatha	5655	6054	2174	3125	9109	23452	6305	3909	1045	190		52	58		
Cladocera	3635	93	1009	6970	1350								58	146	160
Crab juvenile													23		
Ctenophora			78	120	112		350	217							
Cypris		559	155	240	225				36					146	107
Decapod larva	17773	3260	5746	14902	9784	18040	9458	33224	4288	507	249		35		53
Decapoda	404	186							36				12		
Doliolum					112										
echinoderm													23		
Echinoderm larva			78	481	112										
Fish egg	1212	186	699	841	337										
Fish larvae	404	186	155	120	112	601			36	63				146	
Foraminifera	404												12		
Gastropoda	13329	3074	1631	4807	7310	139712	310006	195002	3856	412	290		347	439	53
hydrozoids	1616	373	233										12		
Isopod juvenile				120											
Jelly fish			78		112	200	3503	2606	108	222					
Lucifer			544	721	112	200	701				41				
Oekopleura	1616		466	4927	1125										
Ostracoda		93													
parasitic worm													12		
Polychaete	2424	2422	2795	2283	5960	1604	350	434	180	63				146	
Pteropod		93													
Siphonophora	1616		1553	3726	900			217	36						
stomatopod larva															
water beetle		93													
Water mite													23	146	107
waterfly															
Unidentified arthropod		93													
Unidentified nauplius				120											
unidentified forms									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., S*ubeucalanus* sp., *Nanocalanus minor*, *canthocalanus pauper* and *labidocera* sp., etc. were confined to the river mouth region. moreover, the P*seudodiaptomus* 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).

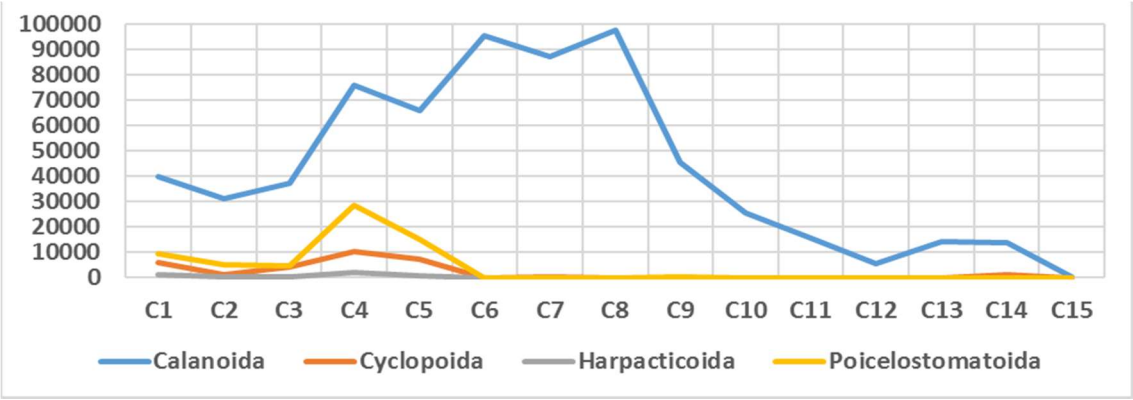


Figure 4.10: Distribution of copepods (Ind/100m^3) from the River mouth (C1) to upstream (C15) regions of the Chapora Estuary.

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/10cm^2) was recorded at station CH3A and lowest (20 ind/10cm^2) 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, Nauplilarvaee, 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%), Crustecean 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 cm^2) 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.

Table 4.7 : Nematoda: Copepoda ratio of Chapora Estuary (Central transect)

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

Table 4.8 : Nematoda: Copepoda ratio of Chapora Estuary (Peripheral transect)

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

Table 4.8?: Continued..

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

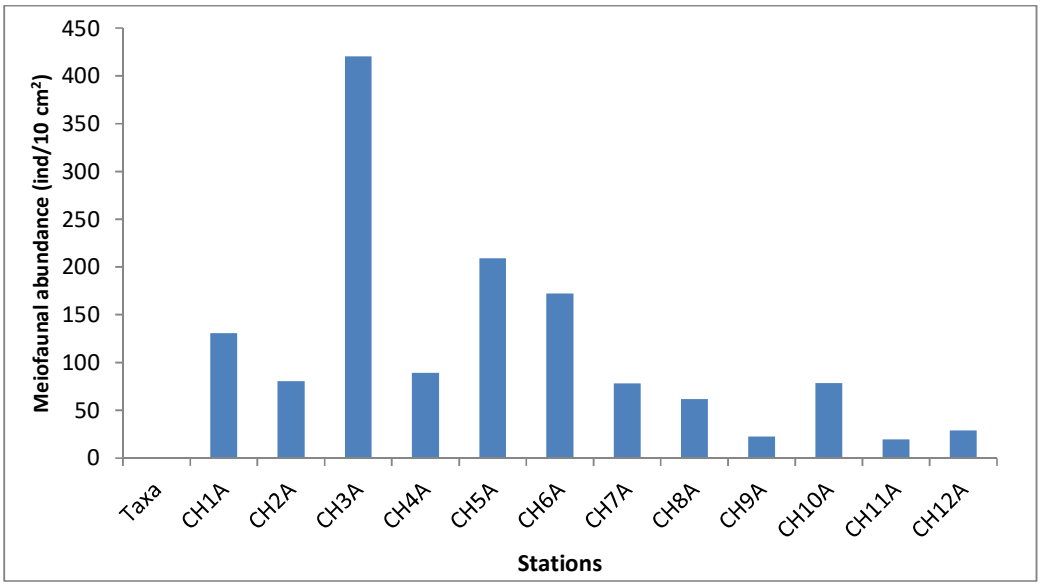


Figure 4.11: Station-wise meiofaunal abundance (ind/10 cm^2) from River Chapora (Central transect).

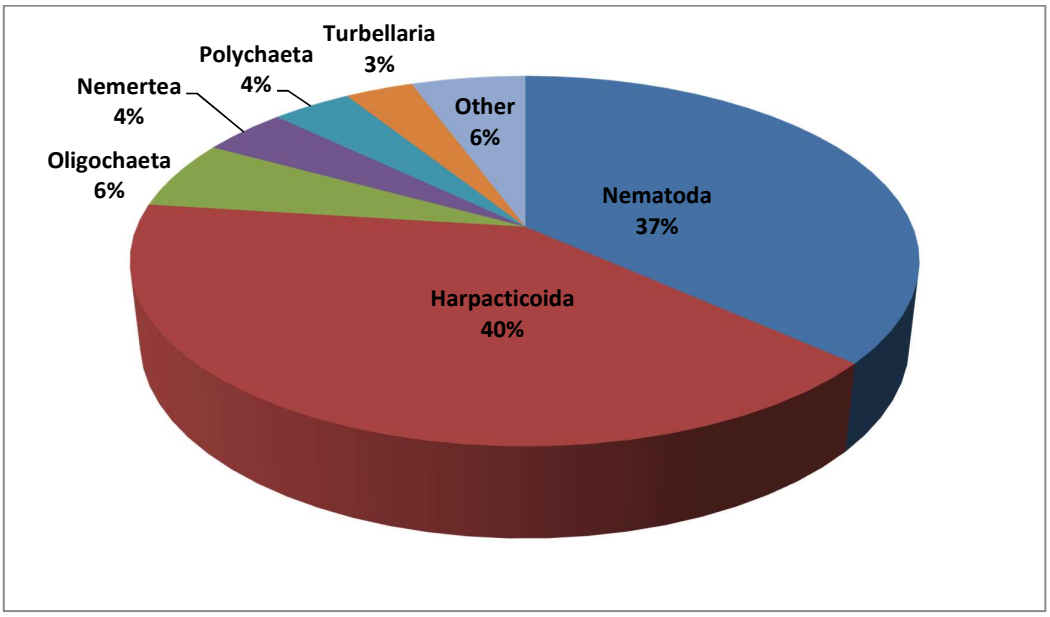


Figure 4.12:Percent composition of meiofaunal taxa from River Chapora (Central transect).

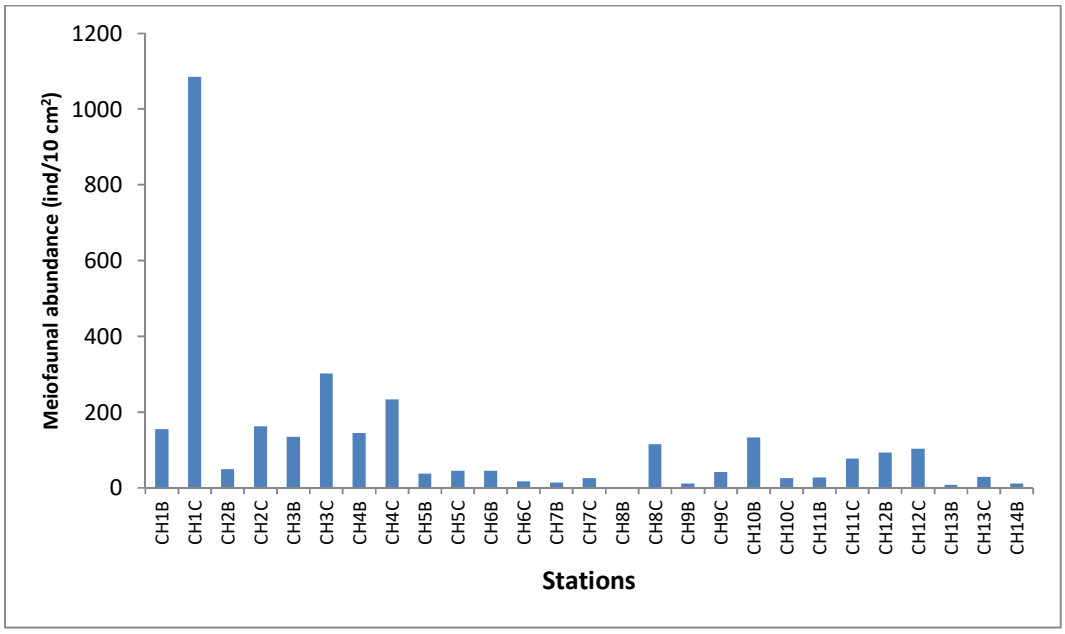


Figure 4.13:Station-wise meiofaunal abundance (ind/10 cm^2) from River Chapora (Peripheral transect).

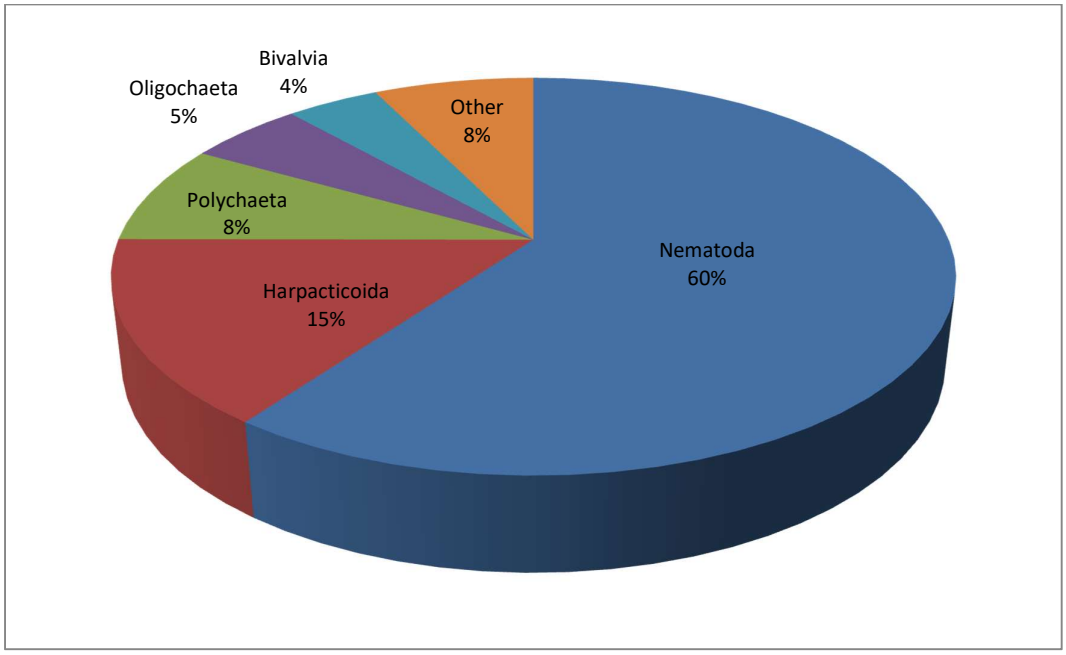


Figure 4.14:Percent composition of meiofaunal taxafrom River Chapora (Peripheral transect).

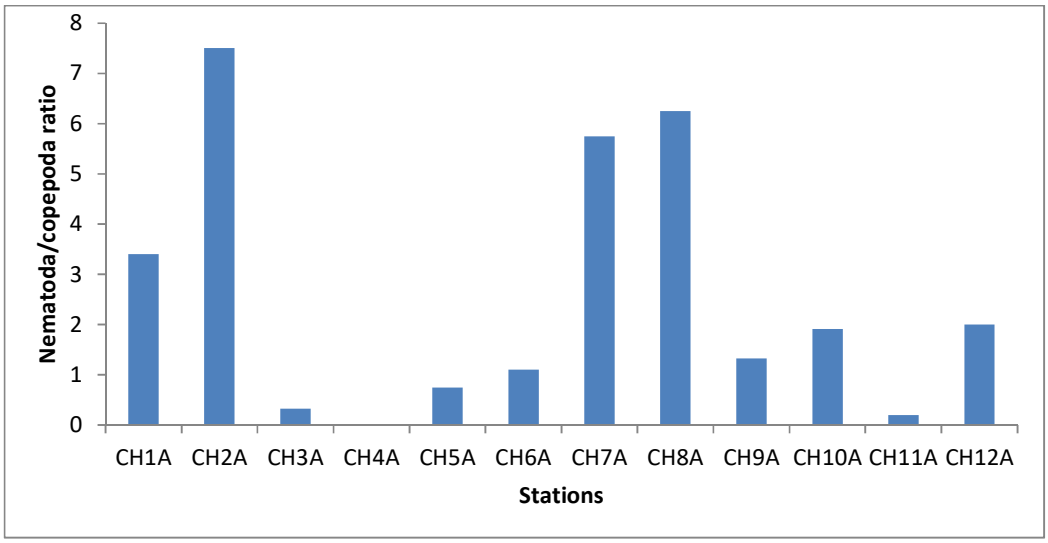


Figure 4.15: Station-wise Nematoda:Copepoda ratio from River Chapora (Central transect).

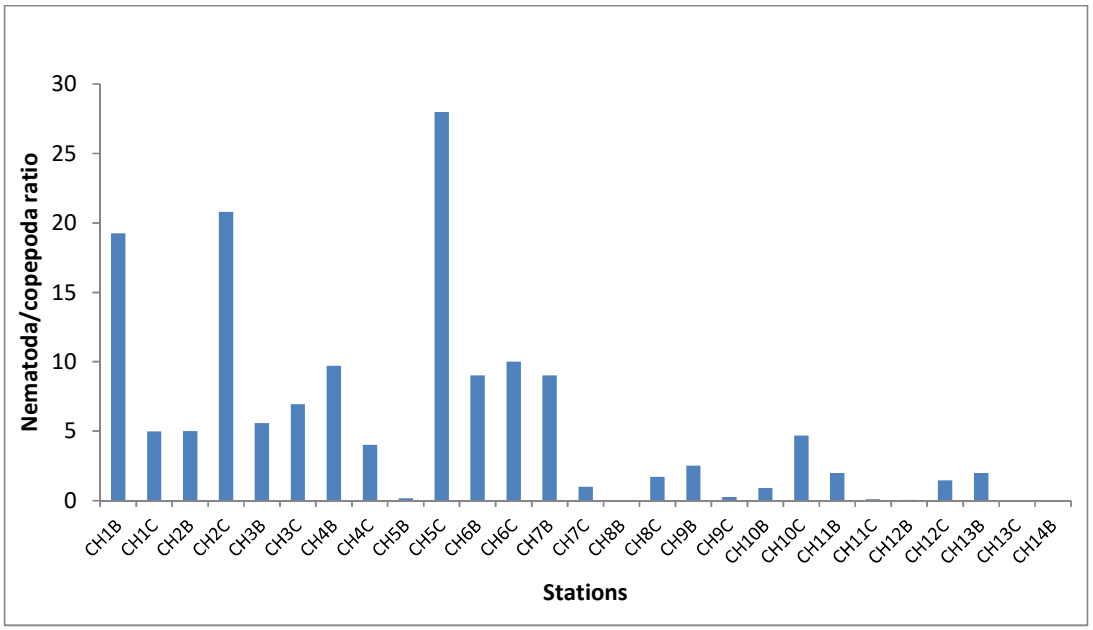


Figure 4.16 :Station-wise Nematoda:Copepoda ratio from River Chapora (Peripheral transect).

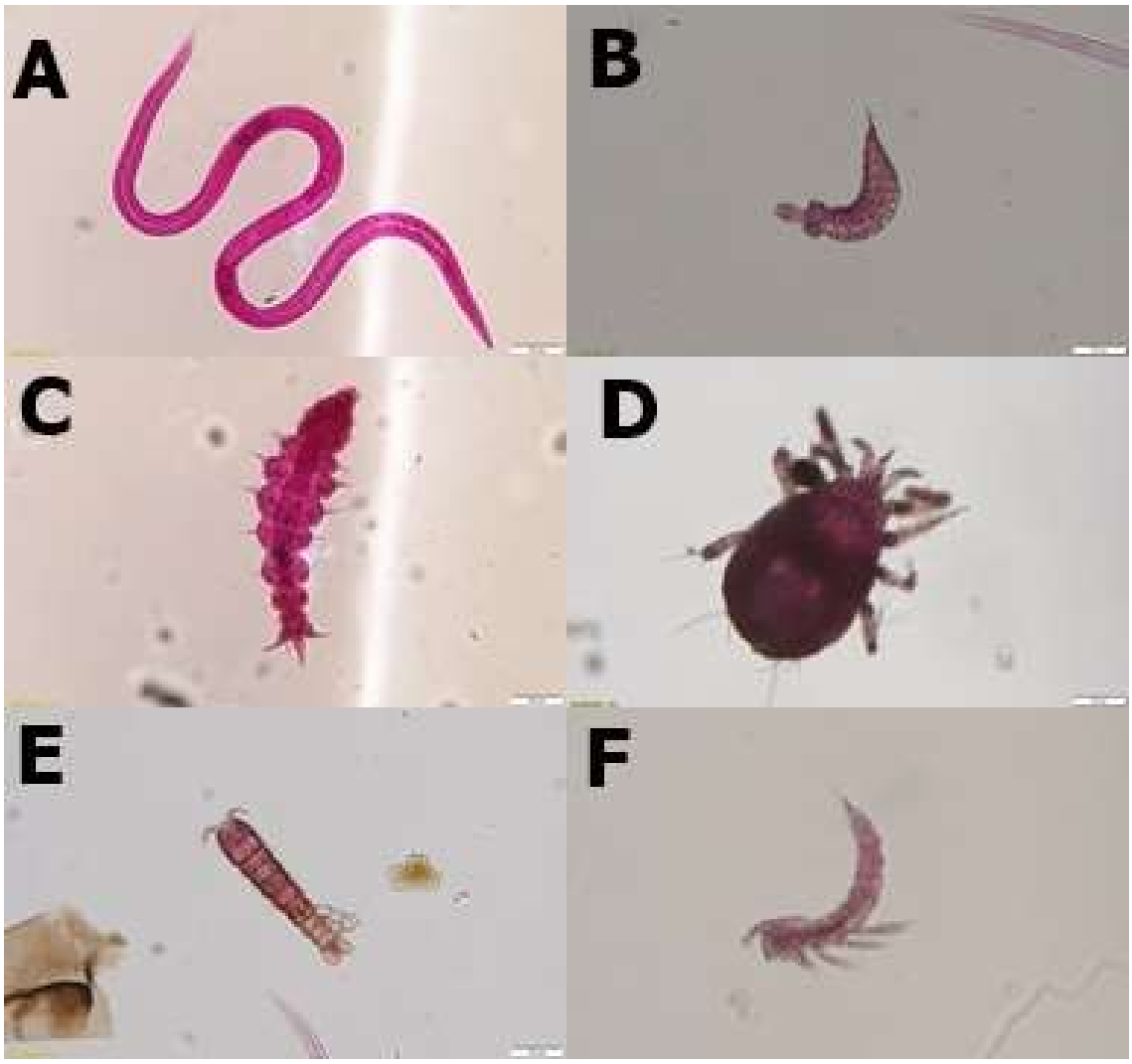


Plate 2: A=Nematoda, B=Kinoryncha, C=Polychaeta, D=Halacarida, E and F=Harpacticoida

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.

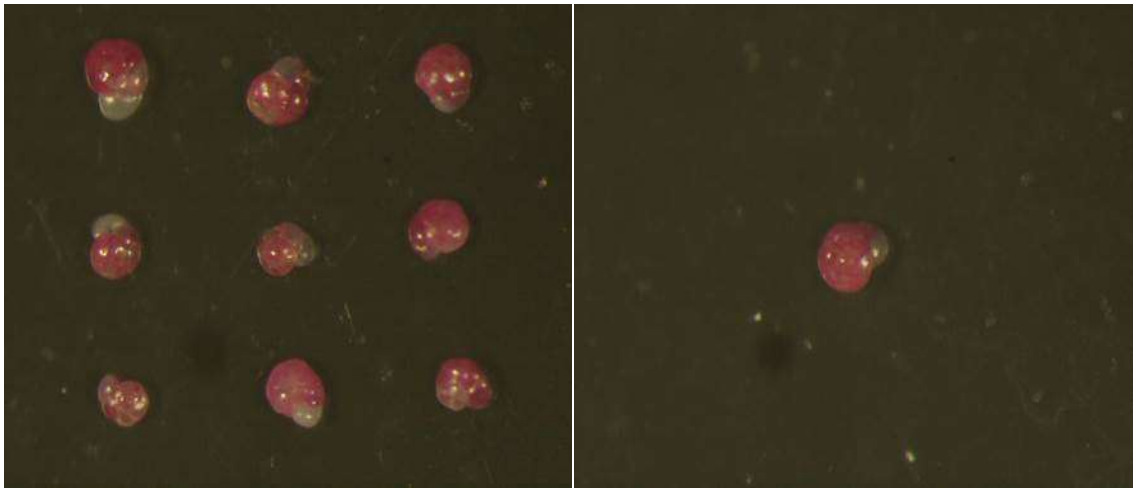


Plate 3: Foraminifera species found in Chapora Estuary.

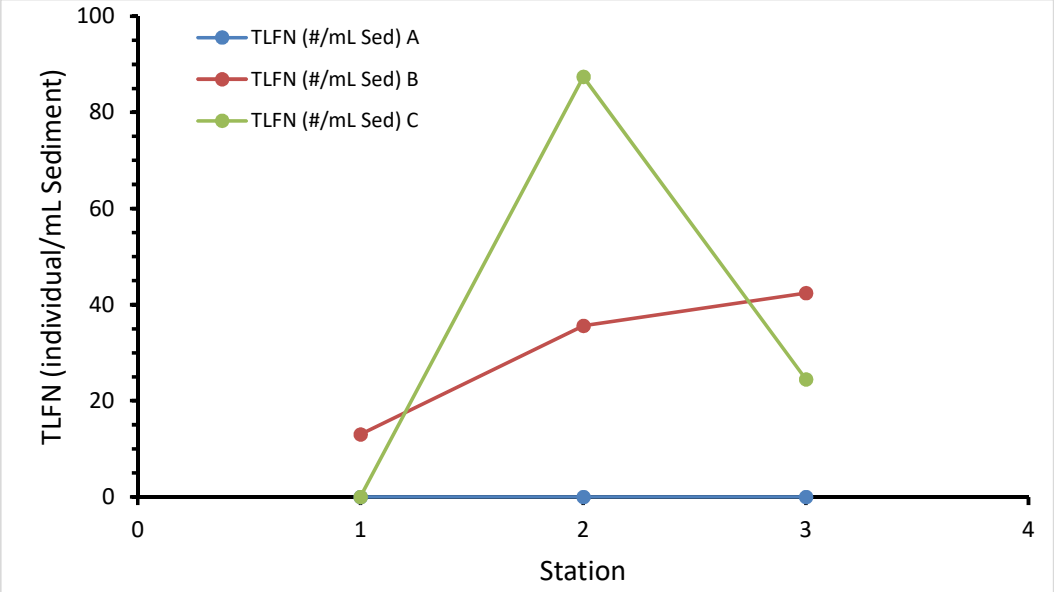


Figure 4.17: Total Living Foraminifera Number in Chapora Estuary

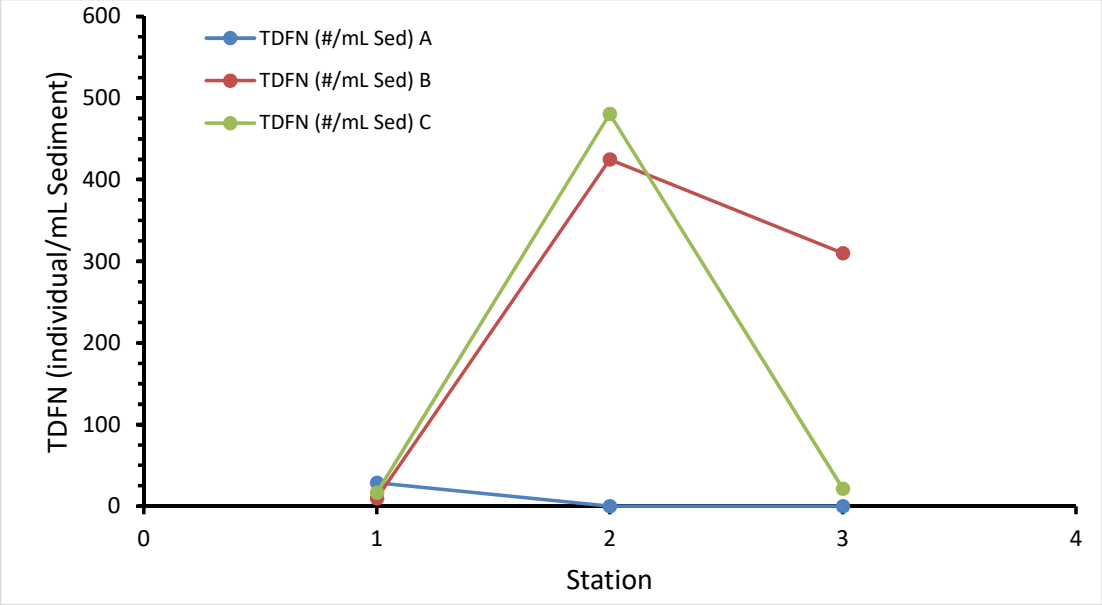


Figure 4.18: Total Dead Foraminifera Number in Chapora Estuary

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/m^2) followed by CH8A (2556 no/m^2). However, lower abundance found in CH 1A (24no/m^2), (Table 4.9). In Polychaeta, *Prionospio pinnata* was the highly abundant species at station CH12A (3345no/m^2), and lower abundance at station CH8A (1696 no/m^2) and was absent at CH1A and CH1B stations. *Glycera alba* was the second dominant species with highest at CH8A (382no/m^2) and lowest abundance found at CH1A, CH2A and CH12A with 24 no/m^2. Bivalvia were the second dominant taxa present at CH6A, CH7A, Ch8A, CH9A and CH12A. Other taxa like Nematoda, Sipunula, Crustacea, Gastropoda, Ophuiroidea, 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, Ophuiroidea, 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/m^2) followed by CH10B (11328 no/m^2) and CH 2B (11200 no/m^2) whereas low abundance was observed at CH8B (48no/m^2) 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/m^2 from all the sampling stations. High abundance of *Nereis* sp. was found in CH11C (6928 no/m^2) and CH12C (6384 no/m^2) and less at station CH1B, CH3B, CH3C and CH8C. *Prionospio pinnata* was the second abundant species with 29136no/m^2 from all the samples. Station CH11C showed high abundance (7360 no/m^2) followed by CH10B (3968 no/m^2) and CH13C (3872 no/m^2) 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/m^2 from all the stations, herein at CH13C and CH10B Amphipoda abundance was found to be 3120 no/m^2, 2912 no/m^2. Chironomidae larvae (3824 no/m^2) were also found upstream region of the river at the station CH10B to CH14B. Bivalvia (1344 no/m^2) and Oligochaeta (3072no/m^2) 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/m^2 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/m^2 and low at CH3C, CH5B and CH8B with 0.02g/m^2 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
*Nereis*sp.	0	0	24	0	0	0	24	0	0	24	0	72	0.59
*Heteromastus*sp.	0	0	0	24	0	0	24	0	0	24	0	72	0.58
Prionospio pinnata	0	0	119	24	96	72	1696	1003	549	1505	3345	8409	68.48
Polydoraciliata	0	0	72	0	0	0	0	0	0	0	0	72	0.58
Glycera alba	24	24	119	143	119	72	382	119	0	0	24	1027	8.27
Ancistrosyllis sp.	0	0	24	0	0	0	0	0	0	0	0	24	0.19
*Lumbrineris*sp.	0	0	0	0	0	0	72	0	0	0	0	72	0.58
Amphictene sp	0	24	0	0	0	72	0	0	0	0	0	96	0.78
Sabellaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0.00
*Poecilochaetus*sp.	0	406	0	0	0	0	0	0	0	0	0	406	3.31
Inemophtys inermis	0	0	48	0	0	24	0	0	0	0	0	72	0.58
Aphrodite sp.	0	0	24	0	0	0	0	0	0	0	0	24	0.19
Orbinia sp.	0	0	24	0	215	0	0	0	0	0	0	239	1.95
Echuira	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
Ophuiroidea	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/m^2)	**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
Nereis sp.	16	0	1568	0	16	16	32	0	0	224	0	32	320
*Mediomastus*sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Heteromastus sp.	0	0	4512	336	416	16	32	128	0	3264	32	48	112
Prionospio pinnata	16	64	2144	32	0	0	416	48	0	208	112	32	544
Polydoraciliata	0	0	0	0	0	0	0	0	0	0	0	16	0
Glycera alba	32	32	224	0	0	0	32	0	0	0	0	0	0
*Ancistrosyllis*sp.	0	0	864	16	0	0	224	0	0	16	0	0	0
Lumbrineris sp.	0	0	32	0	0	0	0	0	0	32	0	0	0
Amphictene sp	0	0	0	0	0	0	0	0	0	0	0	0	0
Sabellaria sp.	0	0	0	0	0	0	0	0	0	16	0	0	0
Poecilochaetus sp.	0	0	64	0	0	0	0	0	32	0	0	0	0
Paraonis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydroides sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Inemophtys inermis	0	32	112	0	0	0	0	0	0	0	0	0	0
Hesione sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
*Chaetopterus*sp.	0	0	32	0	0	0	0	0	0	0	0	0	0
Aphrodite sp.	0	0	16	0	0	0	32	0	0	0	0	0	0

Orbinia sp.	272	16	0	0	0	0	320	0	0	0	0	0	0
*Maldanella*sp.	32	0	0	0	0	0	16	0	0	0	0	0	0
Ophelia sp.	80	0	0	0	0	0	48	0	0	0	0	0	0
Echuira	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
Nereis sp.	0	16	0	0	3808	1200	4000	6928	864	6384	48	3056	1456	912	30896	32.65
*Mediomastus*sp.	0	0	0	0	16	0	0	0	0	0	0	0	0	0	16	0.02
Heteromastus sp.	0	0	16	48	0	0	0	0	0	0	0	0	0	1008	9968	10.53
Prionospio pinnata	0	480	800	672	3968	4112	288	7360	2512	704	448	3872	112	192	29136	30.79
Polydoraciliata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.02
Glycera alba	16	160	32	96	16	16	0	0	0	0	0	32	0	16	704	0.74
Ancistrosyllis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1120	1.18
Lumbrineris sp.	0	0	0	0	128	0	0	0	0	0	0	16	0	0	208	0.22
Amphictene sp	0	96	0	64	0	0	0	0	0	0	0	0	0	0	160	0.17
Sabellaria sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.02
Poecilochaetus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	0.10
Paraonis sp.	0	0	0	0	0	0	0	16	0	0	0	0	0	0	16	0.02
Hydroides sp.	0	0	0	0	0	0	0	0	0	0	48	0	0	0	48	0.05
Inemophtys inermis	0	0	0	48	0	0	0	0	0	0	0	0	0	0	192	0.20
Hesione sp.	0	0	0	0	16	0	0	0	0	0	0	0	0	0	16	0.02
Chaetopterus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0.03
Aphrodite sp.	0	0	0	0	0	0	0	0	0	0	16	0	0	0	64	0.07
Orbinia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	608	0.64
Maldanella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0.05
Ophelia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128	0.14
Echuira	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

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
Platyheminthes	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

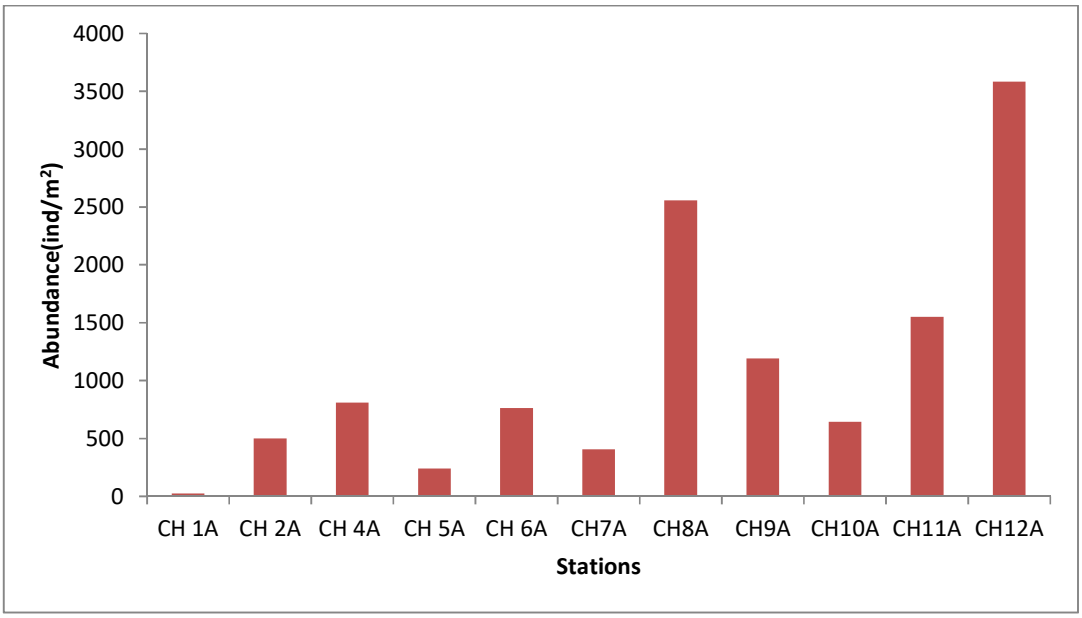


Figure 4.19: Station-wise macrofaunal abundance (no/m2) of the Chapora Estuary (Central transect).

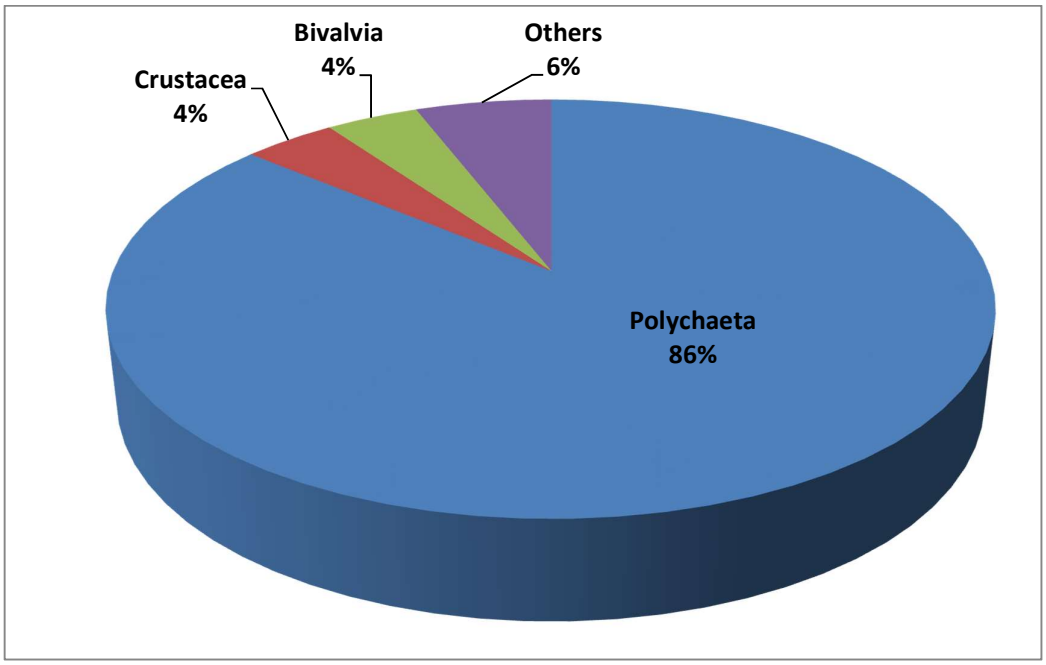


Figure 4.20: Percent (%) composition of macrofaunal abundance of the Chapora Estuary (Central transect).

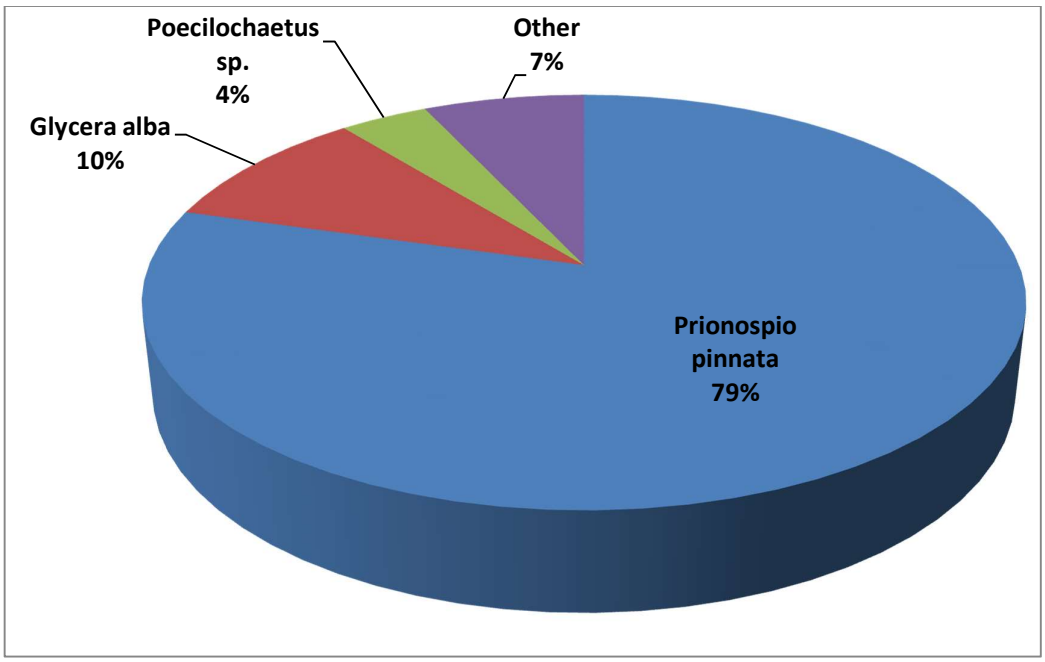


Figure 4.21: Percent (%) composition of Polychaetaof the Chapora Estuary (Central transect).

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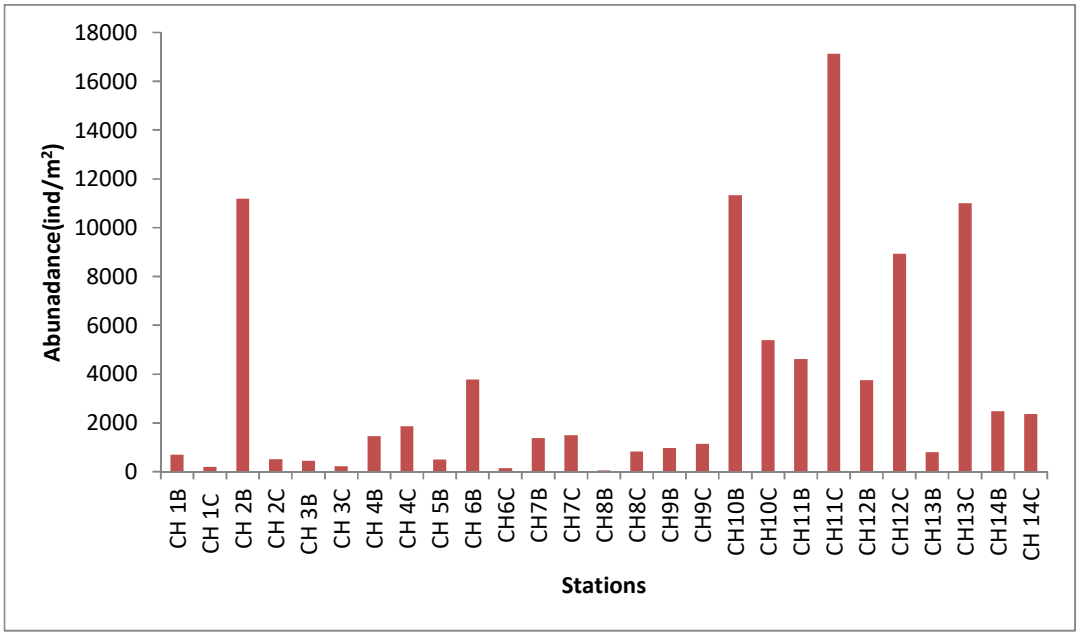


Figure 4.22: Station-wise macrofaunal abundance (no/m2) of the Chapora Estuary (Peripheral transect)..

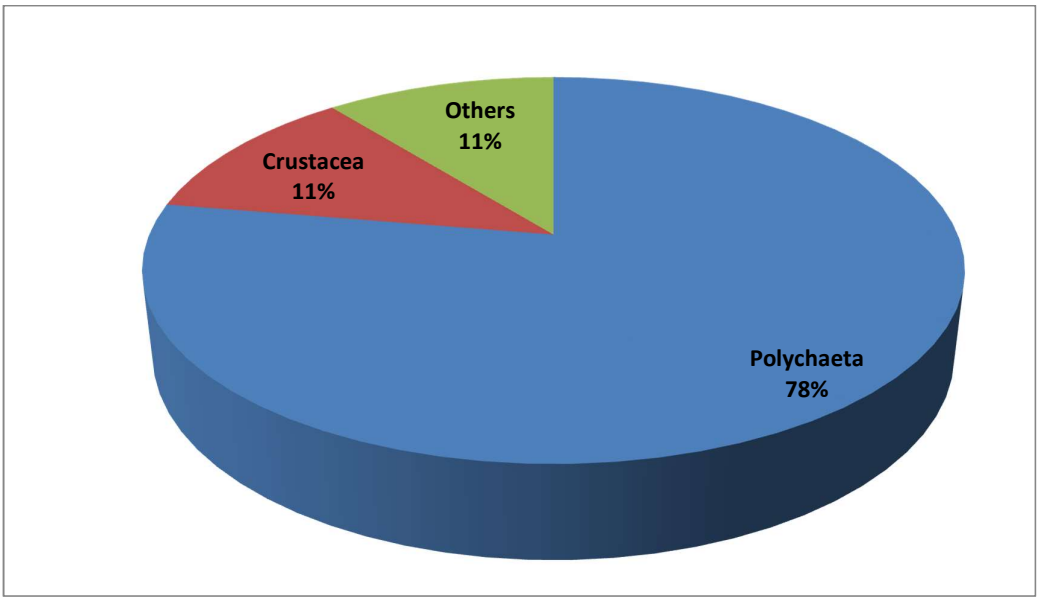


Figure 4.23: Percent (%) composition of macrofaunal abundance of the Chapora Estuary (Peripheral transect).

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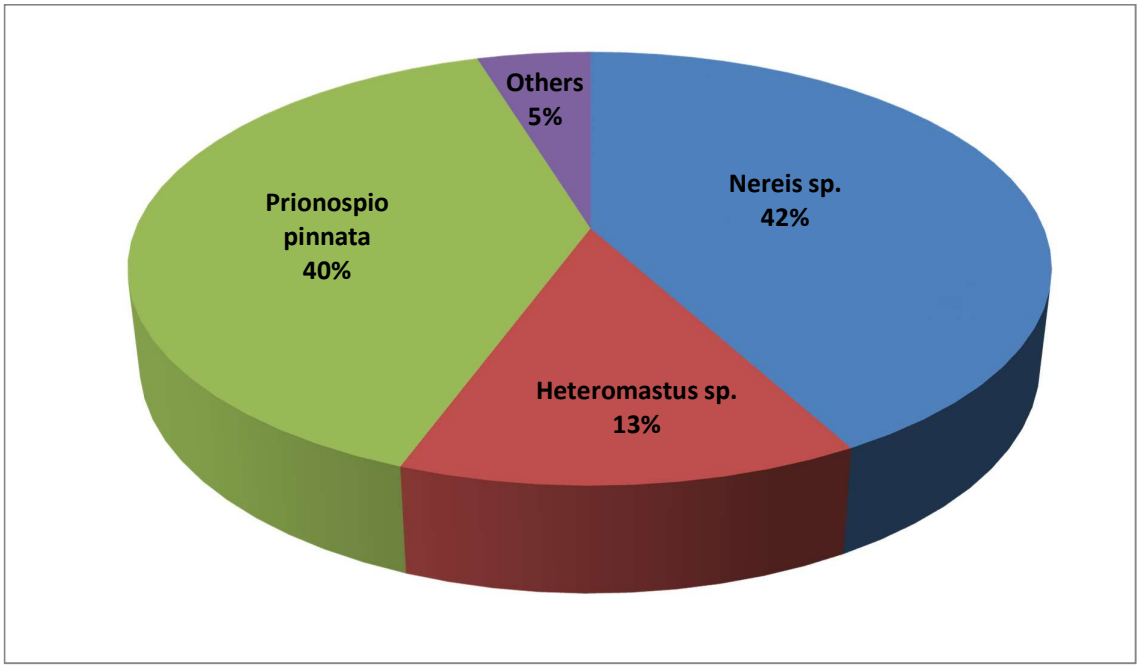


Figure 4.24: Percent (%) composition of Polychaeta of the Chapora Estuary (Peripheral transect).

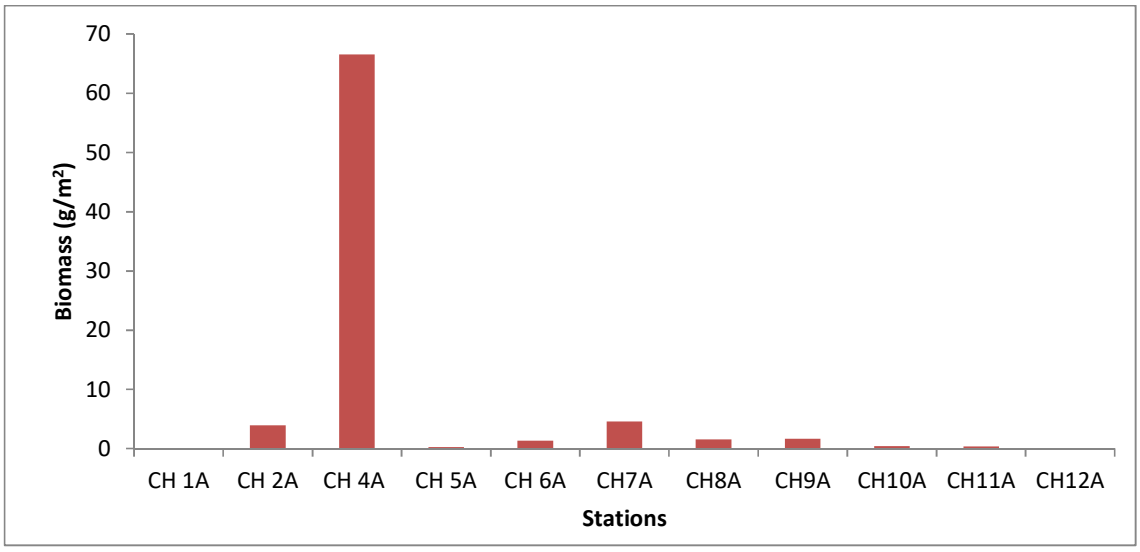


Figure 4.25: Station-wise Biomass (g/m2) of the centre of the Chapora Estuary.

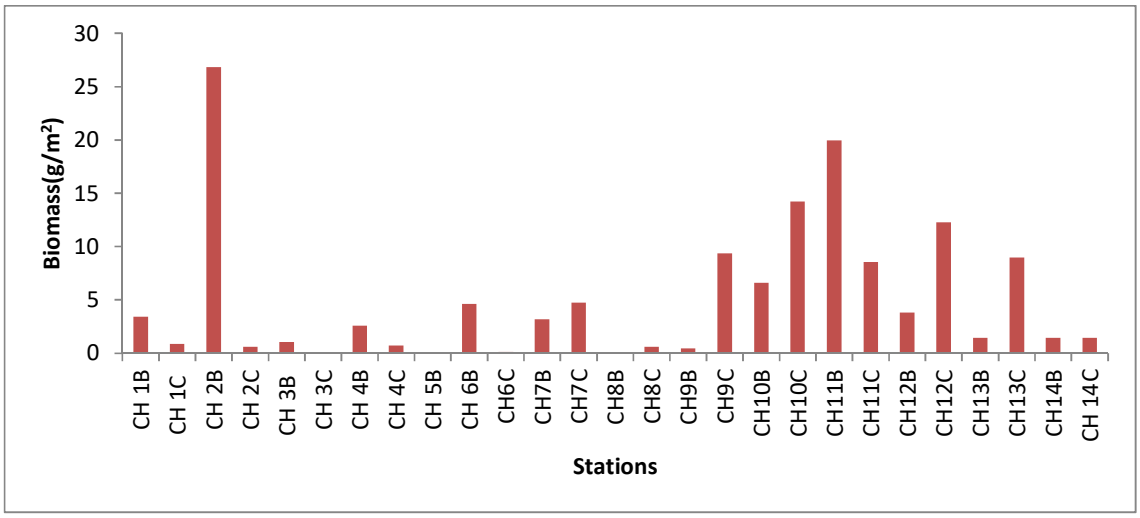


Figure 4.26: Station-wise Biomass (g/m2) of the Chapora Estuary (Peripheral transect).

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Plate 4: Macrofauna of Chapora Estuary A-*Prionospio pinnata*; B-*Heteromastus* sp.*;* C-*Glycera alba;* D- *Inemophtys 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.

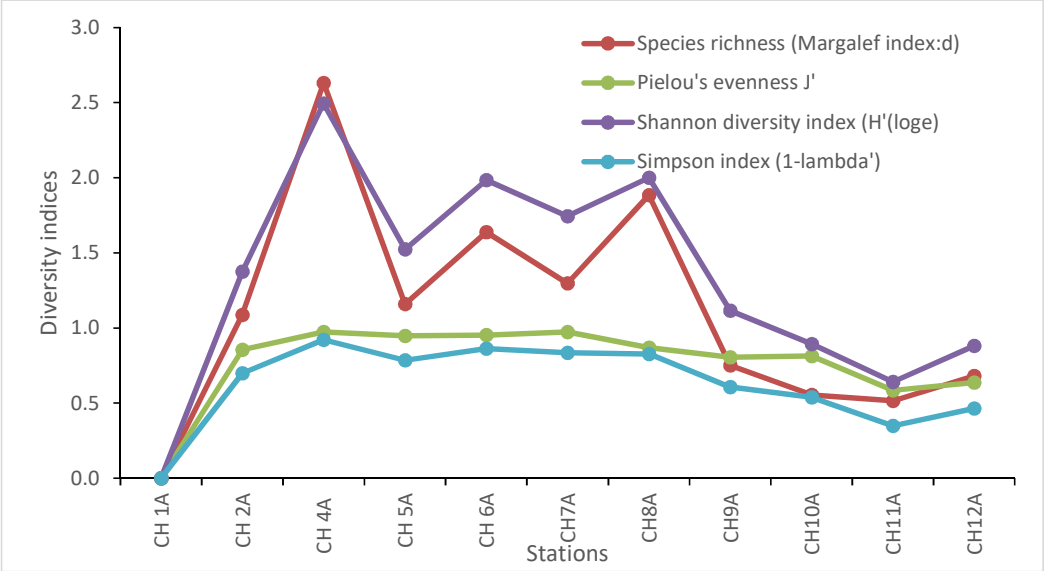


Figure 4.27: Station-wise diversity indices of Chapora Estuary (Central transect).

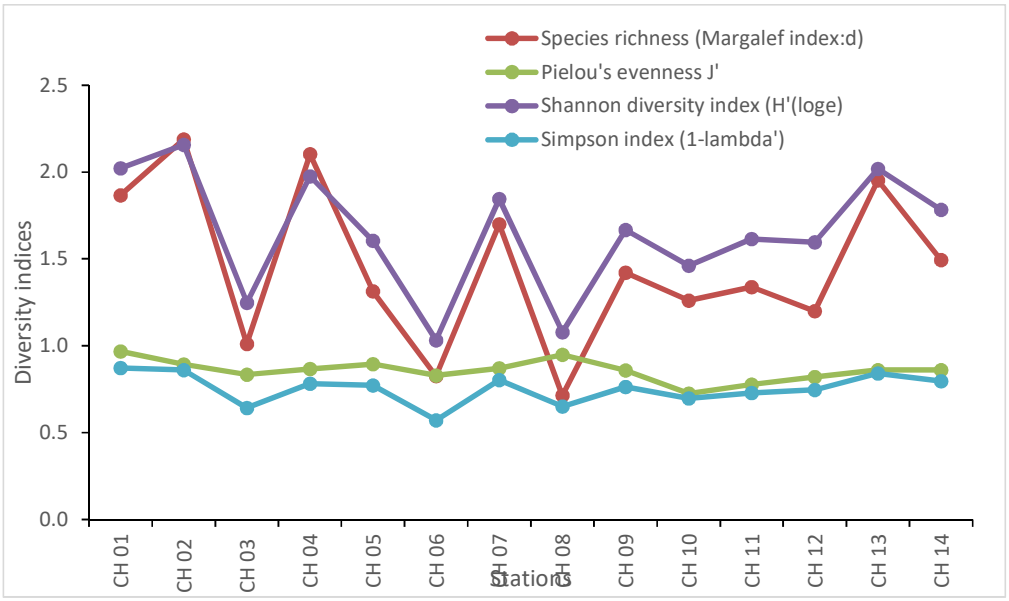


Figure 4.28: Station-wise diversity indices of Chapora Estuary (Peripheral transect).

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:

$$BPA = \log10 [fp/(fa+ 1)+ 1]$$

Where *f*p was the polychaete frequency and *f*a 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 valves 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.

Table 4.11: Benthic Polychaete Amphipode(BPA) ratio of Chapora Estuary (Central transect)

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.

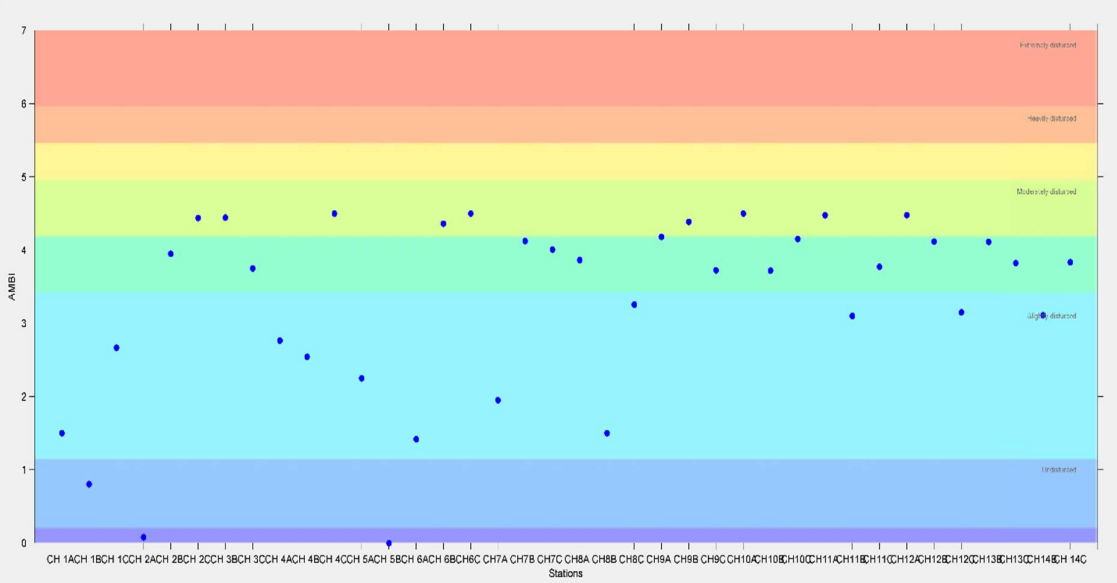


Figure 4.29: Ecological quality status assessment through AMBI index along the sampling sites.

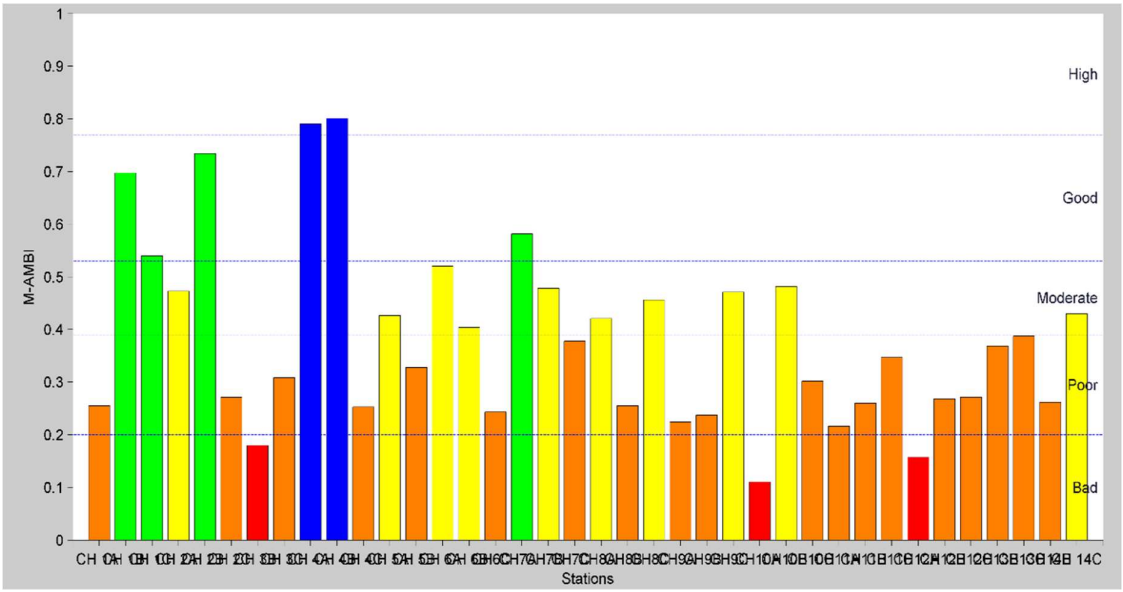


Figure 4.30: Ecological quality status assessment through M-AMBI index along the sampling sites.

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.

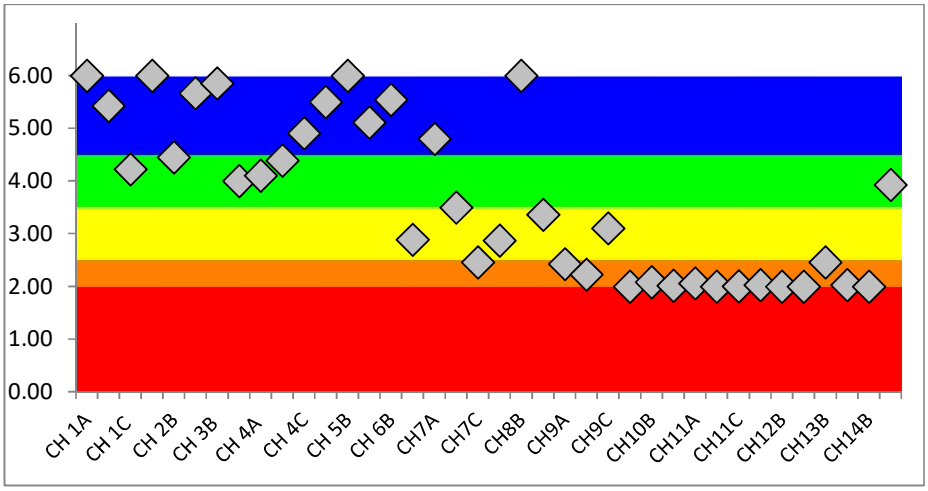


Figure 4.31: Ecological quality status assessment through BENTIX index along the sampling sites.

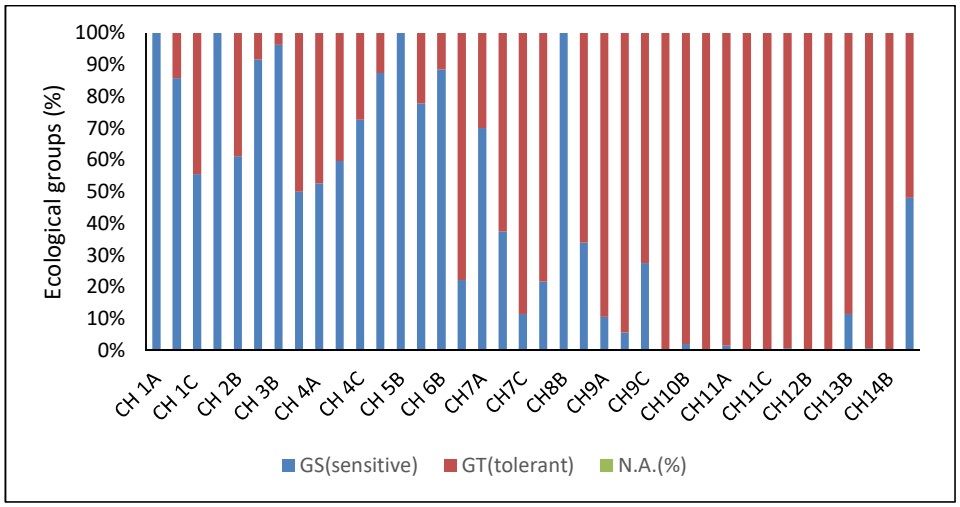


Figure 4.32: Distribution of macrobenthic- Polychaetes based on the ecological sensitivity group assessed through BENTIX index along the sampling sites.

4.5.7Fishery:

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. merguiensis, 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.

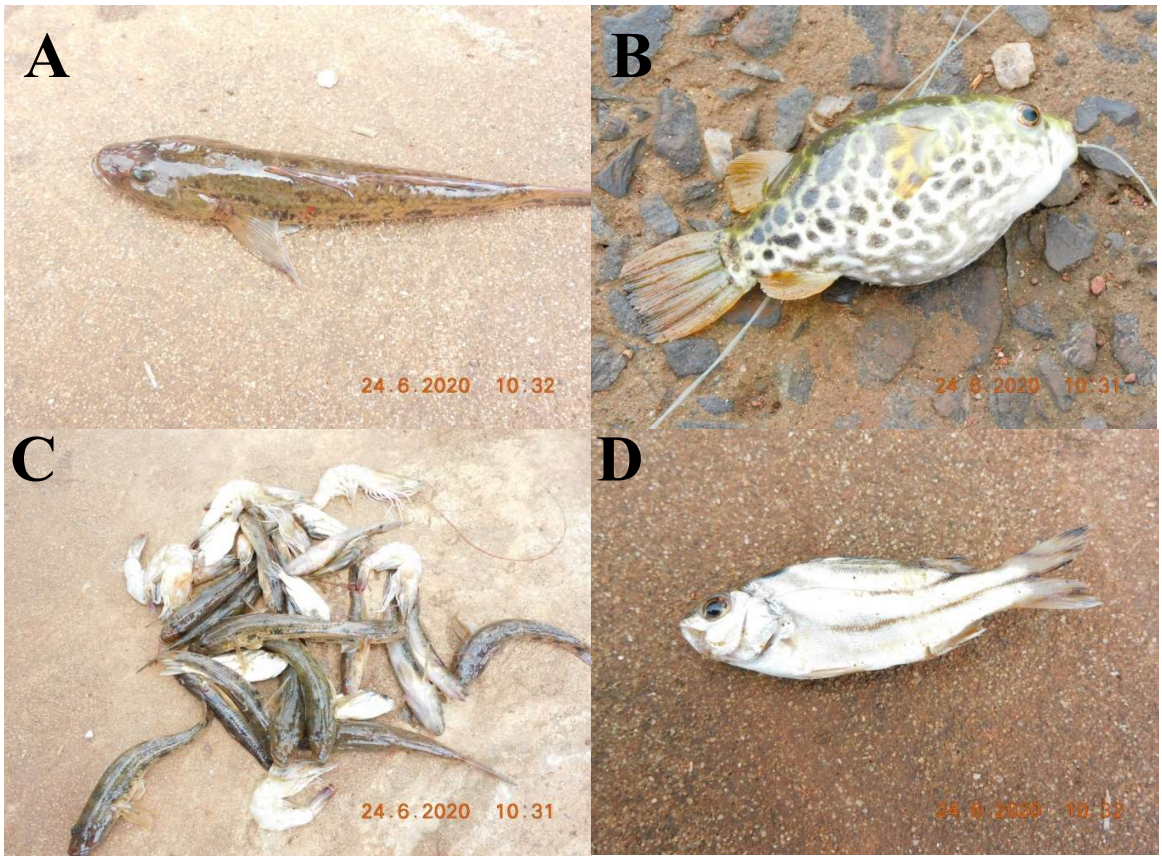


Plate 5: Fish species observed in Chapora estuary [A. Platycephalidae sp.; B.Tetradontidae; C. Total catch; D. Terapontidae]

Table 4.13: Fish diversity from Chapora Estuary

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

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

Diogenidae	*Pagurus sp.*	Hermit crab	-	Demersal
Ocupodidae		Fiddler crab		Demersal
Loliginidae	*Loligoduvauceli (Juv.)*	Indian squid	Manki	Demersal
Sepiidae	*Sepia* sp. *(Juv.)*	Cuttle fish	Bebo	Demersal
Naticidae	*Naticatigrina*	Tiger moon shell	Congo	Demersal
Cyrenidae	*Villoritacyprinoides*	Black clams	Khube	Benthic
Veneridae	*Polymesoda erosa*	Mud clam	Khube	Benthic
	Meretrix meretrix	Asiatic hard clam	Tissryo	Benthic
Ostreidae	*Meretrix casta*	Backwater hard clam	Tissryo	Benthic
	Paphia malabarica	Venus clams	Khube	Benthic
	Paphia textilis	Venus clams	Khube	Benthic
	Crassostrea madrasensis	Oyster	Kalva	Benthic
Mytilidae	*Crassostrea gigas*	Oyster	Kalva	Benthic
	Saccostrea	Oyster	Kalva	Benthic
	Perna viridis	Asian green mussel	Shenanyo	Benthic
Melongenidae	*Hemifususpugilinus*	Sea snail	-	Demersal
Turritellidae	*Turritellaacutangula*	Screw shell	Congali	Demersal
Rostellariidae	*Tibia curta*	Indian tibia	Congali	Demersal
Burside	*Bufonariarana*	Frog shell	-	Demersal
Muricidae	*Murex aduncospinosus*	Spine murex	-	Demersal
Babyloniidae	*Babylonia spirata*	Whelks	-	Demersal
Conidae	*Conus* sp.	Cone shell	-	Demersal
Astropectinidae	*Astropectenindicus*	Star fish	-	Demersal
Rhzostomatidae	*Rhopilema* spp.	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 (*Lepidochelyes olivicea*). 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).

Table 4.14: List of Reptiles and Mammals recorded from Chapora Estuary

Sr. no.	Common name	Scientific name	IUCN status	Wildlife Protection Act (1972)
1	Smooth-coated otter	*Lutrogale perspicillata*	Vulnerable	Schedule II
2	Mugger crocodile	*Crocodylus palustris*	Vulnerable	Schedule I
3	Indian grey mongoose	*Herpestes edwardsi*	Least concern	Schedule II
4	Indian flapshell turtle	*Lissemyspunctate punctata*	Least concern	Schedule I
5	Flying fox	*Pteropus medius*	Least concern	Schedule IV
6	Indian rock python	*Python molurus*	Near threatened	Schedule I
7	Golden jackal	*Canis aureus*	Least concern	Schedule II
8	Wild boar	*Sus scrofa*	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	*Phalacrocorax fuscicollis*	Least Concern	Schedule IV
2	Lesser Cormorant	*Microcarbo niger*	Least Concern	Schedule IV
3	Red-wattled lapwing	*Vanellus indicus*	Least Concern	Schedule IV
4	black headed oriole	*Oriolus larvatus*	Least Concern	Schedule IV
5	Stock billed kingfisher	*Pelargopsis capensis*	Least Concern	Schedule IV
6	White breasted kingfisher	*Halcyon smyrnensis*	Least Concern	Schedule IV
7	Common kingfisher	*Alcedo atthis*	Least Concern	Schedule IV
8	Small green bee eater	*Merops orientalis*	Least Concern	Schedule IV
9	Painted stork	*Mycteria leucocephala*	Near Threatened	Schedule IV
10	White ibis	*Threskiornis melanocephalus*	Near Threatened	Schedule IV
11	Glossy ibis	*Plegadis falcinellus*	Least Concern	Schedule IV
12	Intermediate Egret	*Ardea intermedia*	Least Concern	Schedule IV
13	White breasted waterhen	*Amaurornis phoenicurus*	Least Concern	Schedule IV
14	Brahminy kite	*Haliastur indicus*	Least Concern	Schedule IV
15	White browed wagtail	*Motacilla maderaspatensis*	Least Concern	Schedule IV
16	House crow	*Corvas splendens*	Least Concern	Schedule V
17	Sand Plover	*Charadrius sp.*	Least Concern	Schedule IV
18	Bay-backed Shrike	*Lanius vittatus*	Least Concern	Schedule IV
19	Common Quail	*Coturnix coturnix*	Least Concern	Schedule IV
20	Ruddy Turnstone	*Arenaria interpres*	Least Concern	Schedule IV
21	Asian Koel	*Eudynamys scolopaceus*	Least Concern	Schedule IV
22	Common Sandpipers	*Actitis hypoleucos*	Least Concern	Schedule IV
23	Caspian Gull	*Larus cachinnas*	Least Concern	Schedule IV
24	Heuglin's Gull	*Larus heuglini*	Least Concern	Schedule IV
25	Steppe Gull	*Larus (heuglini) barabensis*	Least Concern	Schedule IV
26	Pallas's Gull	*Ichthyaetus ichthyaetus*	Least Concern	Schedule IV
27	Brown headed Gull	*Chroicocephalus brunnicephalus*	Least Concern	Schedule IV
28	Black headed Gull	*Chroicocephalus ridibundus*	Least Concern	Schedule IV
29	Gull-billed tern	*Gelochelidon nilotica*	Least Concern	Schedule IV
30	Greater Crested Tern	*Thalasseus bergii*	Least Concern	Schedule IV

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

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

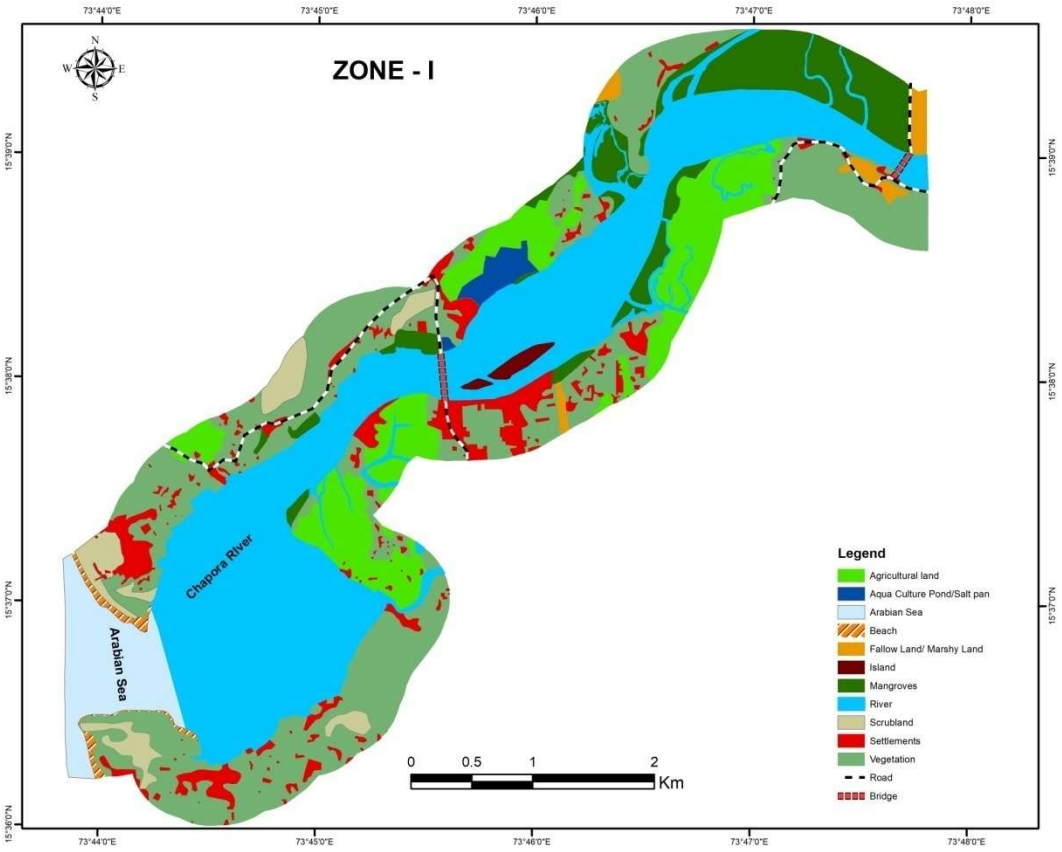
Downstream part of the river has more saline influenced waters with higher salinity compared to upper stretches. Thus most of the areas have been protected by embankments traditionally. These embankments require constant repair and maintenance, as the terrestrial part of it is used for paddy cultivation 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.

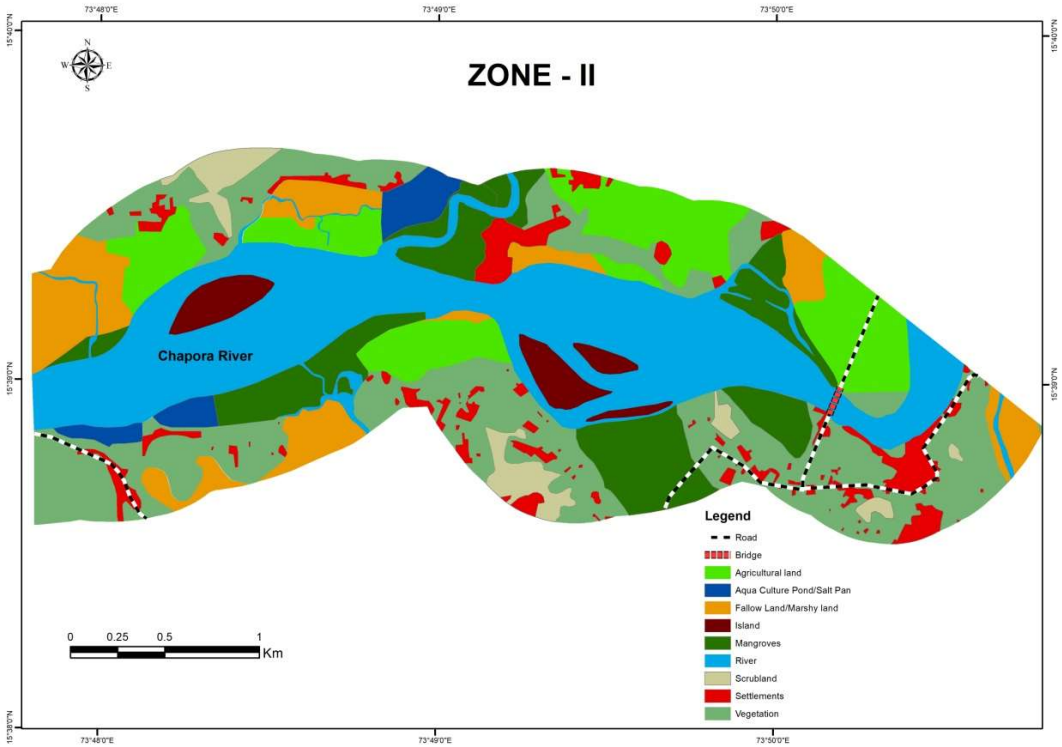
The riparian vegetation along the banks of the river in the upstream stretches consist of typical tropical deciduous species typical to this region and the department of forest categorises this region under open forest (https://fsi.nic.in/isfr19/vol2/isfr-2019-vol-ii-goa.pdf). The area is predominantly 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.

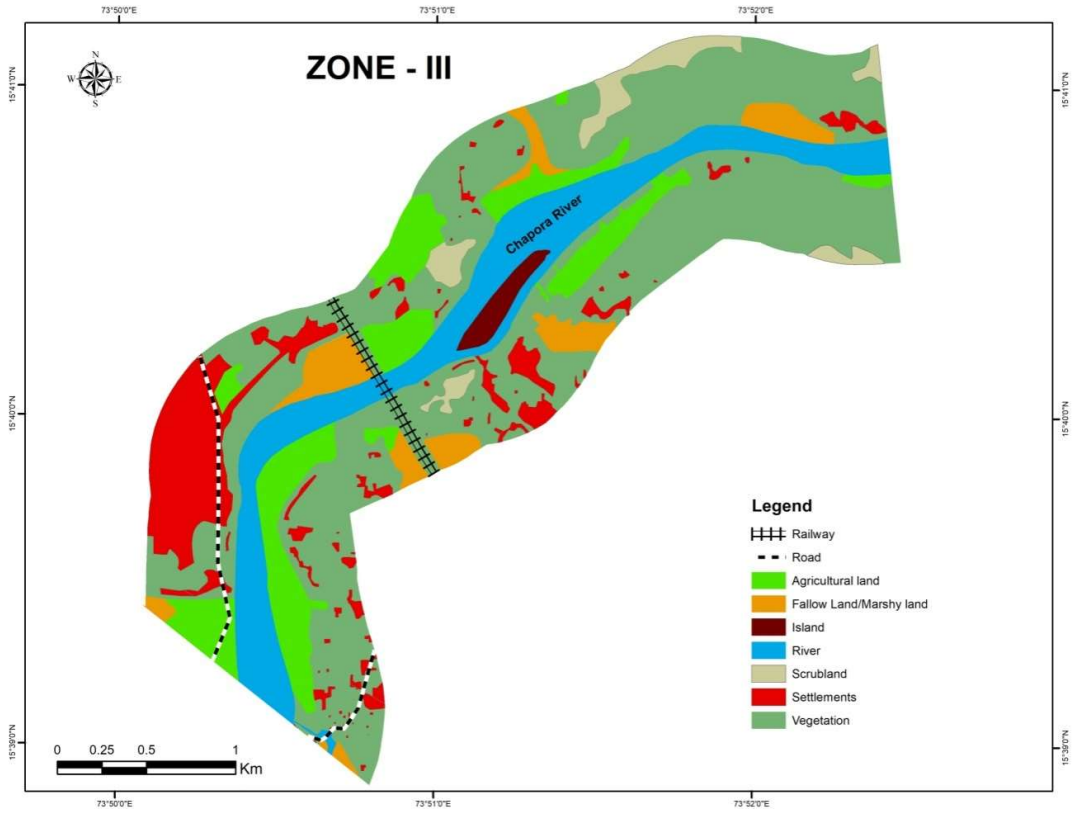
The river bank in the upstream areas (with mostly narrow mudflats) have grasses such as *Cyprus* sp./ *Typha* sp. (Plate 5)which have ability to resist some salinity. Although grasses are known to offer protection from erosion, these grasses may not be able to resist strong current which is visible from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


ZONE - I
Chapora River
Arabian Sea
0 0.5 1 2
Km
Legend
Agricultural land
Aqua Culture Pond/Salt pan
Arabian Sea
Beach
Fallow Land/ Marshy Land
Island
Mangroves
River
Scrubland
Settlements
Vegetation
Road
Bridge


ZONE - II
Chapora River
0 0.25 0.5 1
Km
Legend
Road
Bridge
Agricultural land
Aqua Culture Pond/Salt Pan
Fallow Land/Marshy land
Island
Mangroves
River
Scrubland
Settlements
Vegetation



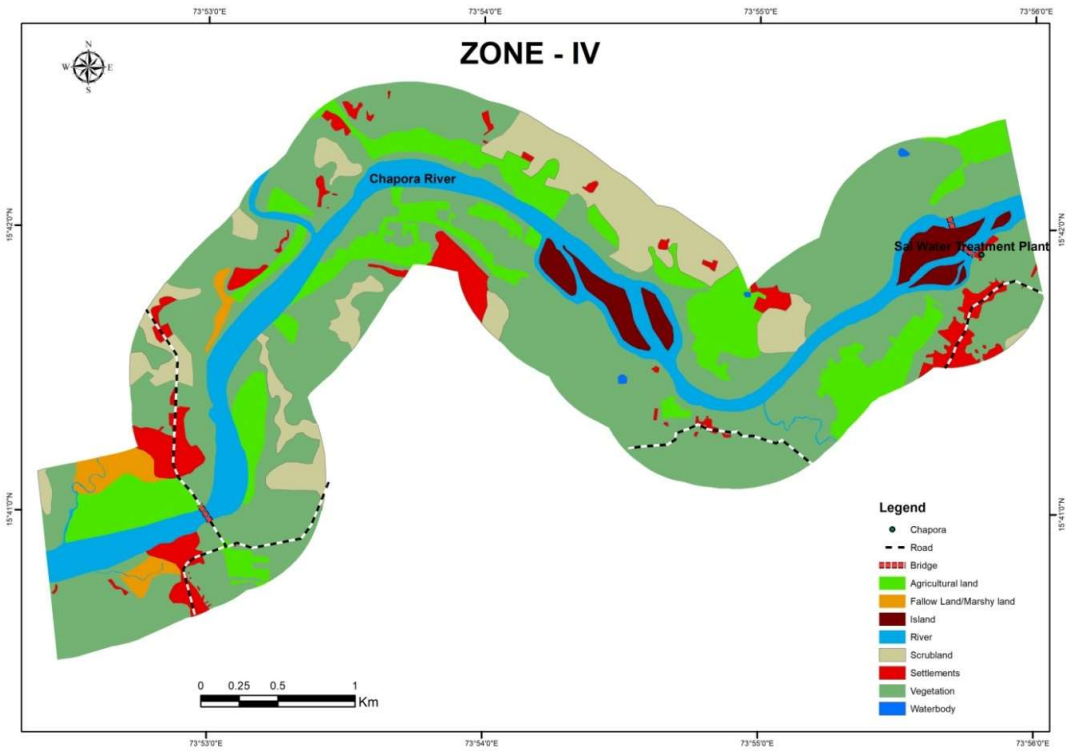


Figure 4.33: LULC Map of Chapora Estuary (Divided in 4 zones, image used LISS-IV, December 2019)

Table 4.16: LULC Chapora			
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).

Table 4.17: List of Seaweed/Grass found in Chapora Estuary

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



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

4.5.11 Sand Dune Vegetation:

Sand dunes are a mount, 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.

4.5.12Mangrove:

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.

Table 4.18: Mangroves and associated species found in Chapora estuary.

Sr. No.	True mangrove species	Mangrove associate species
1	*Avicennia marina*	*Cleredendrum inerme*
2	*Avicenniaofficinalis*	*Derris heterophylla*
3	*Rhizophoramucronata*	*Porterasiacoaretata*
4	*Kandeliacandel*	*Calophylluminophylum*
5	*Sonneratiacaseolaris*	*Acrostichum aureum*
6	*Sonneartia alba*	
7	*Ceriopstagal*	
8	*Brugieracylindrica*	

9	*Aegicerascorniculata*	
10	*Acanthus ilicifolius*	
11	*Excoecariaagallocha*	

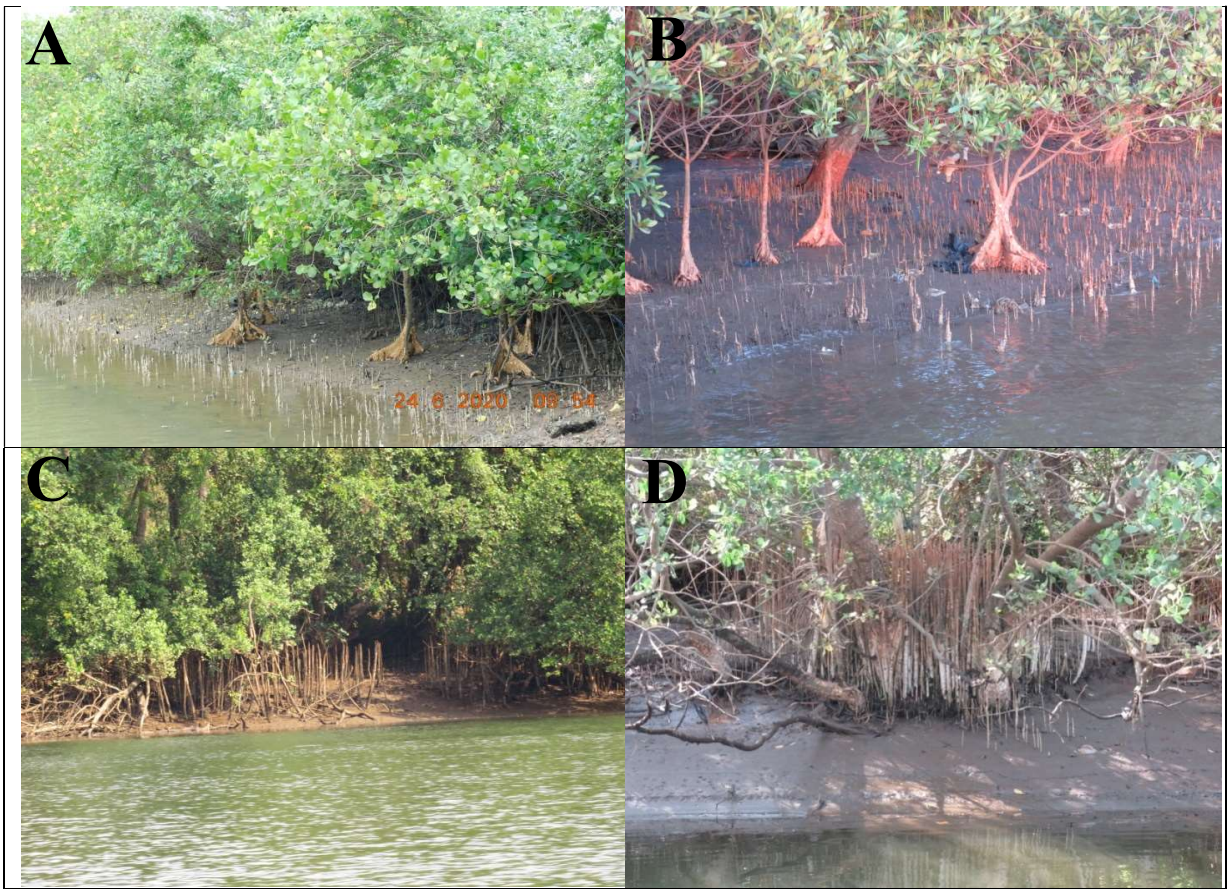


Plate 7: Mangroves from Chapora estuary

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 m^3/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, Noth 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.

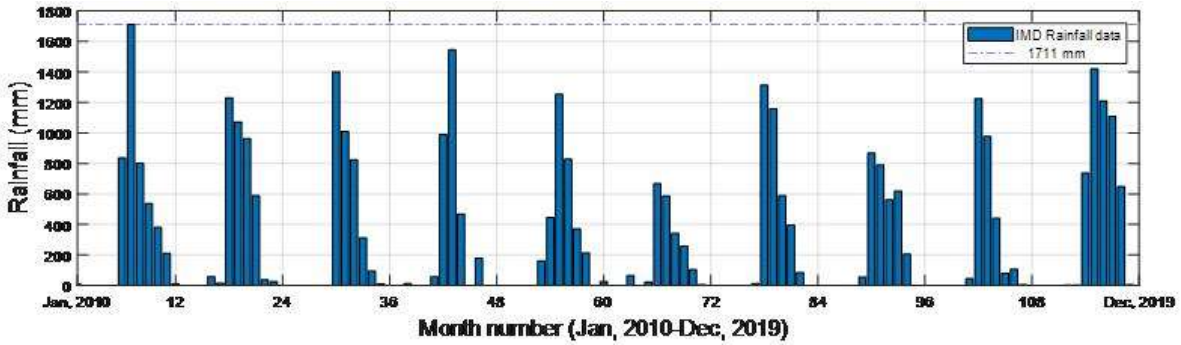


Figure 5.1. The monthly rainfall data at Pernem, North Goa from 2010-2019 (source IMD)

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.

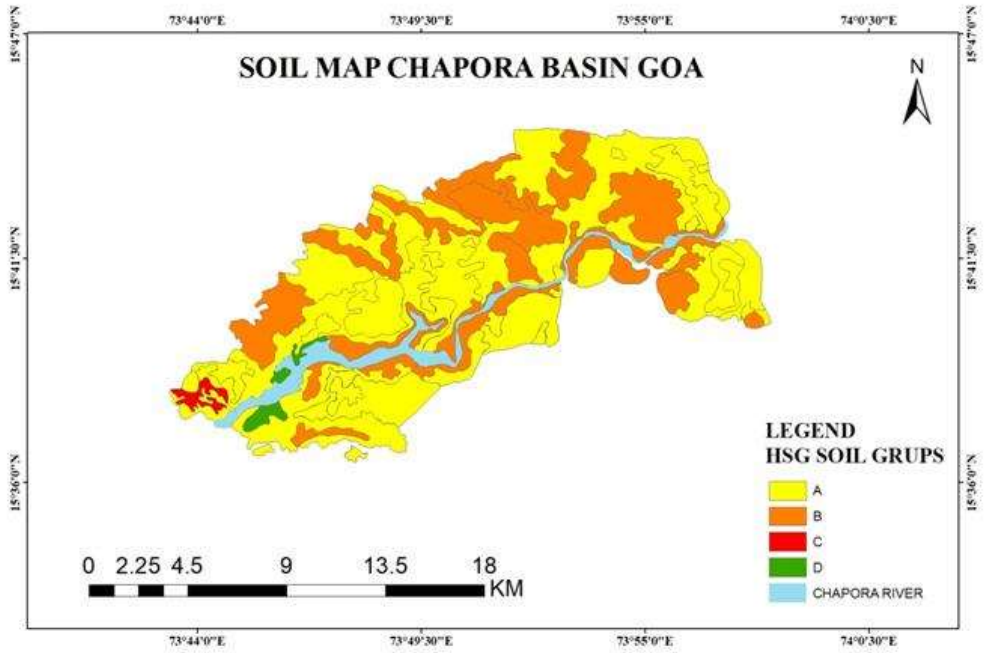


Figure 5.2.Soil map of Chapora basin, Goa (Source: NBSS&LUP)

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 Longitude	15°38’58.3” N 73°50’05.4” E	15°38'57"N 73°50'11"E	15°36'31"N 73°44'19"E	15°41'22.9"N 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

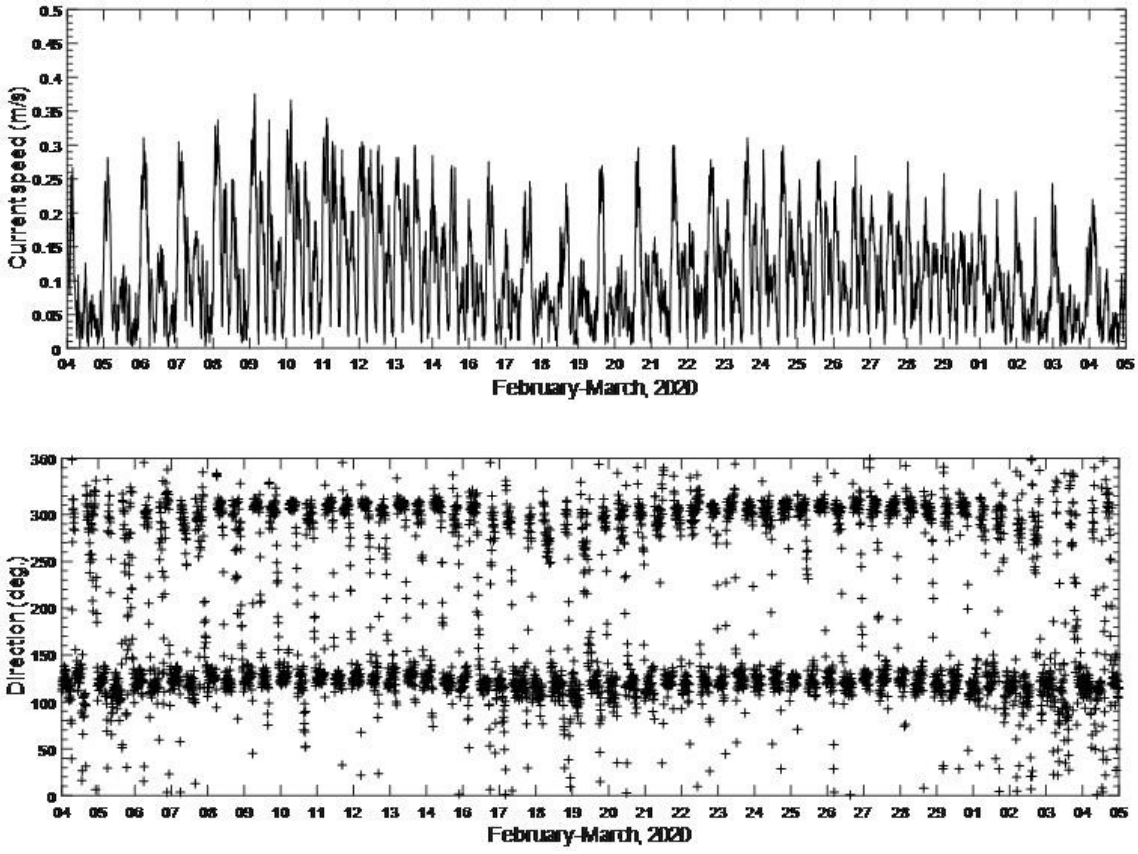


Figure 5.4. Variation of measured current speed and directions at CR1 during pre-monsoon 2020.

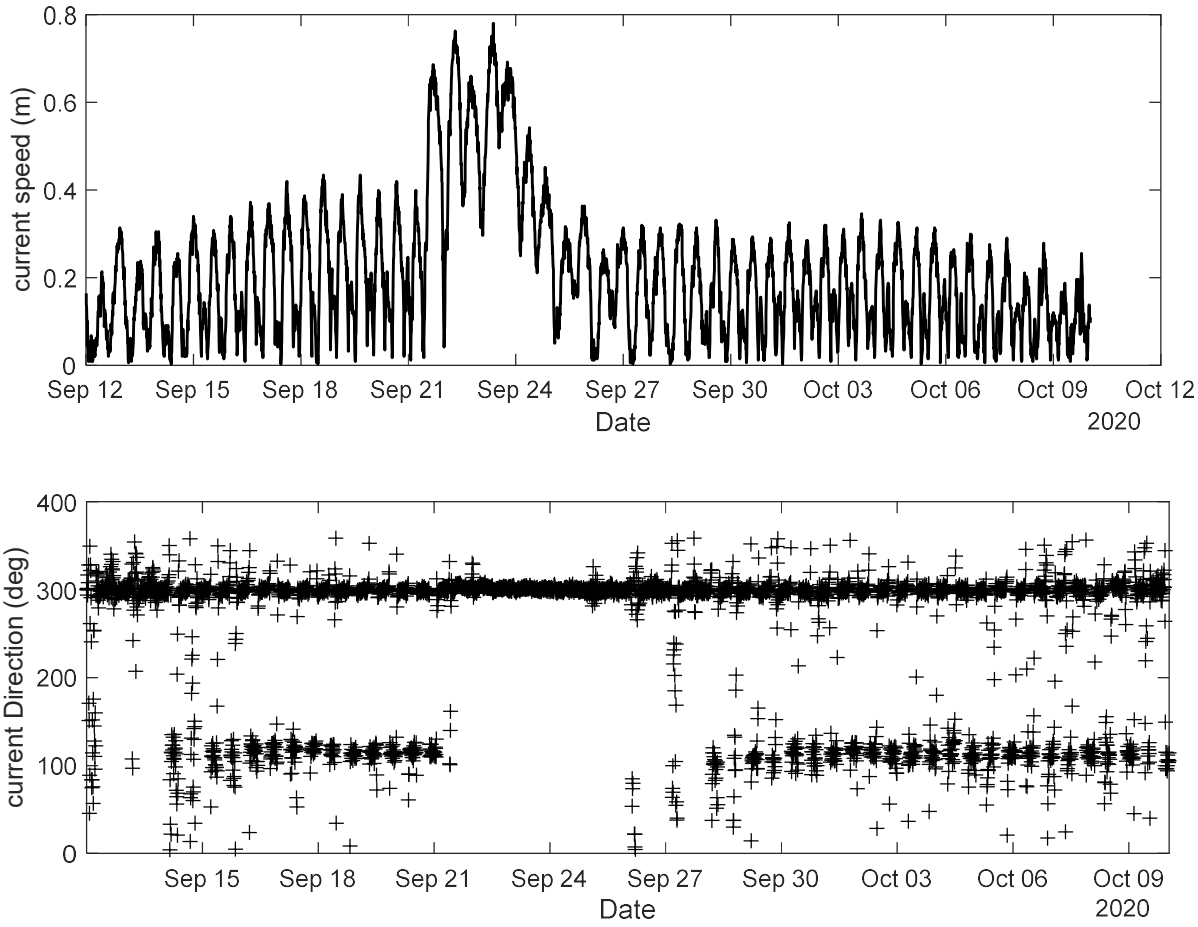


Figure 5.5. Variation of measured current speed and directions at CR1 during monsoon, 2020.

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.

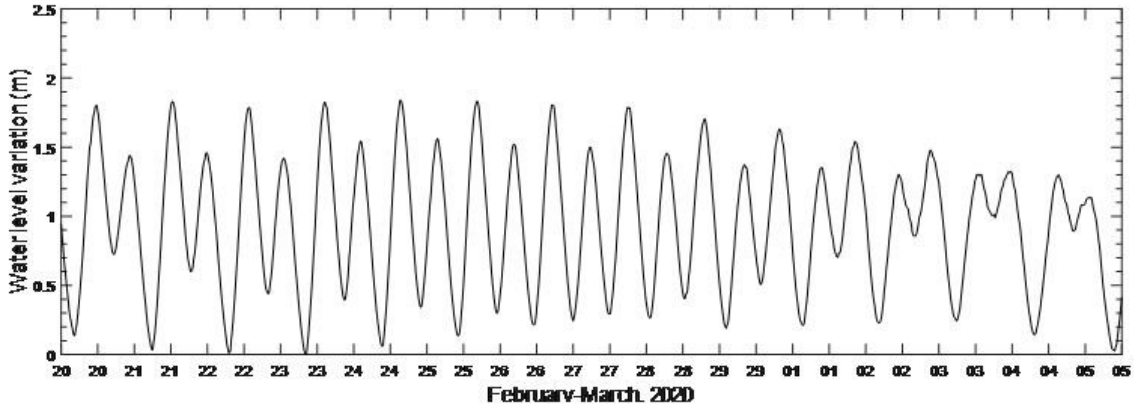


Fig 5.6. Variation of water levels at Location-1 CR1

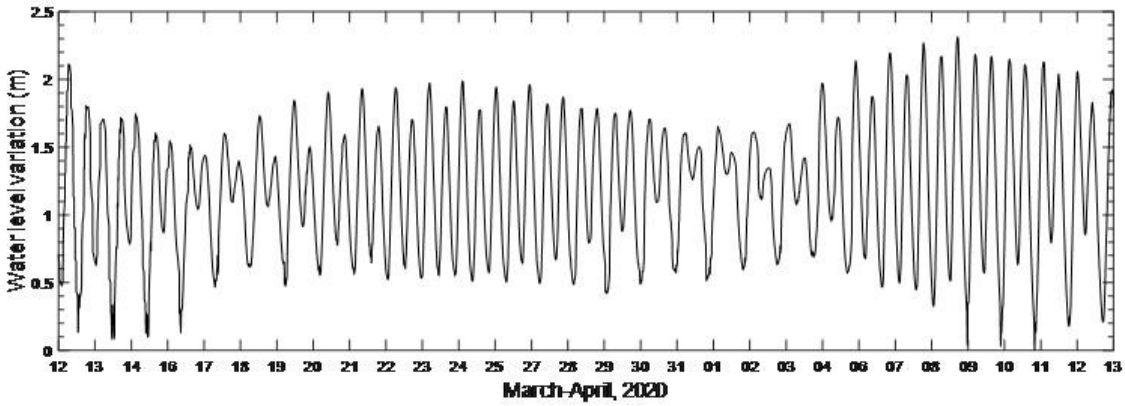


Figure. 3.1.

Fig 5.7. Variation of water levels at Location-2 CR2.

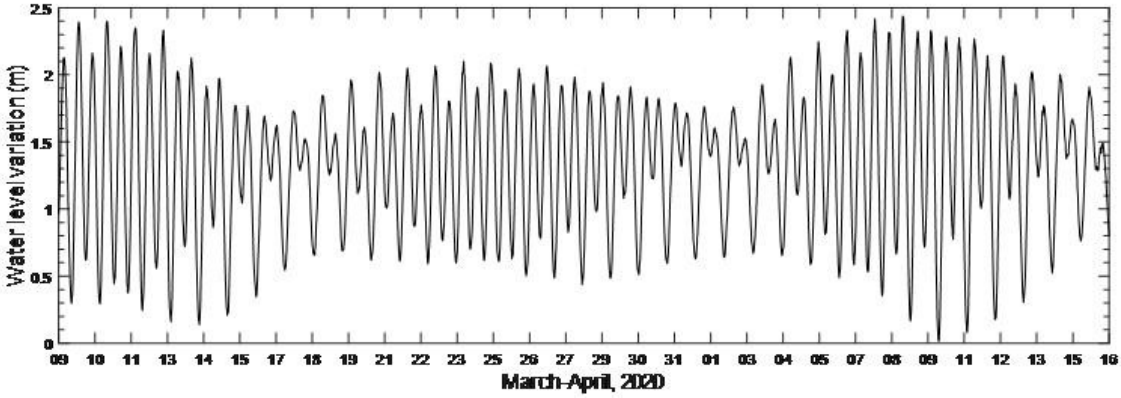


Figure. 3.2.

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.

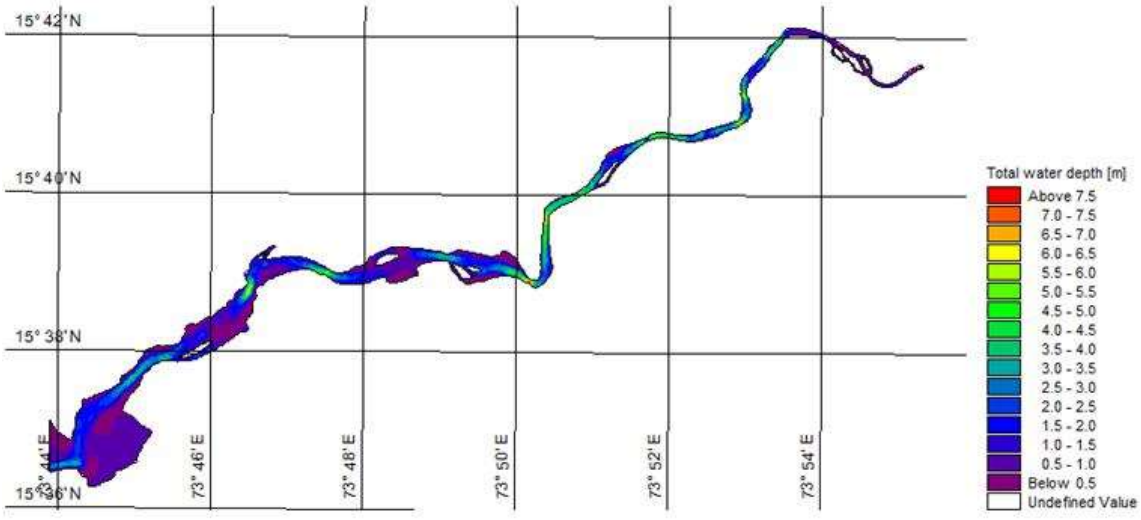


Figure 6.1. Model domain of the Chapora Estuary

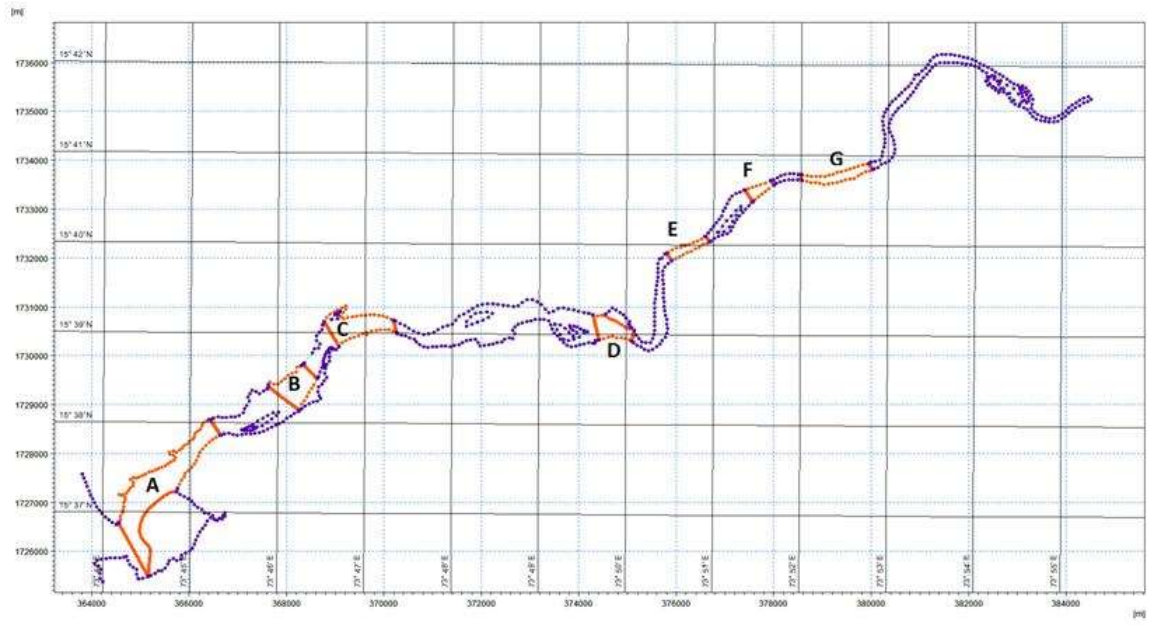


Figure 6.2. Figure showing seven different sections (A-G) in the model domain.

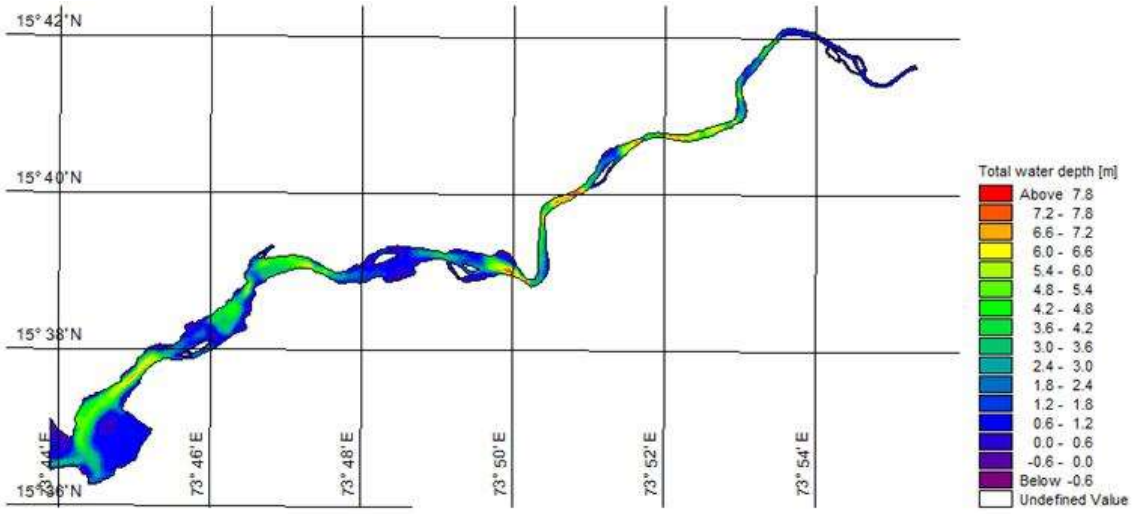


Figure 6.3. Model domain for modified bathymetry increasing depth by 3 m at different sections (A-G)

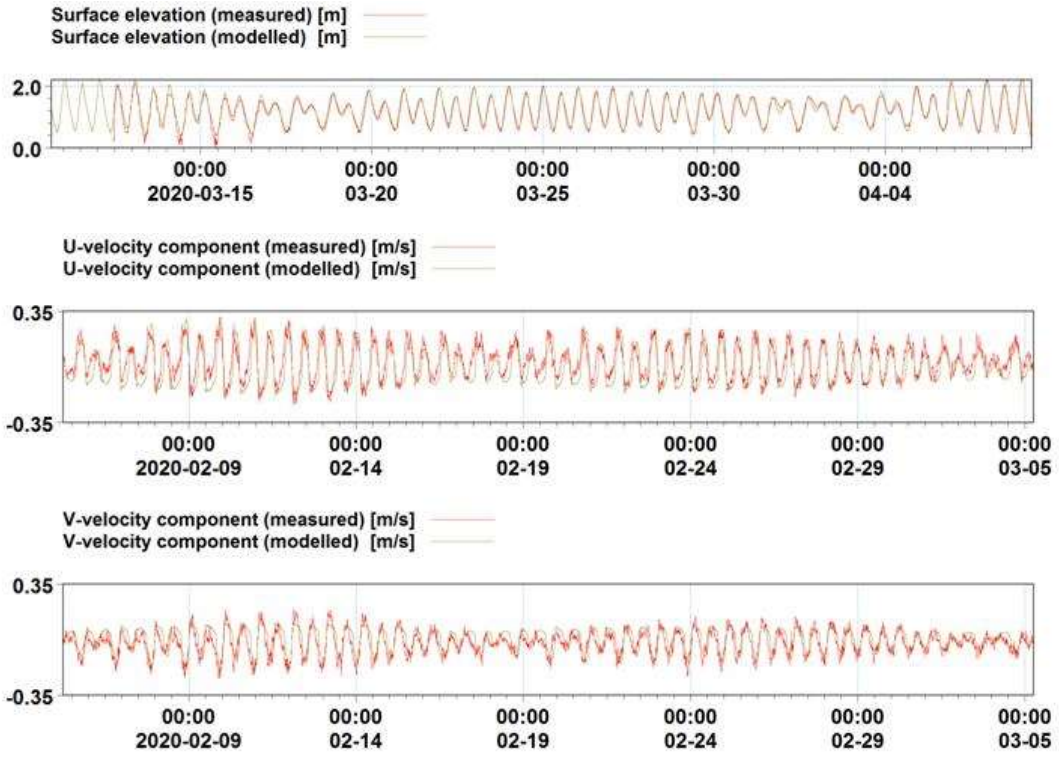
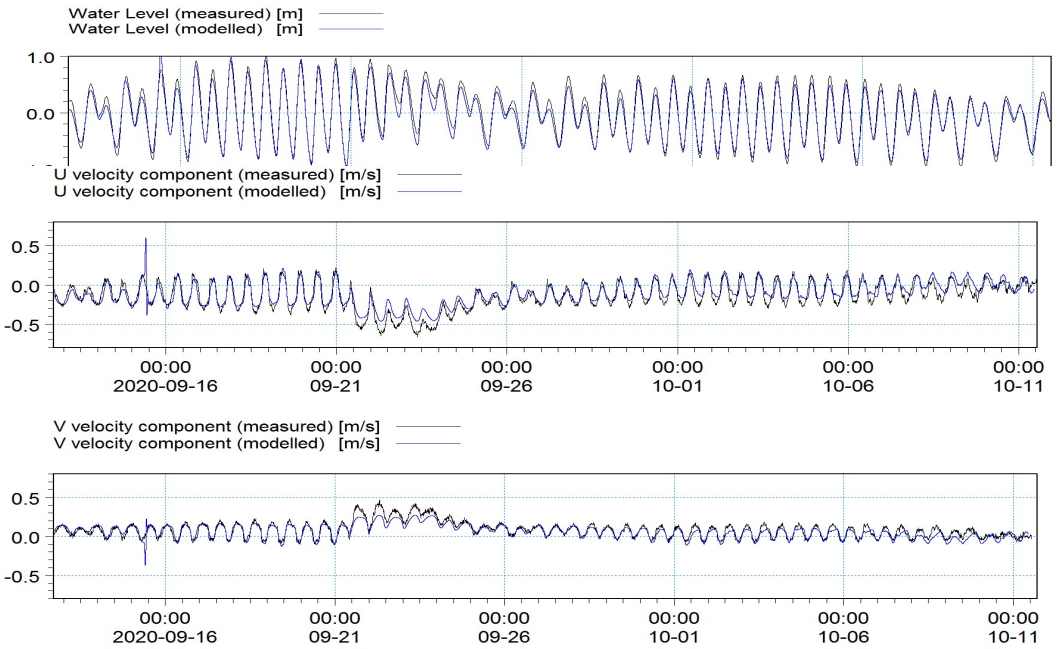


Figure 6.4a. Comparison between measured and modelled surface elevations and U&V component of current during pre-monsoon.



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.

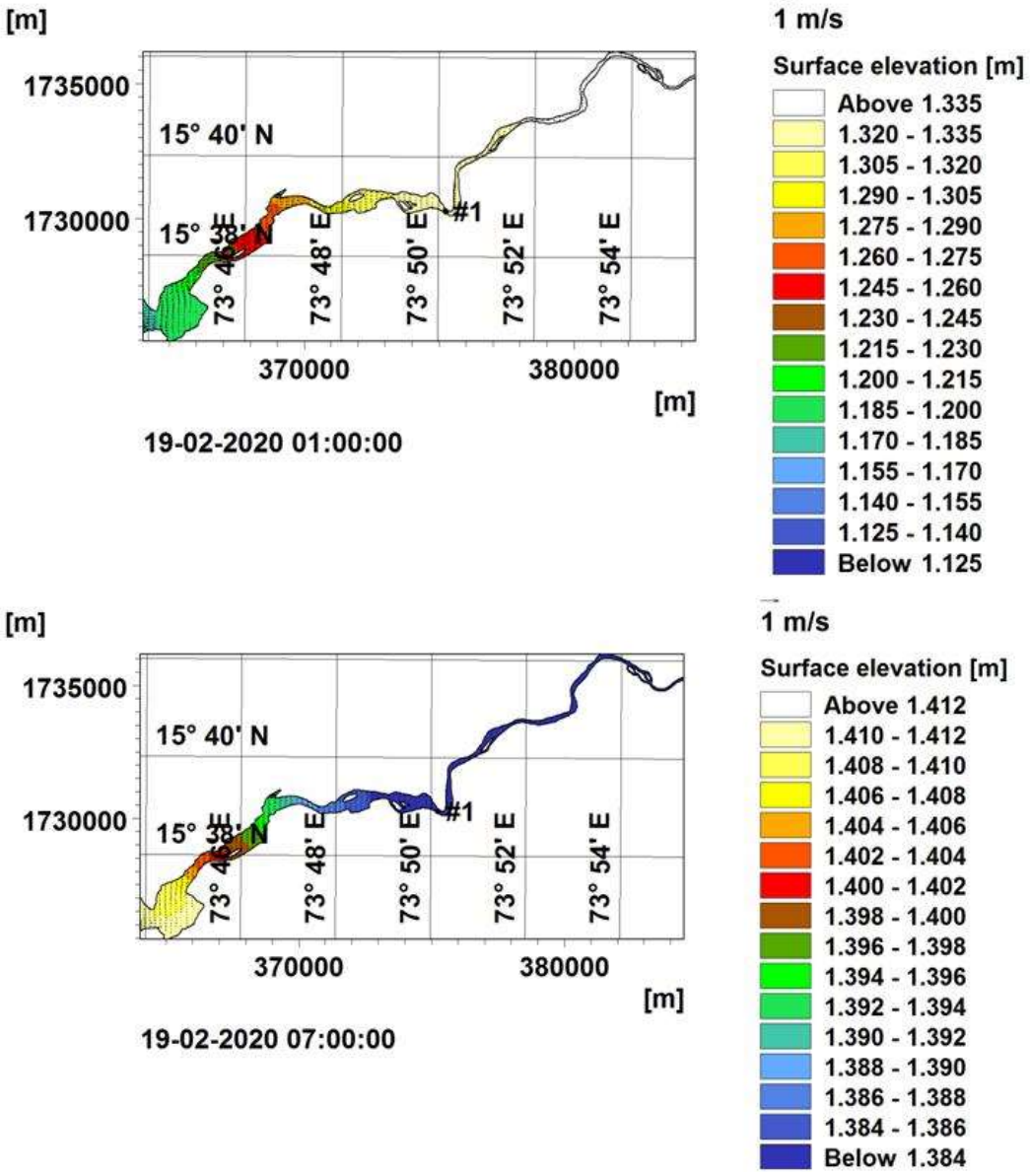
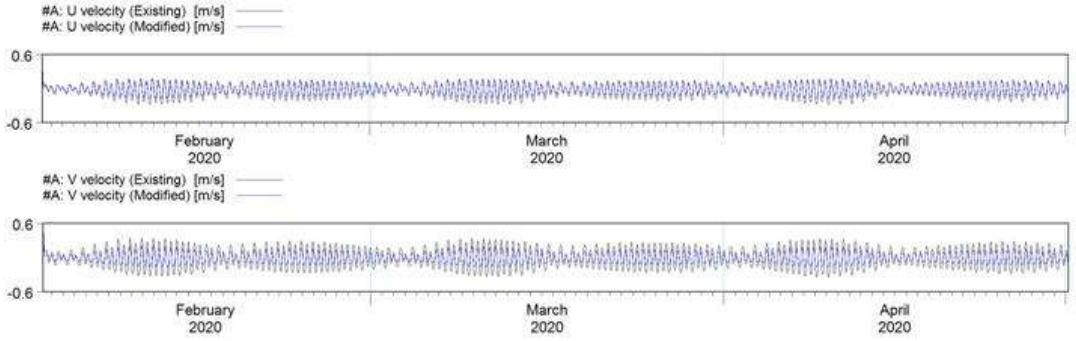
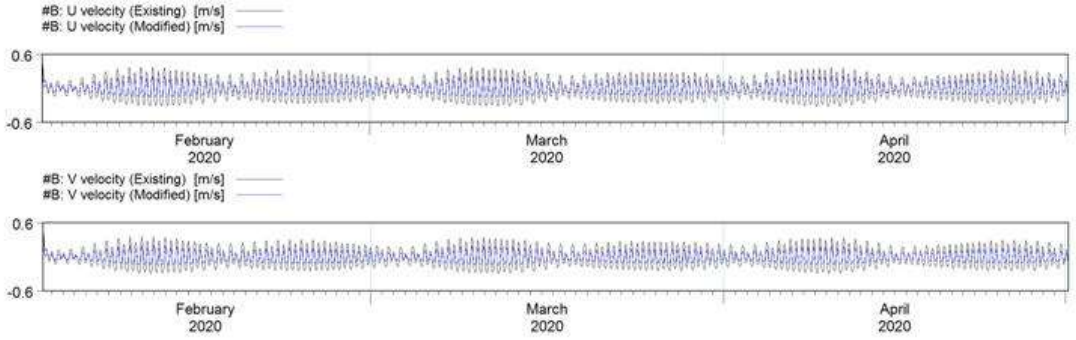


Figure 6.5. Flow patterns and surface elevations during typical ebb and flood tide for Case-1.

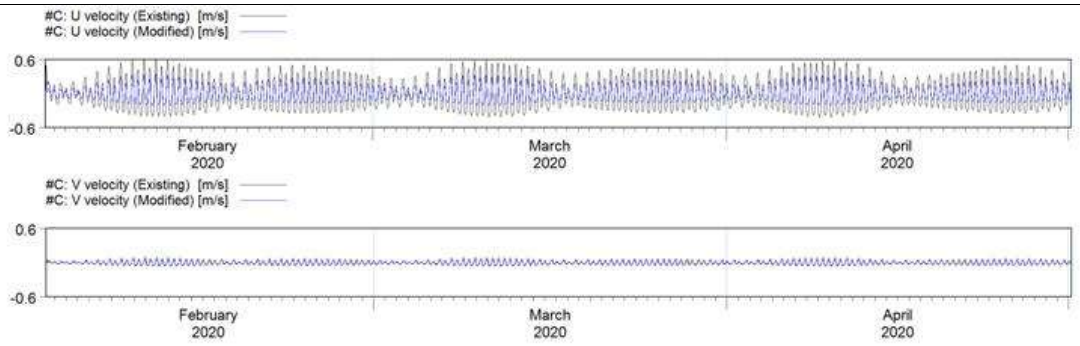
A comparison of current speeds between the Case-1 (base case) and Case-2 (Modified bathymetry case) is carried out. A total of 7 points covering the seven sections A to G as in Figure 6.2 are considered for comparing the currents. The comparison Figures are presented in Figure 6.6. The maximum current 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.



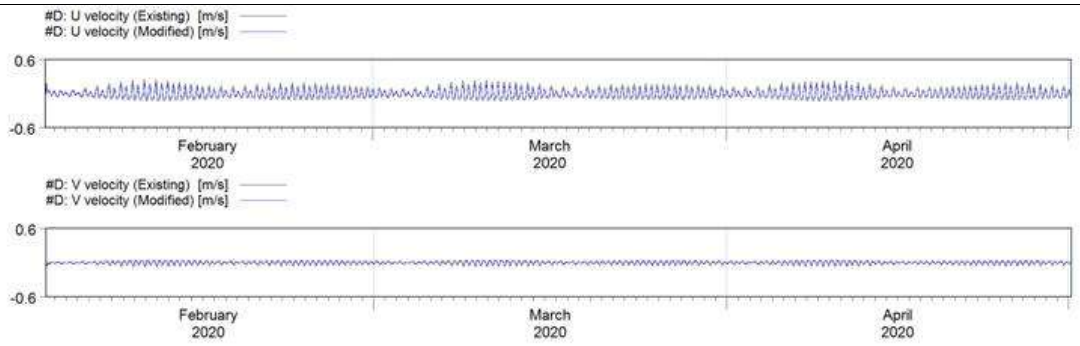
Comparison between existing and modified current U & V component at section A



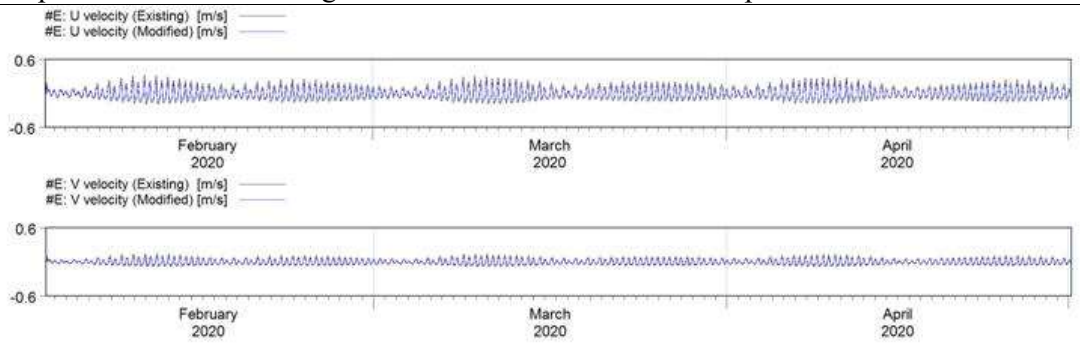
Comparison between existing and modified current U & V component at section B



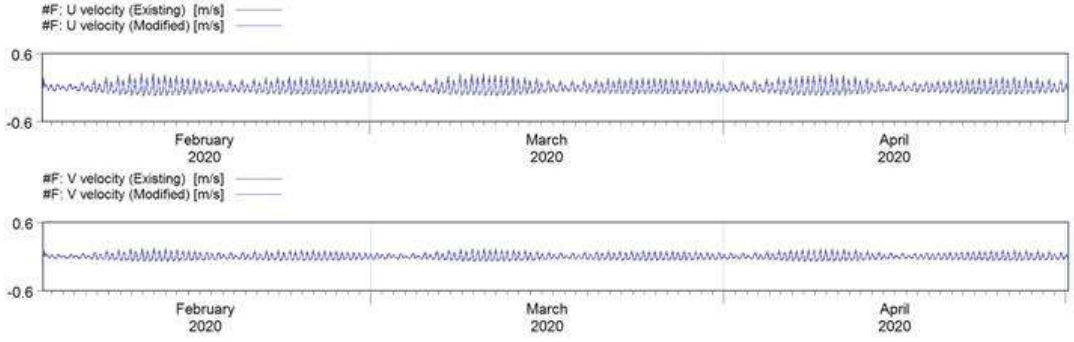
Comparison between existing and modified current U & V component at section C



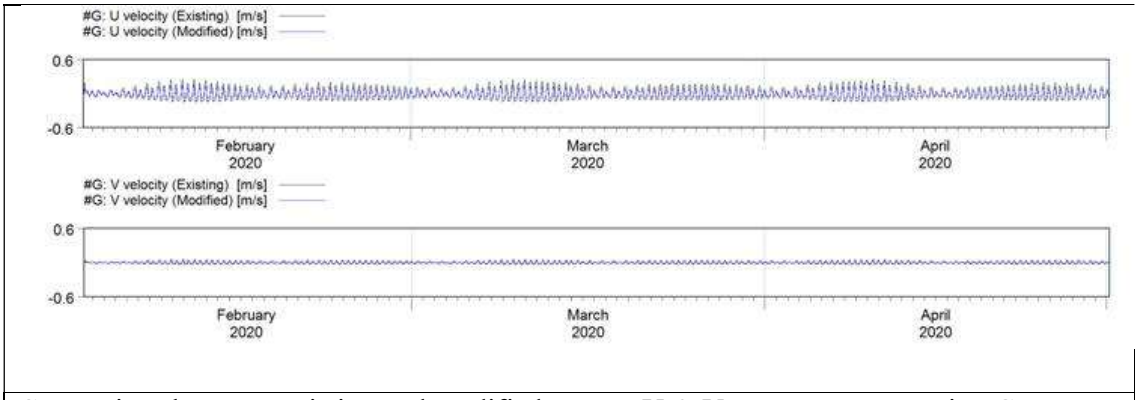
Comparison between existing and modified current U & V component at section D



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

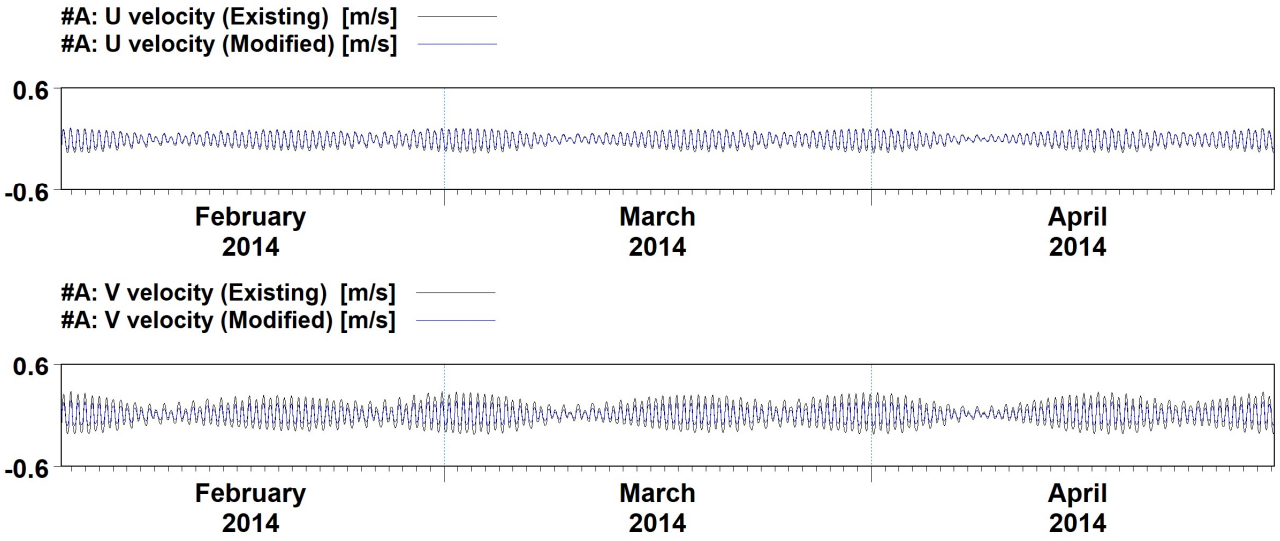


Figure 6.7 Comparison of U & V velocity between Case-1 and Case-2 during February-April 2014 at section A.

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.

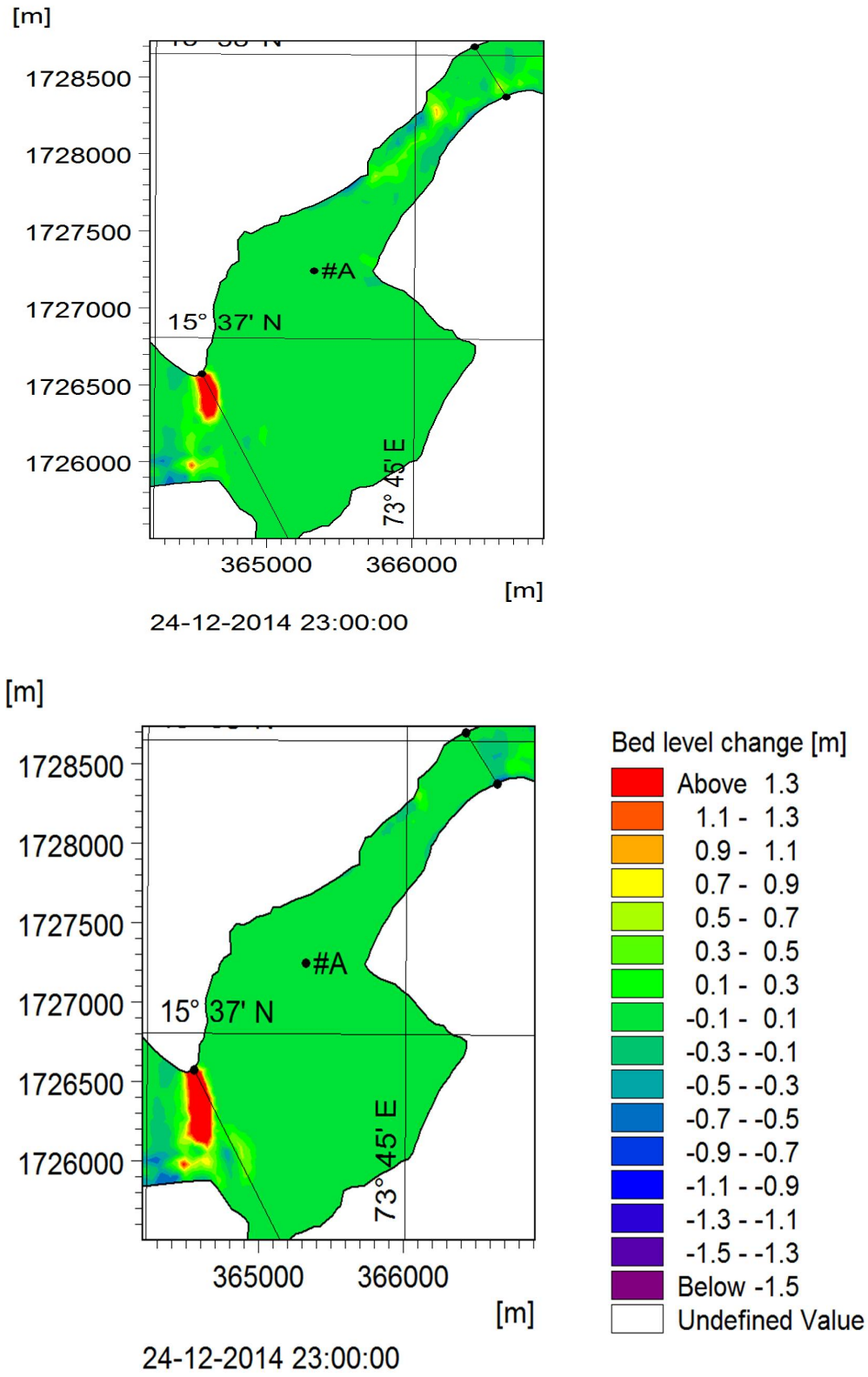
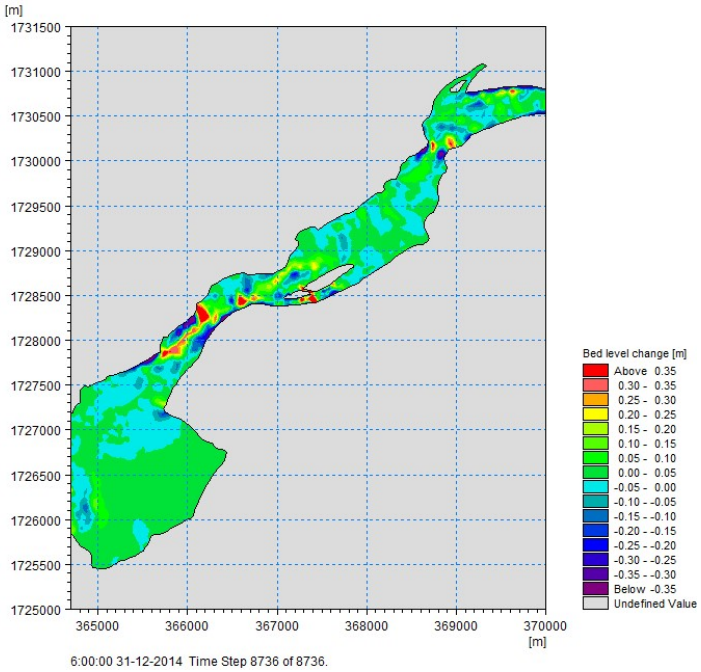


Figure 6.8. showing the deposition/erosion at the Chapora estuary mouth. Top figure is Case-1 and bottom is Case-2

Base Case Scenario (Case-1) for Chapora Part I



Modified Bathymetry Scenario (Case-2) for Chapora Part I

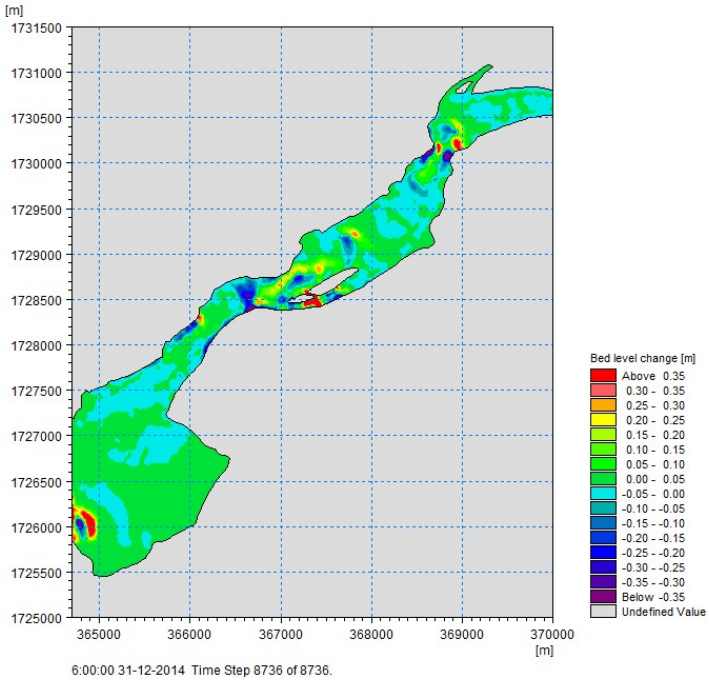
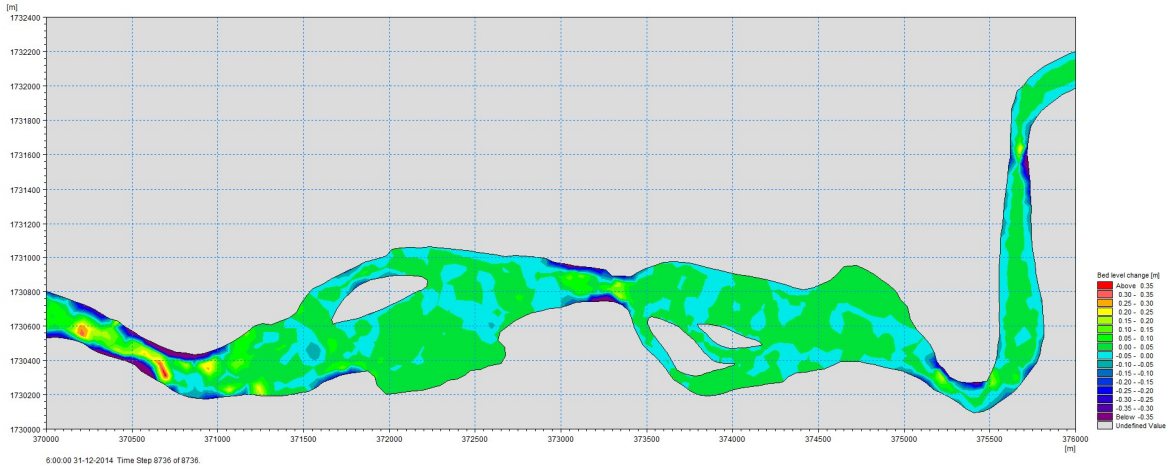


Figure 6.9.showing the deposition/erosion in the Chapora Part I

Base Case Scenario (Case-1) for Chapora Part II



Modified Bathymetry Scenario (Case-2) for Chapora Part II

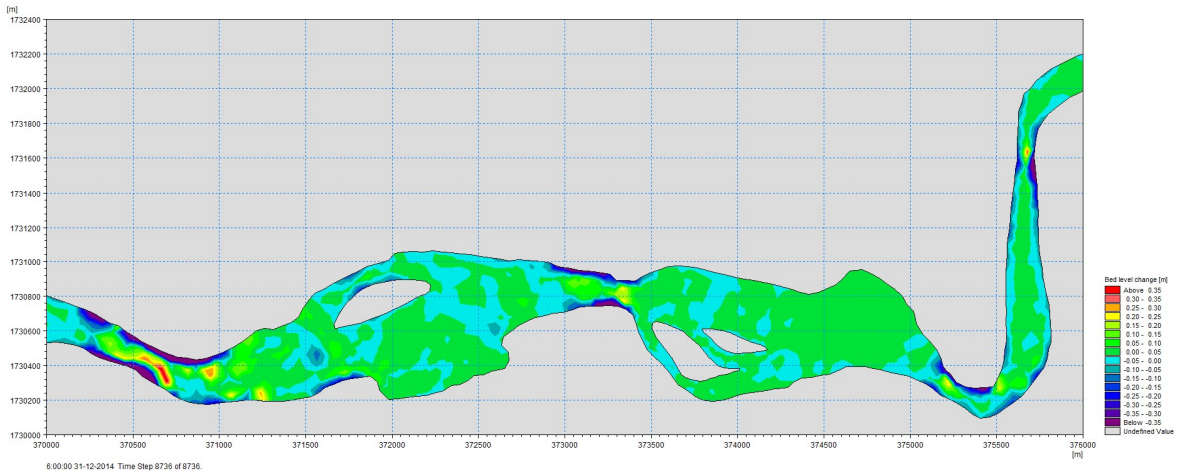
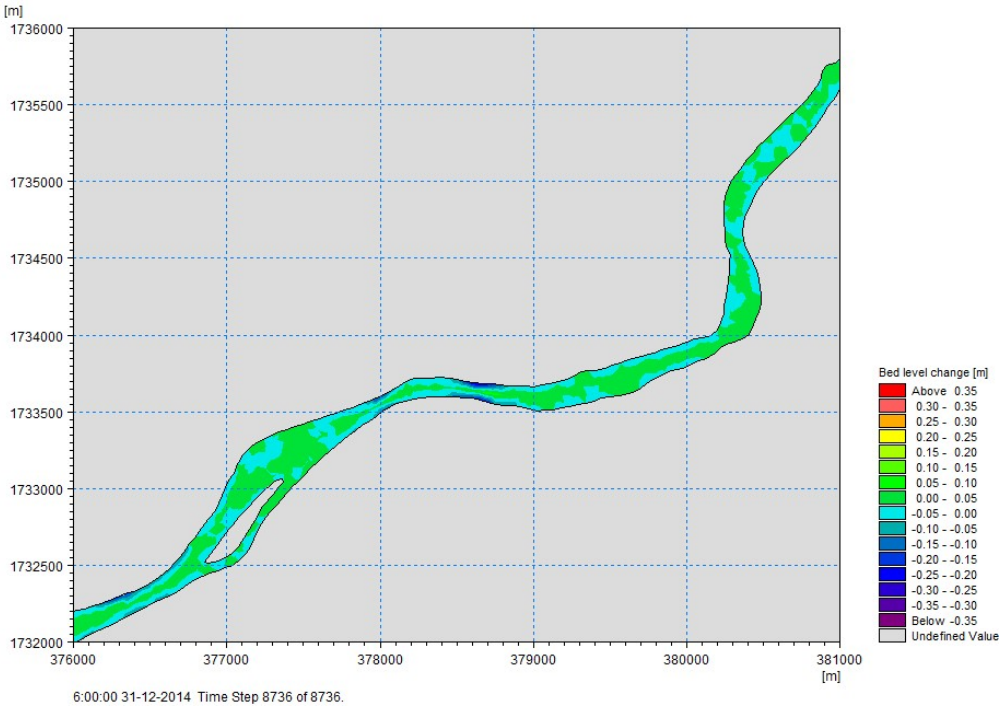


Figure 6.10.showing the deposition/erosion in the Chapora Part II

Base Case Scenario (Case-1) for Chapora Part III



Modified Bathymetry Scenario (Case-2) for Chapora Part III

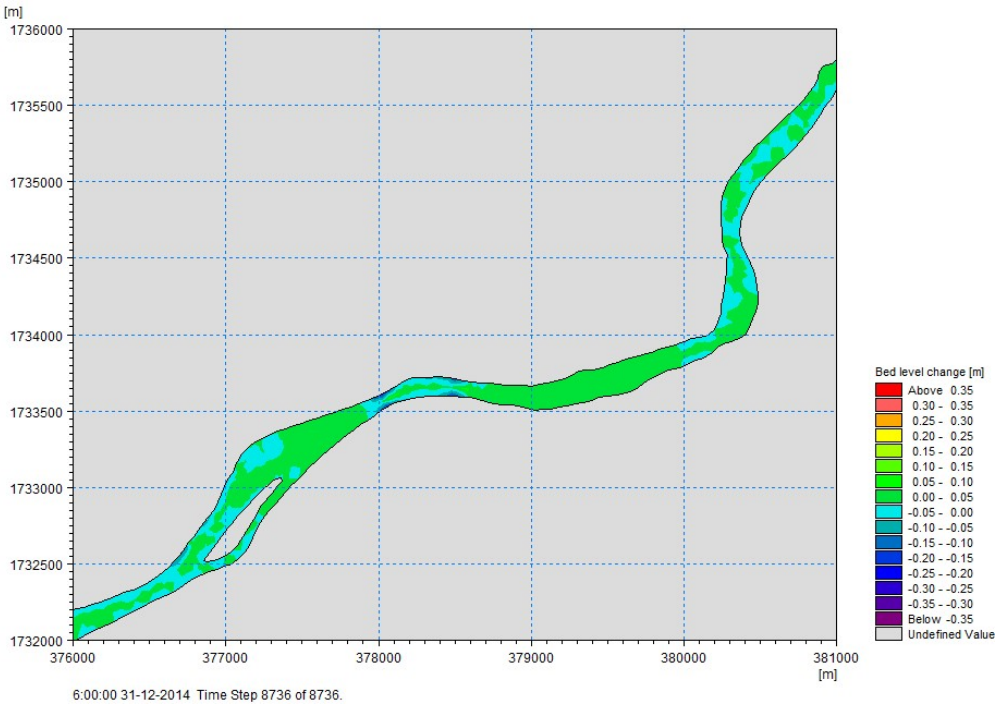


Figure 6.11.showing the deposition/erosion in the Chapora Part III

CHAPTER 7ANTICIPATED 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. Tin 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 changes the nutrient regime of the water column and may results 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 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 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, 1972nesting 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 geo-morphology, 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

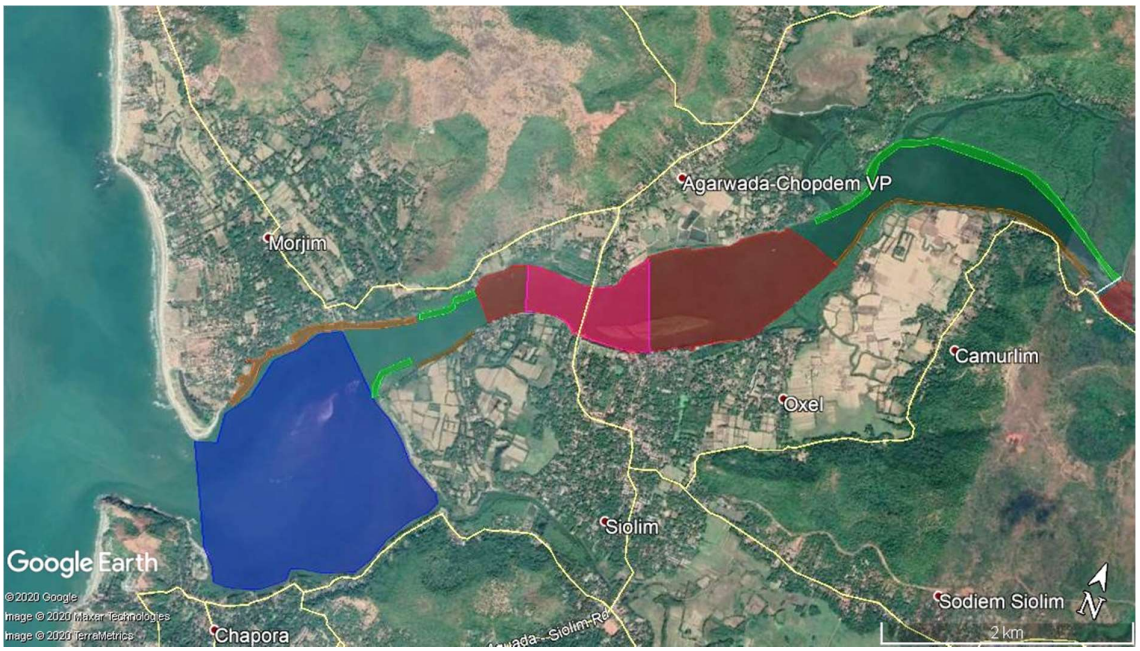
restricted for mining. East to the bridge an Island (North of Oxel village) vegetated with mangroves, and considering the Hon'ble NGT order (28/2015 (WZ) an area of 1000m (upstream and downstream) has to be restricted for mining. Based on the baseline geo-morphology and bathymetry, the profiles reveal 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 down-streams 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

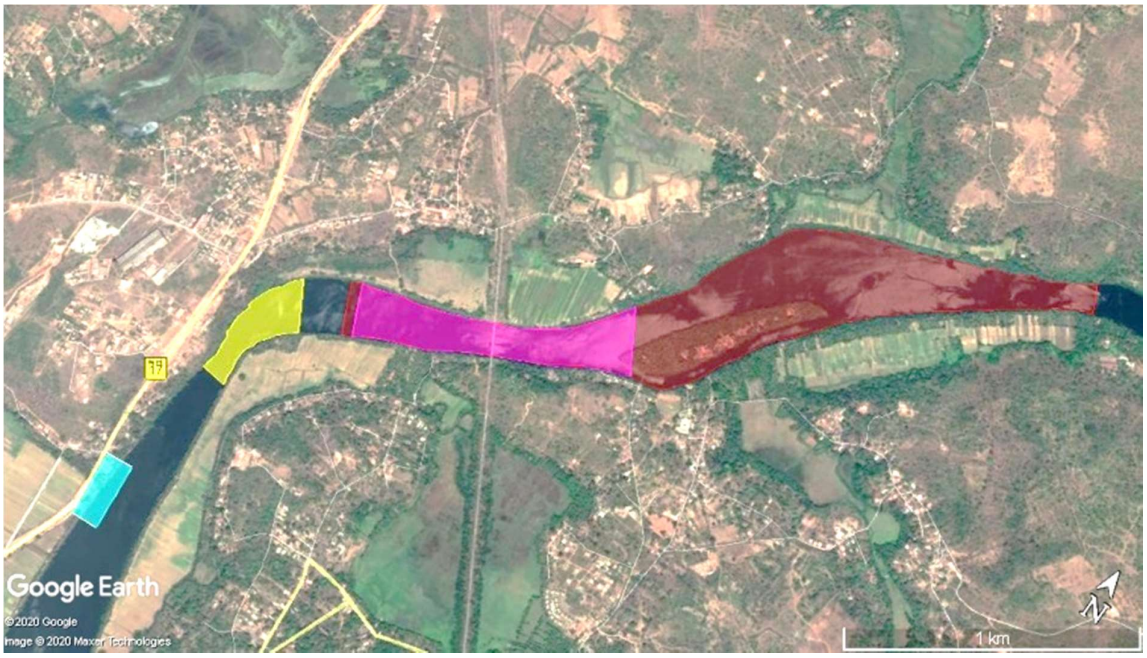
and Bentix therefore the impact of sand extraction will be minimum on the benthic biota but Shannon-Wiener's and Simpson's Index shows high values. While the stretch between Camurlim- Chopdem has higher indices (Figure 7.2) which indicates sand extraction will have higher impacts on the benthic biodiversity.



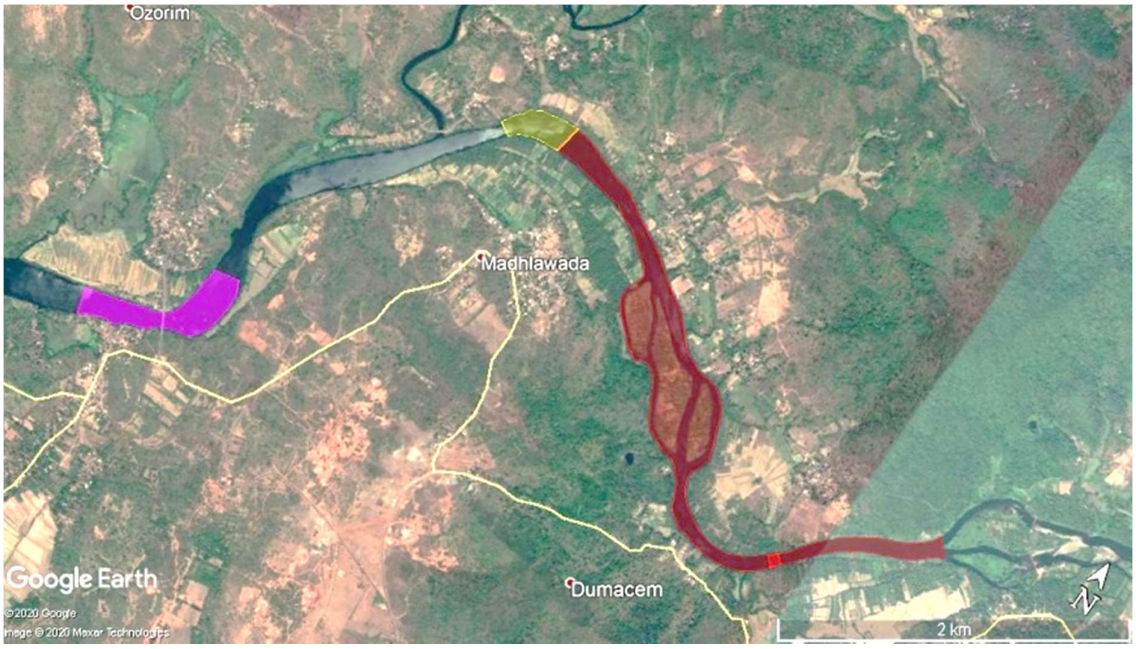
Zone-I



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-stremas& 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

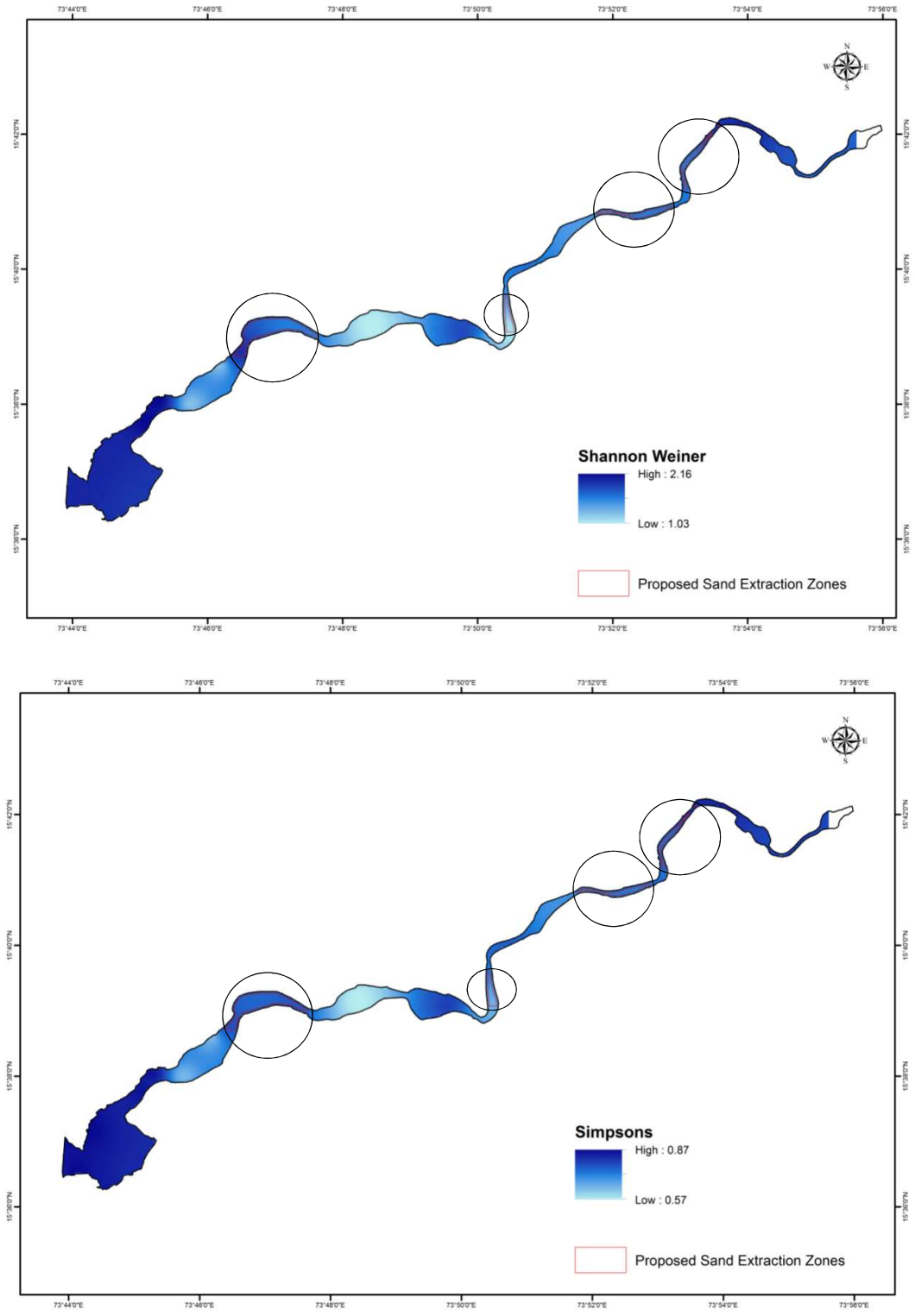


Figure 7.2: Shannon-Wieners and Simpsons Index depicted on the river stretches with encircled proposed sand extraction zones.

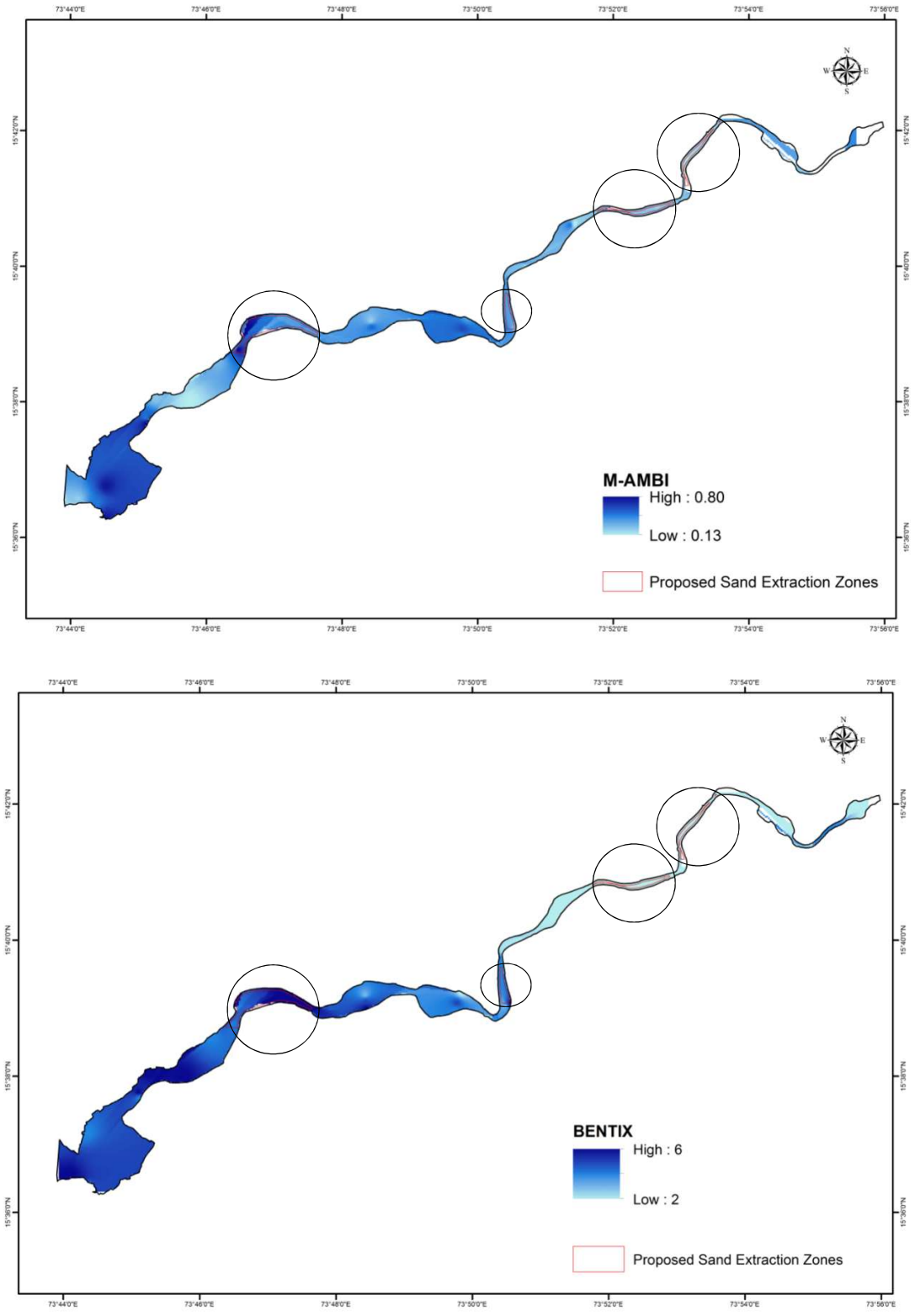


Figure 7.3: M-AMBI and BENTIXindices depicted on the river stretches with encircled proposed sand extraction zones.

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 Figure7.51A-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.

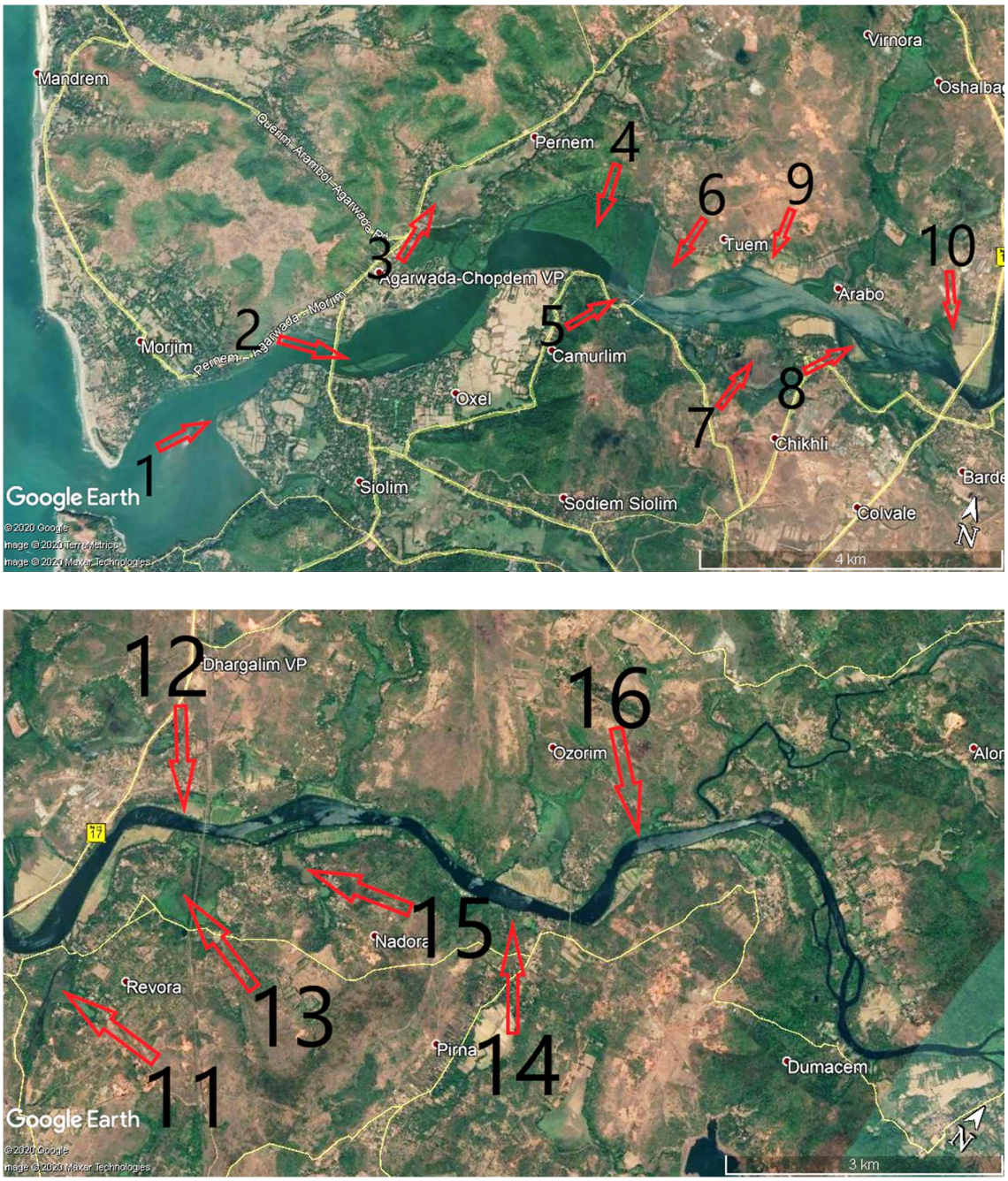


Figure 7.4: Two sections of the rivers depicting areas highlighted in the subsequent Figure 7.5 for land use changes.

2003	2019
	
1A	**1B**
	
2A	**2B**
	
3A	**3B**



4A



4B



5A



5B



6A



6B



7A



7B



8A



8B



9A



9B



10A



10B



11A



11B



12A



12B



13A



13B



14A



14B

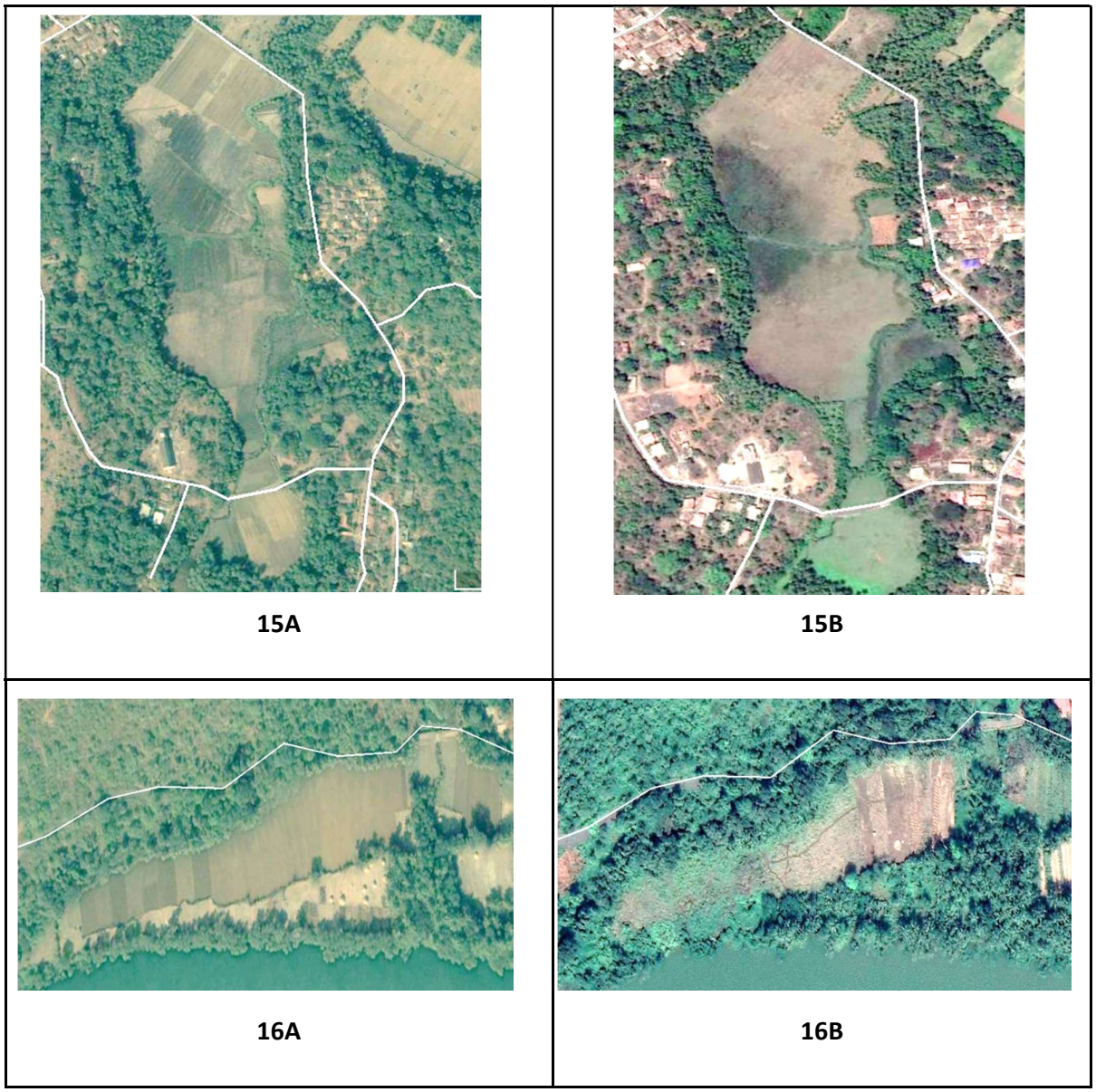


Figure 7.5: Areas depicting Land Use Land Cover along the Chapora Estuary.

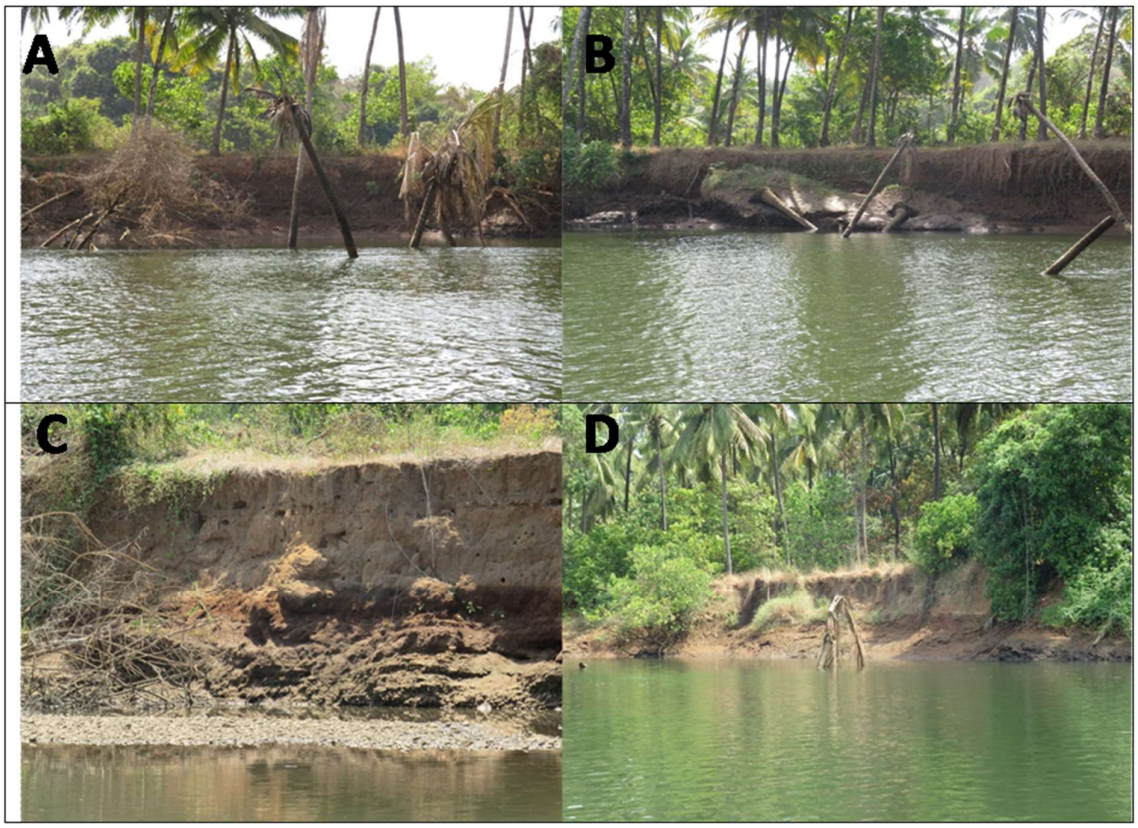


Figure 7.6: Erosion of banks in the upstream stretches of Chapora Estuary.

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 it's 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 ¼th 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.

8.5Limiting 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.

8.6Prevention 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 auditsneed 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.

8.7Protection 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 9ENVIRONMENTAL 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 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.

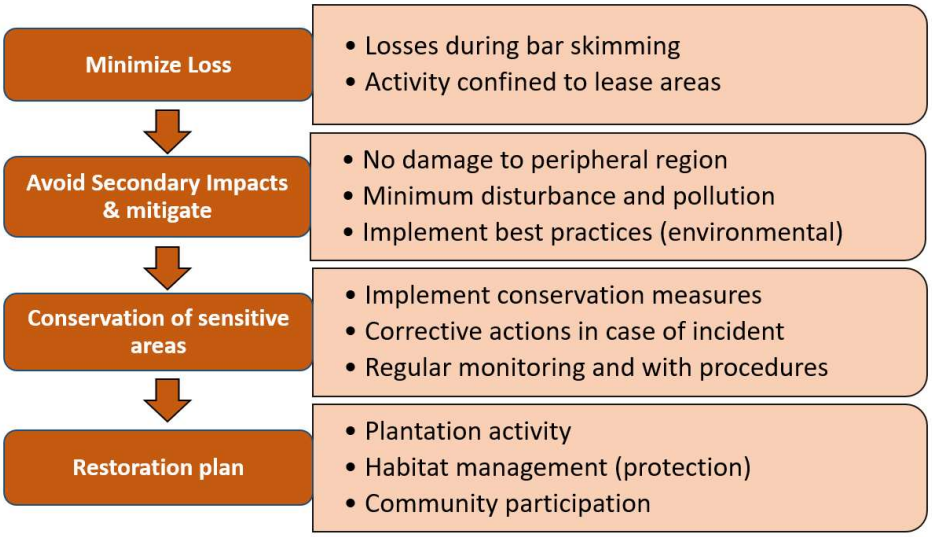


Figure 9.1. Schematic diagram of management of sand mining

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).

9.5Management 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.

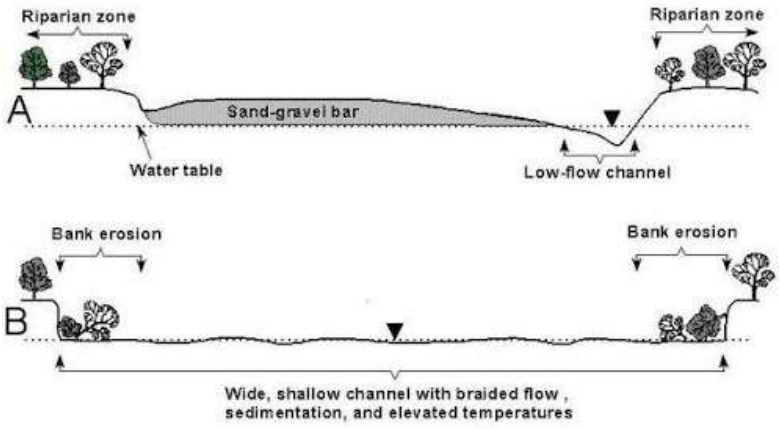


Figure 9.2. Diagram of channel cross sections showing

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).

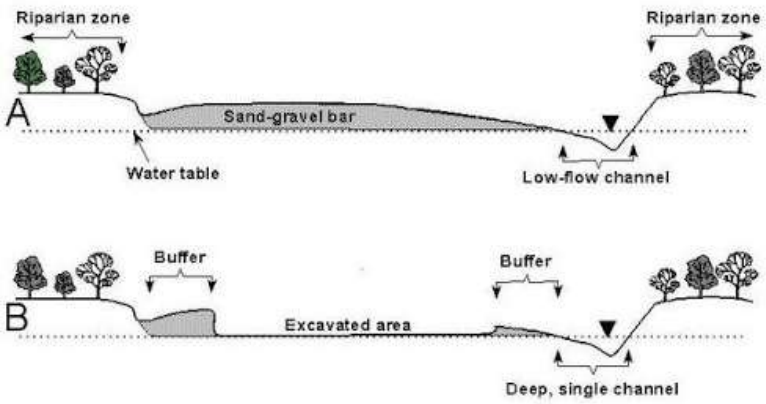


Figure 9.3. Diagram of channel cross sections showing

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.

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 (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).

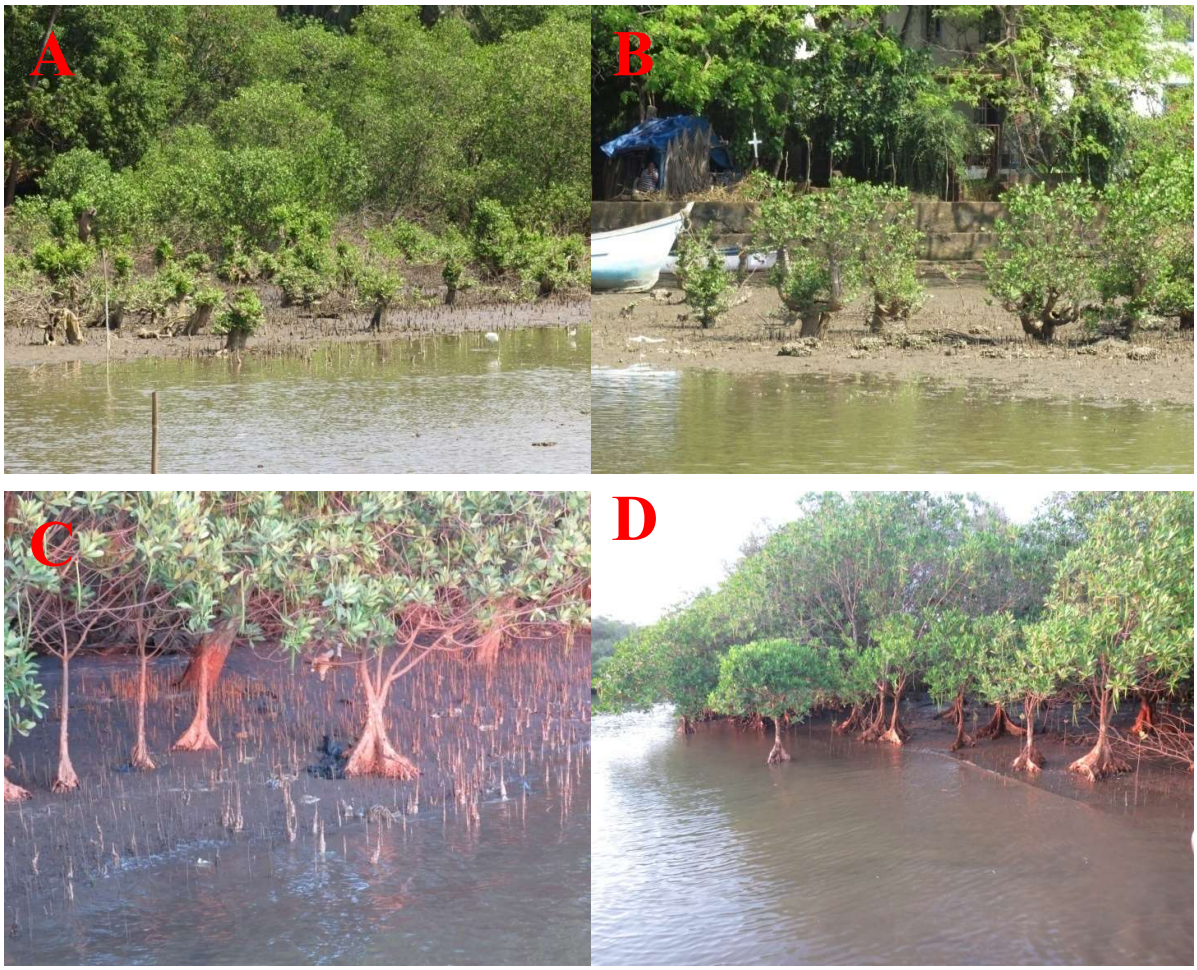


Figure 9.4: Exposed mangrove cutting and root buttresses of Chapora Estuary.

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, Meretrixc 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, Sillag osihama, Nematalosanasus, Ilisha toil, Escualosathoracata, Leiognathusbrevirostris, Thryssamystax, Alepeskleinii, Tenualosailisha, Harpadonnehereus, Pamapama, Setipinna*sp, *Coiliadussumieri, Msytusgulio* etc. The major penaeid species caught in the estuary are *Fenneropenauesmerguiensis, F. indicus, Marsupenaeusjaponicus, Metapenaeusaffinis, M. brevicornis, M. dobsonii, Penaeussemisulcatus, 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, Polymesoda*sp., *Tegillarcagranosa, Marcia opima, Meretrixmeretri*and *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*), Pearlspot (*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	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. 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. 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.
2.	Financial Assistance for setting up of Crab farming Unit in Goa	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. 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.

3.	Financial Assistance to Freshwater Aquaculture farm	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. 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. C. <u>Financial Assistance for purchase of Farm Equipments:</u> 50% limited to Rs. 60,000/- per ha. Eligible after every 5 years.
4.	Financial Assistance to Mussel Culture and Oyster Farming in Goa	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. 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.
5.	Financial Assistance for setting up of Ornamental Fish Unit in Goa	A. For setting up of Breeding unit-50% of the actual cost limited to Rs.1, 50,000/-. B. For setting up of Rearing unit-50% of the actual cost limited to Rs.1, 50,000/-. C. For setting up of Rearing unit and Breeding unit- 50% of the actual cost limited to Rs.2,50,000/-.

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 ate 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 s*sp.

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 ain 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 Anadaragranosa*.

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 m^2 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 mossambi*cus). 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. Costal 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 *Penaeusindicus,* White leg shrimp *P. vannamei* and tiger prawn *P. monodon*. Apart from these candidate species other commercially important species such as *Metapenaeusensis*, *M. monoceros*, *M. brevicornis*, *P. semisulcatus* and *P. merguiensis* 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, soilconditions. 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/m^2. 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. s. 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. Pearlspot fish culture

Pearlspot, *Etroplus suratensis* (locally known as “Kalundhar”) is another important candidate species for culture in ponds, cages and tanks. Polyculture of pearlspot 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 undertaken 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).

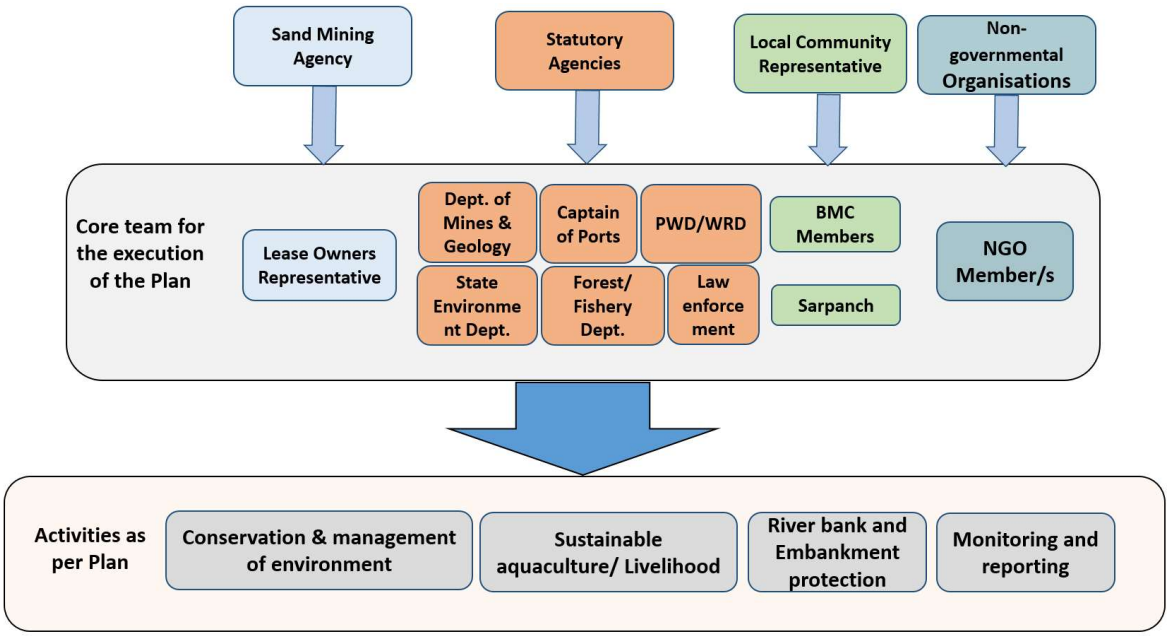


Figure 9.7. Schematic diagram depicts execution of management plan

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 con-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.

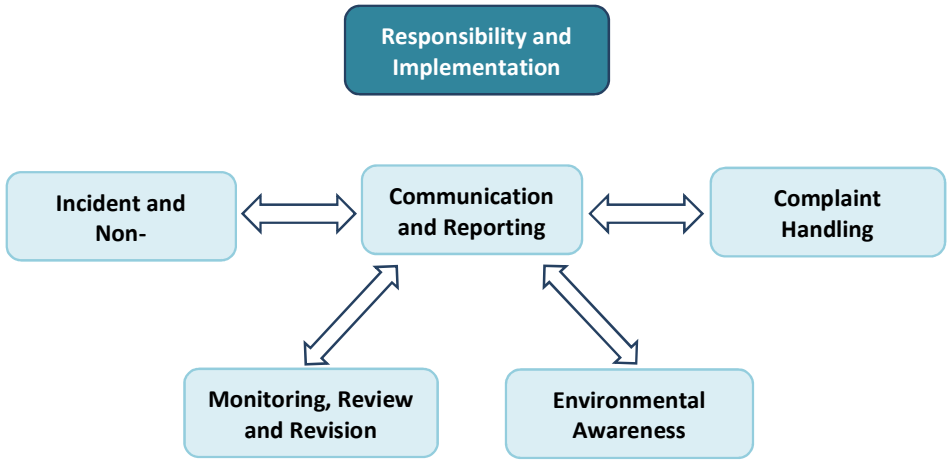


Figure 9.8. Schematic diagram of development and functioning of team

9.13.7 Attempts to deal with the illegal trade (WWF, 2018)

The Directorate of Mines & Geology, the Costal 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)

Alternatives 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.

10.1Mining 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.

10.3Surveillance & 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 (PM_{10}), Particulate Matter 2.5 ($PM_{2.5}$), Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx), 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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CSIR - National Institute of Oceanography

Geo-morphological studies and EIA/EMP for the sand mining clusters of Rivers in Goa

Chapora River

Pre- and Post-Monsoon Report

Submitted to

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Chapora River Survey Report

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Executive Summary

This report summarizes the field-work, preliminary data processing and filed observations of the acquired multi-platform geophysical data acquired with-in Chapora River stretch of 26line km.

Pre- Monsoon Survey Period: 07th March March2020 to 18th March2020 (26 Line Km side scan sonar, single beam echo sounding, seismic and sediment sampling) for studying geomorphology and subsurface imaging to understand the Chapora river bed and collected to characterize the sediment properties (Geological and Geochemical analysis).

Post- Monsoon survey Period: 06th Jan2021 and 18th Jan2021 (26 Line Km side scan sonar, single beam echo sounding, seismic) for studying the post-monsoon geomorphology changes across the Chapora river bed.

Key Observations

Pre-Monsoon

Sonography survey

- The Side Scan Sonar images is generated from the mouth of Chapora river (Chapora Fishing Jetty) to Alorna Fort.
- The Side Scan Sonar image shows varying ripples. However, three regions have been spotted in the sonography dataset where rippled bedform as well as heavily rugged riverbed has been observed.
- Spatial variations observed in the backscatter sonar intensity and ripple patterns.

Shallow Seismic 2DHR

- Sparker system achieved a maximum subsurface penetration of ~15-20 m in the survey area. The seismic derived bathymetry data show that the depth (represented as TWT) varies from 7 ms to ~20 ms.
- Due to the shallow depth of riverbed, multiples (up to second-order) are observed in the study area.
- Sand Volume are estimated using side scan sonar image zonation of sand features, sediment thickness from seismic data.
- Based on EIA/EMP studies six feasible sand mining regions are identified

Sediment Sampling

- Sediment samples were acquired at different stations using small hand grab
- Sand dominates the sediments followed by silt. Clay content is very low except at one station.

Pre-Monsoon:

- Repeat geophysical survey is carried out in Chapora river to study the post monsoon impact on the river bed geomorphology.

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Chapter 1. Introduction

Background

Undoubtedly sand is essential part of river ecosystem. Like flow and fish, it helps rivers stay healthy, sand is critical for ground water recharge, replenishes the nutrients in moving water and provides habitat to numerous forms of aquatic and riparian fauna. Sand has become an essential component of most of modern infrastructure. From roads to buildings and other structure, usage of sand is ubiquitous all over the planet. Sand mining is the extraction of sand from beaches or ocean and riverbeds. The dredging and mining often cause several alterations to the physical characteristics of both a river and riverbed. The erosion caused by the process of mining to the ocean or river floor can also adversely affect the biodiversity of the region (river and riparian habitats). Although several policy measures have been undertaken, the sheer demand for sand worldwide has given rise to a large network of sand mining operators including Goa, India.

To address impact of sand mining on the health of the riverine systems of Goa, four major rivers have been identified viz; ***Chapora, Terekhol, Mandovi*** and ***Zuari*** rivers. In each of these rivers a total of twenty-four active sand mining clusters have been identified (Annexure-I). Other than the above four, Goa harbors few more rivers. This proposal also includes an estimate for carrying out studies in the nine rivers (***Sal, Talpona, Galjibag, Cumbarjua, Valvanti, Mapusa, Sinquerim, Khandepar, Kushavati***) and at other sand mining areas in other rivers as second phase of this project. Presently there is no data available for the rivers with respect to sand, availability, areas, its extraction etc. Goa State Biodiversity Board (GSBB) an autonomous body of Government of Goa under Department of Science, Technology and Environment, would like to carry out a study to understand the geo-morphology, bathymetry, sand budgetary and flow dynamics of these clusters and the impact of sand mining on the biodiversity of these identified river clusters in in Goa. GSBB has approached CSIR- National Institute of Oceanography (CSIR-NIO), since the CSIR-NIO is having scientific expertise, infrastructural and logistic facilities and capability for carrying out such studies.

"In the present report the study is focused on the river Chapora for Geo-morphological studies (pre- and post-monsoon studies) (Fig.1)."

Chapter 2. Data Acquisition: provides the detail information about the geophysical survey and various equipment's deployed for the survey like side scan sonar (SSS) for imaging the geomorphology of the river bed, single beam echo sounding for imaging the river bed depth, high resolution seismic (HRS, squid) system for imaging the subsurface image below the river bed, multibeam bathymetry (MBES) for river bed bathymetry (regional river bed depth).

Chapter 3. Data Processing: provides the detail information about the geophysical data processing and various parameters for processing the side scan sonar (SSS), single beam echo sound, seismic (HRS), multibeam bathymetry (MBES) data. Geological sampling location and sampling protocol.

Chapter 4. Interpretation: provides the detail interpretation and cross correlation between different geophysical data sets across the Chapora river for identification of various geomorphological features associated with the sand distribution (sand ripple marks, sand bars), river bank, active mining, exposed bed rock and river bank erosion, from side scan sonar data, corresponding depth from single beam and subsurface sediment thickness (probably sand).

Chapter 5. Geological observations: provides the detail analysis and observations from the geological samples collected across the river Chapora.

Chapter 6. **Post Monsoon Geophysical Survey*:*** provides the post-monsoon geophysical survey, analysis and comparison between the pre- and post-monsoon data in the Chapora river

Chapter 7. **Conclusions:** This Chapter highlights the observations from the pre-monsoon geophysical and geological sample analysis and post-monsoon geophysical survey and executive summary based on the pre- and post-monsoon comparison studies.

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Chapter 2. Data Acquisition

Geophysical data acquisition

Chapora River is a river in northern Goa, India. It runs westward into the Arabian sea at Chapora and demarcates the border between the North Goa talukas of Pernem and Bardez. The river originates at Ramghat in the neighboring state of Maharashtra enters Goa and flows into the Arabian Sea. Vagator Beach, a tourist destination, is located at the estuary to the south, and to the north is the village of Morjim (Fig.1).

General

Geophysical survey is a systematic collection of multi-platform geophysical data for spatial studies. They have many applications in geology, archaeology, mineral and energy exploration, oceanography, and engineering. Geophysical surveys are used in industry as well as for academic research. Such surveys are classified as seismic and non-seismic and provide various levels of detail, but all generate useful data based on the purposes for which the surveys are conducted. In the present study, the geophysical surveys carried out include seismic, and sonography survey along with the single beam survey and multibeam for the Chapora river (Fig.1).

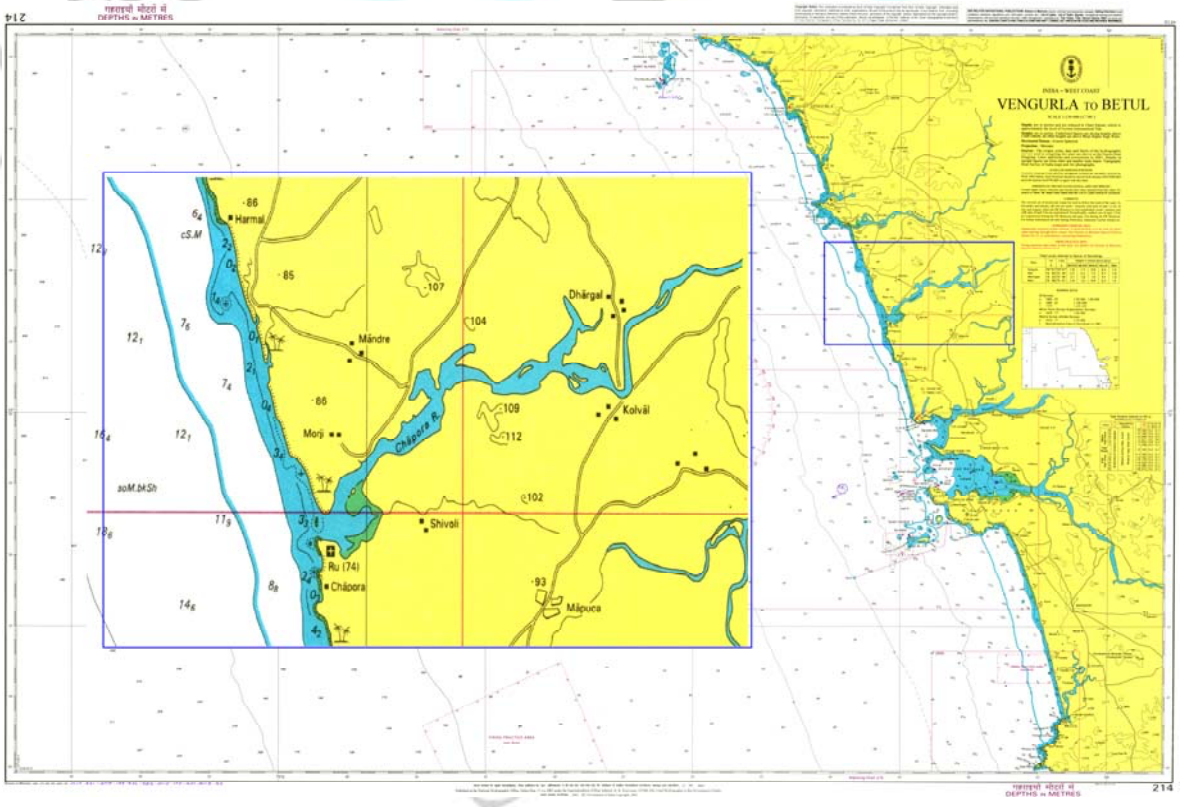


Figure 1. Hydrographic Map of Goa. Insight zoom area of river Chapora

Geodesy and controls

The survey was conducted in WGS 84 datum i.e. World Geodetic System version 84 spheroid which is invariably used by the various constellation of Global Navigation Satellite System (GNSS).

GEODETIC PARAMETERS	
Satellite Datum	
Spheroid	WGS-84
Datum	WGS 84
Semi-Major Axis	6378137.000 m
Semi Minor Axis	6356752.314 m
Inverse Flattening	298.2572
Projection Parameters	
Grid Projection	Universal Transverse Mercator
Latitude of Origin of Projection	0□ (Equator)
Longitude of Origin of Projection	75° E, Zone 43
Hemisphere	North
False Easting (meters)	500000
False Northing (meters)	0
Scale Factor on CM	0.9996
Units	Meters

Table 1. Geodetic survey parameters

Survey Plan

The entire geophysical survey was planned in three phase manner. Phase – I consist of sides can survey (SSS), single beam echosounder profiling and seismic sparker survey are carried out along the navigating channel in the Chapora river. In a similar manner, the Phase-II consist of sediment sample by using hand grab sampling equipment and Phase-III is multibeam bathymetry (Google map; Fig.2).

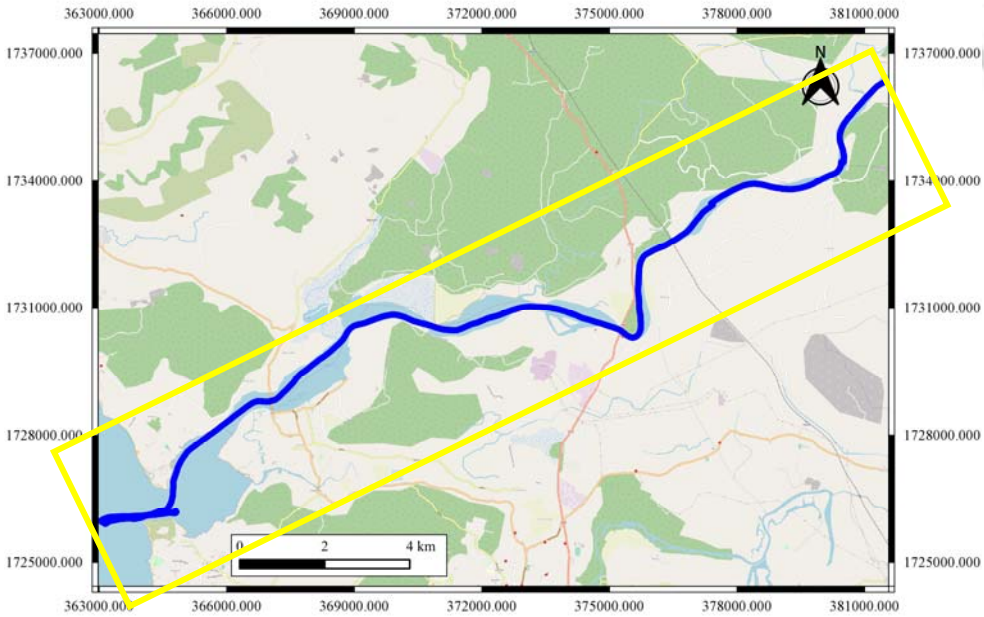


Figure 2. Google Map of the survey region (Chapora River)

Survey boats deployed for geophysical survey in Chapora river

Two different boats are deployed for various geophysical survey in Chapora river for side scan sonar (SSS), single beam echosounder profiling, high resolution seismic (HRS) (Fig.3) and multibeam bathymetry survey (Fig.3).



Figure 3.Boat deployed for survey for side scan sonar (SSS) imaging, single beam echosounder profiling, high resolution seismic (HRS squid) survey and geological sampling and multibeam bathymetry survey across the Chapora river.

Single Beam Echo sounder profiling

Data Acquisition Software

The acquisition software used is HYPACK® Max (Fig.4a), a marine surveying, positioning, and navigation software package. The software provides interface between various sensors such as motion sensor, heave sensor, global positioning system, echosounder, seismic data acquisition and side-scan sonar. The acquisition hardware is composed of three separate units: a GPS system on the survey vessel (rover), a motion sensor (vessel heave, pitch, and roll), and a Single beam echosounder. All the above hardware units were interfaced with acquisition system (HYPACK® Max). The acquisition software combines the data streams from the various components into a single raw data file, with each device string referenced by a device identification code and timestamped to the nearest millisecond.

The HYPACK® acquisition software combines the data streams from the various components into a single raw data file, with each device string referenced by a device identification code and timestamped to the nearest millisecond. The raw data thus gets recorded on hard disk of the computer, which was the copied to the portable hard disc. The time stamping to navigation and other geophysical data was accomplished in Greenwich Mean Time (GMT) provided by the Global Positioning System (GPS) receiver clock throughout the survey.

Navigation and Planning

The survey track lines were planned, oriented, in the navigation channel with the help of local navigator as no depth values are readily available in such a way that the underway survey would fulfil the objectives of the project indicated in the WORK. The survey vessel is navigated and maneuvered along navigation track lines by the master of the survey boat. In order to assist the master in track navigation, a helmsman monitor was placed in the wheel house of the vessel. This was interfaced to the data acquisition PC, running one of the most widely used software package called HYPACK® Max. It is basically a Windows PC based integrated software package for automated hydrographic data acquisition and processing routines, developed by Xylem Inc., USA.

The data from the GPS receiver, motion sensor, and echosounder are streamed in real time to a computer running the Windows operating system. Over to this, it also provides tools to i) Design preplanned survey track lines ii) Navigate along the planned track lines iii) Provide position data to other geophysical systems (echo sounder and high-resolution sub-bottom profiler) iv) Log raw position and depth data and v) Realize the quality control in real time navigation.

Bathymetric Equipment's and Software's

The single beam bathymetric survey equipment used for the survey consists of boat-based hull mounted Bathy-500HD echosounder. The Bathy-500HD is a high-resolution, precision echo sounder. It is basically a triple frequency echosounder having 33kHz, 50kHz and 210kHz frequency acoustic bursts (Fig.4a, 4b). It is designed exclusively for hydrographic marine surveys up to 100 meters of water depth. It meets or exceeds all current IHO hydrographic requirements for single beam echo sounders.

The Bathy-500HD system is configured as a flexible acoustic measurement sensor device capable of providing an excellent solution for shallow water hydrographic applications. Both

applications make use of the appropriate signal processing features to perform accurate and reliable bottom digitizing. The Bathy-500HD makes use of sophisticated algorithms for first/peak bottom echo detection, automatic mode controls for: receiver gain, bottom tracking, pulse length and power level controls greatly reduce the probability of inaccurate bottom detection/tracking.

Bathymetric surveys allow us to measure the depth of a river bed as well as map the underwater features on the seabed. Bathymetric charts are typically produced to support safety of surface navigation, and usually show sea-floor relief or terrain as contour lines and selected depths soundings.

Sparker data acquisition system

High-resolution shallow seismic system (make: Applied Acoustics Squid 500) was deployed to acquire the sub-bottom information of the region. The system includes Power Supply, Trigger capacitor bank, (Fig. 4c), hydrophone streamer array and an acquisition unit (model Mini-Trace II). In this technique, a source of seismic energy (squid system) is towed behind the survey vessel just below the sea surface. The transmitted pulse travels through the water column and sub-surface and are reflected when changes in acoustic impedance are encountered. Acoustic impedance changes commonly occur at the boundaries; i.e., interfaces between water and sediments, inter-sediments, and sediments and basement.

The reflected pulses travel back towards the sea surface, and the reflections are detected by an 8-element hydrophone. These reflections are converted to an electrical signal, which is amplified and converted to digital samples and stored in the hard disk of the data acquisition system (Mini Trace II) in native GeoTrace format. This data is then processed, filtered and displayed in graphic form as a function of travel time. The raw data is copied in SEGY format and later processed at CSIR-NIO using seismic data processing software ProMAX.

Side scan sonar

EdgeTech 4125 digital side scan sonar system and SonarWiz digital geophysical data acquisition system was used for SSS data on board (Fig.4d)

Rub Test: The side-scan sonar system was set up on the deck of the respective survey vessels and a ‘rub test’ was carried out on both port and starboard transducers of the tow fish.

Wet Test: The tow fish was thereafter, lowered into the water and a ‘wet test’ was performed to check that echo from targets were returning to both the channels. The gain and grey-scale settings were adjusted to balance the port and starboard channels of the side-scan sonar system. Side-scan sonar data was acquired using SonarWiz software geophysical digital data acquisition system.

The raw data was recorded in *.jsf format and the processed data were recorded in XTF format. The SonarWiz software processed and displayed the real time acoustic data on the computer screen for online quality control (QC). Output was controlled by specifying or editing

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various parameters, e.g., filter settings, automatic bottom tracking settings for known fish height at any time, time variable gain settings, output file format (XTF) settings.

Dual-channel dual frequency EdgeTech 4125 side-scan sonar performed well during the survey. The tow system was operated using recommended manufacturers procedures. The tow fish was towed astern of the survey vessel over an arm and its height above the seabed was maintained at ~20% of the horizontal range selected, providing optimum seabed return.

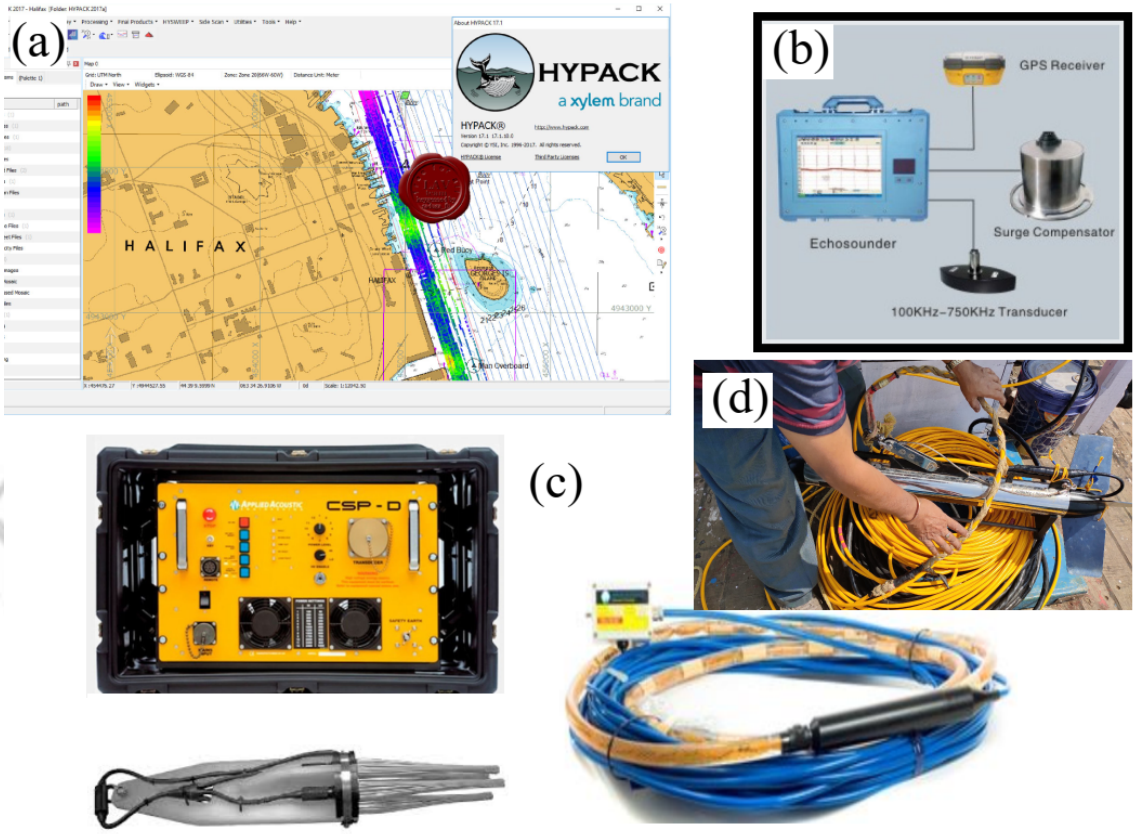


Figure 4.a) Hypack software used for recording Navigation and single beam echosounding data; b) Single beam echosounding system; c) Squid Sparkar System with 8 element streamer; d) Side Scan Sonar system (400kHz/900kHz).

Multibeam bathymetry survey

As compared with the single beam bathymetry (echo sound) which provides the point depth values along the navigation track, multibeam bathymetry provides swath bathymetry and morphological changes on the riverbed.

The equipment's that are used in multibeam survey is shown in Figure 5.

Positioning System

Vessel positioning was carried out by the Seapath 130 DGPS system. Vessel track and offset positions were recorded digitally in the navigation software. The positioning system was interfaced to the navigation software as well as the digital data acquisition system. DGPS positioning accuracy of the moving vessel was better than ±1m. The vessel offset schematic diagram is shown figure.6b and offset details are provided in the Table. 4.

The basic functionalities and features of the positioning system are given below (Fig.5a),

Product components

The main component is the Sensor Unit with the integrated GNSS antennas and receivers. The Sensor Unit mounts on top of the vessel mast or a pole. On top of the transducer the inertial sensor of type MRU H is mounted within lightweight subsea housing. The Seapath operator software is installed on a connected PC for configuration and monitoring. All the components are connected through a spider cable with MRU connection, three configurable output serial lines, DGNSS correction input, 1PPS output, network communication and power.

Function:

The advanced Seapath navigation algorithms integrate RTK GNSS data with the inertial sensor data from the MRU. This gives the Seapath 130 unique advantages compared to stand-alone TK products. The Seapath product's accurate roll, pitch and heading measurements allow the RTK antenna position to be referenced to any point on the vessel where accurate position and velocity are required. All data from Seapath have the same time stamp and the output is in real-time. position accuracy can be achieved through download of satellite orbit and clock data from the internet and by post processing of satellite and IMU data.

Features:

- Compact and robust integrated INS/GNSS system
- 0.008° to 0.08° roll and pitch accuracy wrt to the MRU
- No accuracy degradation in roll, pitch and heave measurements during turns
- 5 cm real-time heave output for periods up to 25 seconds
- Precise heave at long wave periods by use of the PFreeHeave® algorithms
- 120-channel dual frequency GPS/GLONASS receiver
- Robust against GNSS dropouts due to the inertial sensor part of the product
- Multiple differential correction support including SBAS
- RTK correction on RTCM format supported
- SeaSTAR®, OmniSTAR® and Marinestar® corrections supported
- All data are provided with time stamp with an accuracy of 0.001s to the actual measurement time
- Outputs on RS232, RS422 and Ethernet
- Up to 100 Hz data output rate

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- Dual-frequency GPS/GLONASS ionospheric compensation
- Logging of raw satellite and IMU data possible
- Meets IHO special order requirements

The computed position of the vessel from the DGPS receiver was interfaced to the navigation computer system. Hypack navigation and data acquisition software is used to provide track guidance information to the survey crew and also output the position of the vessel to assist the helmsman in maintaining the selected track guidance line. The VDU displays the selected survey line, the position of the vessel in relation to that line and numerical data to assist the helmsman such as the along-line and off-line distances, vessel speed and course made good, distance, heading and bearing to end of line and water depth. The position of each fix, together with other information such as fix numbers, depths, PDOP and along-line distances were logged to the hard drive. The DGPS positioning system also provides the heading information.

Multibeam Echo Sounder

A GeoAcoustics Geoswath Plus Multibeam Echo Sounder (MBES), operating at a frequency of 500 kHz, was used to delineate the topography of the seabed. The measured sound velocity and observed tide was fed into the system during data processing. The Equipment features and details are explained below (Fig.5b, & 5c).

Technical Specification	
Freq	500 kHz
Max Water Depth below Transducer	50 m
Max Swath Width	190 m
Max Coverage	Up to 12 x water depth
Depth resolution	1.5 mm
Two Way Beam Width (Horizontal)	0.5°
Transmit Pulse Length	32 µs to 224 µs
Max swath update rate	30 per sec (range dependant)
Transducer Head dimensions	330 × 109 × 75 mm
Transducer Head weight	16.kg
Power Requirements	24 VDC, 55W peak

Table 2. Multibeam techincal specifications

Key features

- Ultra high resolution swath bathymetry
- IHO SP-44, special order
- Frequency versions: 125, 250, 500 kHz
- Up to 12 times water depth coverage

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• 240º view angle
• Dual transducer set-up with versatile mounting options
• Full software solution included: data acquisition, processing, presentation
• Interfaces to all customary peripheral sensors
• Interfaces to all customary software packages

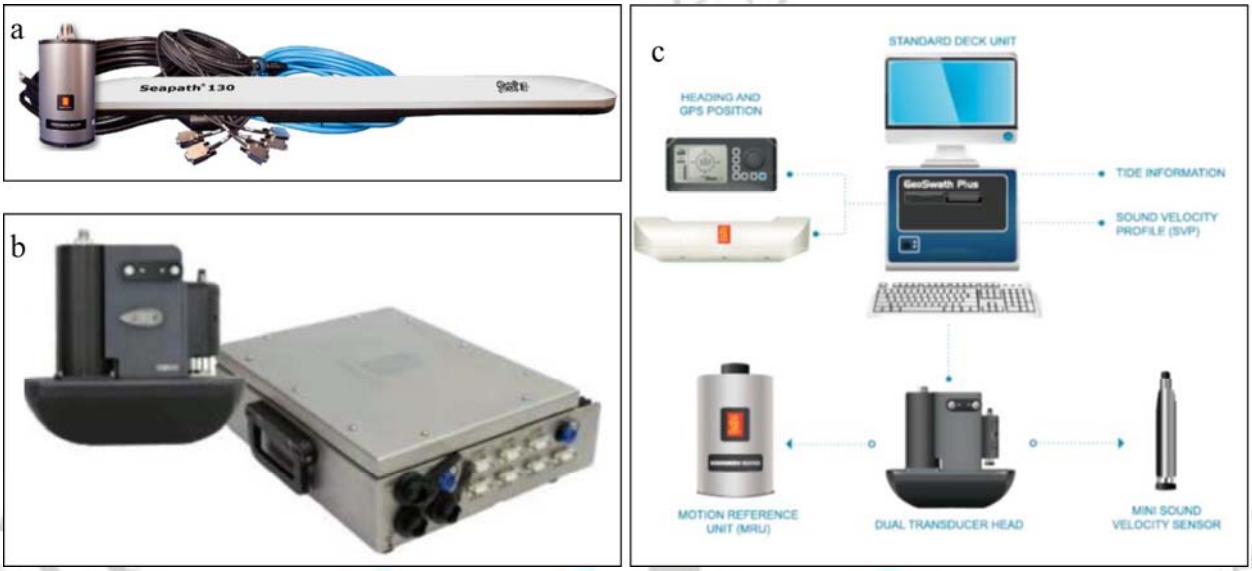


Figure 5. Positioning System; Geoswath Plus Multibeam Echosounder; Simplified diagram illustrating the system configuration

Calibration

The following calibration report documents procedures used to measure and adjust sensor biases and offsets for multibeam echosounder systems. Calibration must be conducted,

a) Prior to survey data acquisition
b) After installation of echosounder, position and vessel attitude equipment
c) After changes to equipment installation or acquisition systems
d) Whenever the Hydrographer suspects incorrect calibration results

Multibeam echosounder calibrations must be designed carefully and individually in consideration of systems, vessel, location, environmental conditions, and survey requirements. The calibration procedure should determine or verify system offsets and calibration correctors (residual system biases) for draft (static and dynamic), horizontal position control (DGPS), navigation timing error, heading, roll, and pitch (Fig.6a).

Instrument correction

An initial leadline confidence check was measured against the multibeam echosounders prior to the start of field operations on 21st March 2020 at the survey site. The purpose of this check was to verify the systems during static conditions by confirming that the digital depths being recorded reflected the actual depths. A sound velocity cast was performed at the site. The leadline was performed approximately 5 meters to port of the multibeam system. The sonar's acquisition systems were logging data while the leadlines were performed. The GS4 Swath Editor was then used to verify the depth soundings. Soundings were queried approximately 5 meters to port of the nadir beam and verified with the leadline values. No instrument correction was necessary because of insufficient evidence of systematic error.

Patch Test

The swath bathymetry system was calibrated according to methods described in the manufacturer's manual. The swath transducer system was aligned with the roll/pitch/heave sensor. Great care was taken to mount the heads and pitch/roll/heave sensor as accurately as possible and the final calibration was carried out during sea trials by running several lines near the survey area. The following calibrations were carried out:

i. Roll calibration
ii. Pitch calibration
iii. Heading / Yaw calibration and
iv. Latency checks

MBES Patch Test Calibration Results:

Parameter	Value	Comments
Latency	0.191s	Seapath 130 positioning system with becon corrections.
Port Roll	-0.08º	Seapath 130-H MRU accuracy 0.03º in roll
Starboard Roll	0.25º	Seapath 130-H MRU accuracy 0.03º in roll
Pitch	0.00º	
Yaw	-3.80º	Accuracy better than 0.2°

Table 3. Patch Test Results

Site Description for Latency, Pitch, Roll and Yaw Procedures

Several areas within the Chapora Riverbank were chosen for the patch test procedure. The areas identified provided the steep and smooth slopes with little change in across track depth to accurately assess the latency, pitch, and yaw biases for the Geoswath multibeam system. Two planned survey lines were oriented perpendicular to slope, parallel and spaced apart to ensure

overlap of outer beams for the yaw calibration. A sound velocity cast was performed prior to conducting the patch test in the immediate vicinity. A total of seven lines were surveyed. Vessel speeds were consistent for the latency, pitch and yaw transects at approximately 5 knots. Navigation latency was determined by examining the roll timing error as per the precise timing procedure.

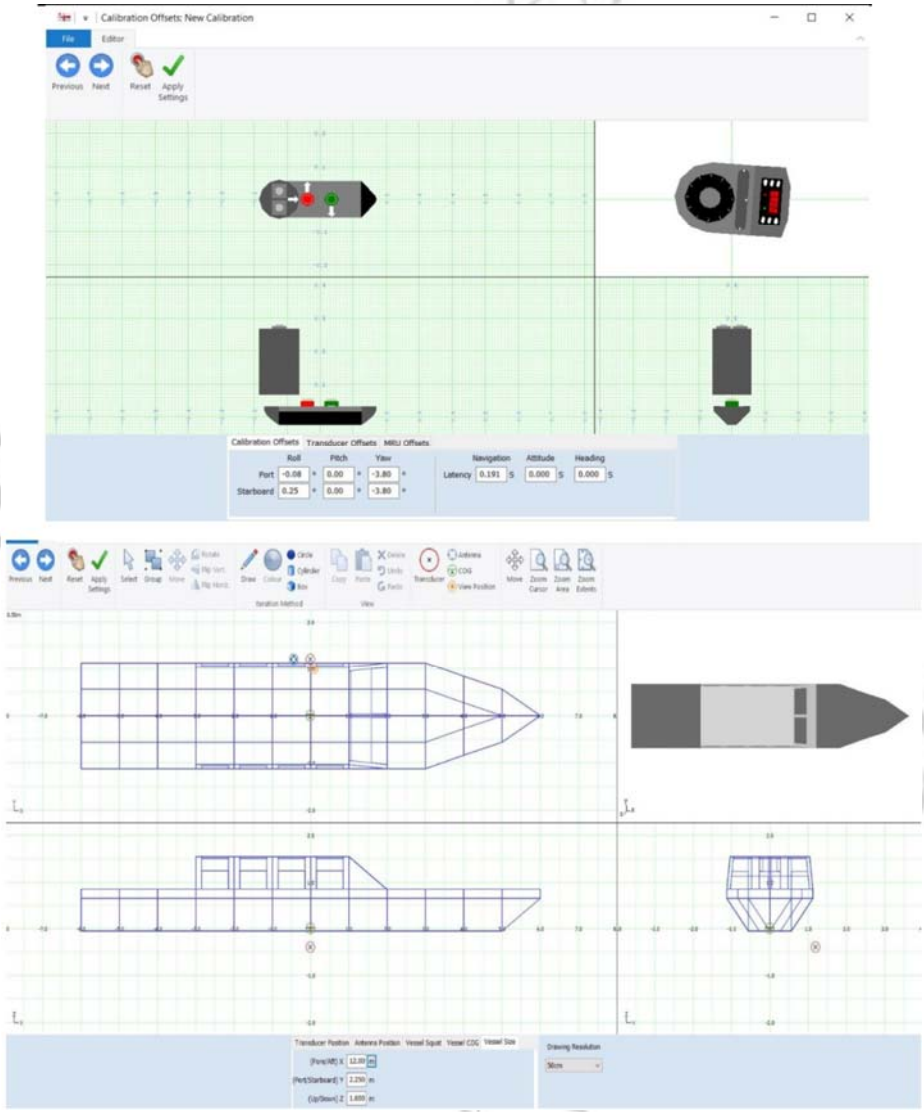


Figure 6. Calibration Offset; Vessel Offset

Parameter	Value	Comments
(Fore/Aft) X	12.00	Length of the Vessel
(Port/ Starboard) Y	2.250	Breadth of the Vessel
(Up/Down) Z	1.600	Draft of the Vessel

Table 4. Vessel Offsets

Sediment Sampling

In Phase-II we have carried out sediment sampling at selected locations based on the side scan sonar images across the Chapora river region (Fig.7). The sediment samples are collected for geological analysis and cross correlated with the geological features interpreted from side scan sonar (SSS) to understand river bed morphology.



Figure 7. Sediment sample (hand grab sampler) photographs in Chapora river

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Chapter 3. Data Processing

Geophysical data processing

High resolution Seismic data processing

The raw seismic data collected across the Chapora river for subsurface imaging is processed for increasing the signal to noise ratio for better subsurface imaging. raw data was loaded with Seismic Unix processing software and applied bandpass filtering 400-450-1900-2000.we have seen first order to 3rd order riverbed multiples

Single beam bathymetry data processing

Raw single beam echosounder bathymetry data collected along the navigation track line is processed for the tide correction based on the tide gauge data collected at Colvale bridge.

Side Scan Sonar Data Processing

Raw data processing and analysis is carried out through "SonarWiz7" software following processing steps listed in Fig. 9. Common processing steps include bottom tracking, signal processing (automatic gain control, beam angle correction, time varying gain), and offset & layback correction for determining towed sensor positions. The resultant side scan sonar image is created by mosaicking which is a process of assembling geo-referenced sonar images from adjacent track lines to create a comprehensive image of the seabed that represents the acoustic character of the seabed of the survey area. Finally, processed data and images are exported into formats compatible with Geographical Information Systems/other spatial image analysis software.

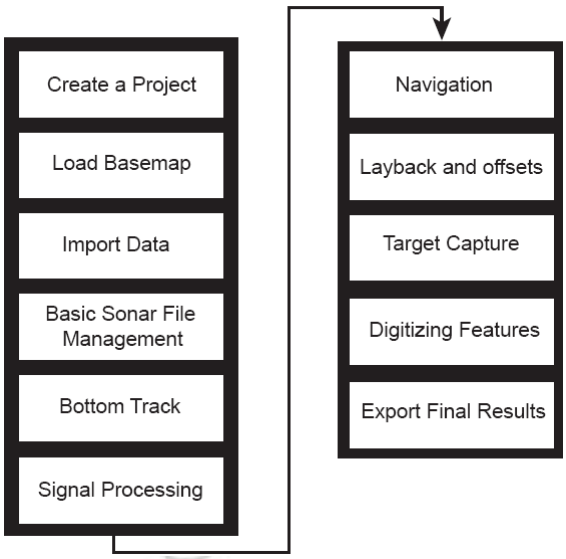


Figure 8. Flow diagram of side scan sonar data processing

Side Scan Sonar Data

The side scan sonar (SSS) is deployed from the star boat side upto 0.5 m below water column and towed. The survey is navigated along the channel at 3.5 knots speed and the continuous data is collected from mouth of the Chapora jetty to Alorna Fort (Fig. 2). The side scan sonar data record is done with 100 m swath both in star and port side of the boat, which total coverage is of 200 m (Highlighted in yellow rectangle box; Fig. 2). The side scan sonar image is the intensity image of the scatter from the seabed and river banks.

Fig. 9 shows side scan sonar images of various salient features from different locations within the river basin. Fig.9a shows river banks and river bank erosion and few sand extractions marks on the riverbed. Fig.9b represents google map and side scan sonar image highlights roads at the river banks and shows zones of the bridge pillar and river banks erosions. Fig.9c highlights tributary joins the main stream and sand mining marks. Fig.9d shows sand extraction marks and Fig.9e & Fig.9f shows the google map of sand bar and developed vegetation and google map with side scan sonar data highlights the bar bank.



Figure 9.Side Scan Sonar data. a) River banks and small boulders, active mining, b) shadow zones of bridge pillars c) conflux of river channel d) active mining marks (e) google map island developed in the river basin, f.) side scan sonar image across the island

Multibeam processing

The raw data was processed for various associated noise using various filter methods to produce the final georeferenced outputs. There are four main outlier filters that were used to filter the raw data from noise, namely

- Amplitude filter
- Limits filter
- Across track filter
- Along track filter

The multibeam data are corrected for sound velocity and tide correction to derive the accurate river bed depths which are used for calibrating and corrected the seismic data time to depth conversion.

Tide Corrections

Existing water level stations at Colvale (Fig.10), Goa were used in conjunction with height and time correctors in the GS4 Software. Preliminary tides were adjusted to Chart Datum (CD) level. Verified water level and final tide zone correctors were applied while post processing the data. The estimated tidal error contribution to the total survey error budget was at 95% confidence level, and included the estimated gauge measurement error, tidal datum computation error, and tidal zoning error. It should be noted that the tidal error component could be significantly greater than stated if a substantial meteorological event occurred during time of hydrography, although none were observed.

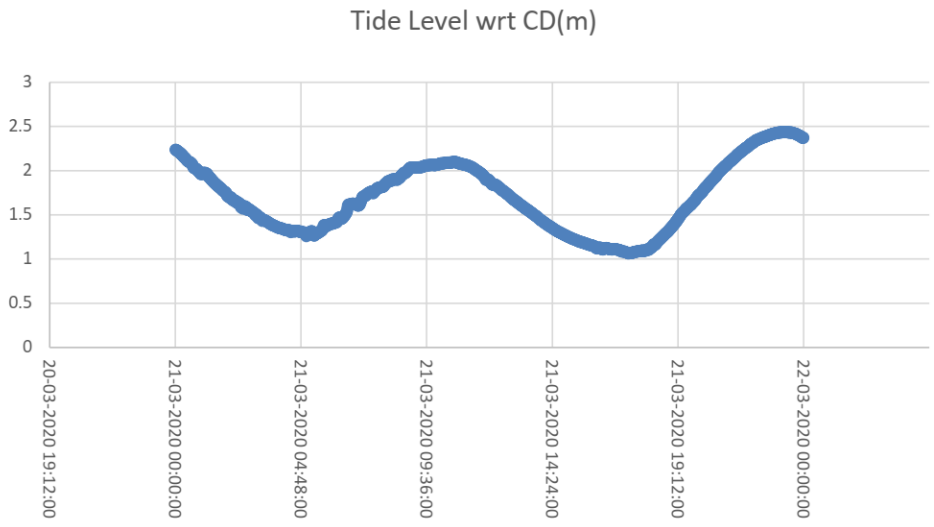


Figure 10. Tide Data at Colvale station

Sound Velocity Correction

Measurement of water sound velocity (SV) prior to survey operations in the immediate vicinity of the calibration site was done and conducted SV observations as often as necessary to monitor changing conditions and acquire an SV observation at the conclusion of calibration proceedings. Even if SV measurements are measured at the transducer face, surface SV was monitored for changes and recorded with profile measurements.

A Seagaurd tide gauge was installed at the site in close proximity to the survey location at Colvale. The Benchmark at Chapora Jetty was used to reduce the tide to the given CD level. The CD level at the benchmark has been transferred to the tide gauge for reducing the tide with respect to CD.

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Chapter 4. Interpretation

Major features identified from the side scan sonar (SSS) imaging

Riverbed morphology through the side scan sonar images have been carefully analyzed in order to infer the sand distribution, and to mark active sand mining zones in the study area. Entire surveyed area has been divided into 12 zones for interpretation of side scan sonar images. The processed images are presented along with a key map in figures 17 to 28. The analysis of the side scan sonar images reveals that the riverbed is carpeted by sediments in the entire surveyed area except at some locations. At Colvale (between Colvale road-bridge and river touch bar) the riverbed appears to be rocky and sediments are filled in small patches (Fig. 11.). Whereas at Revora, Nadora, Ozorim rock outcrops at the river banks appear to extend across river basin. Apart from this, at some locations near the river bank rock outcrops and rock debris are also identified (Figs. 12).

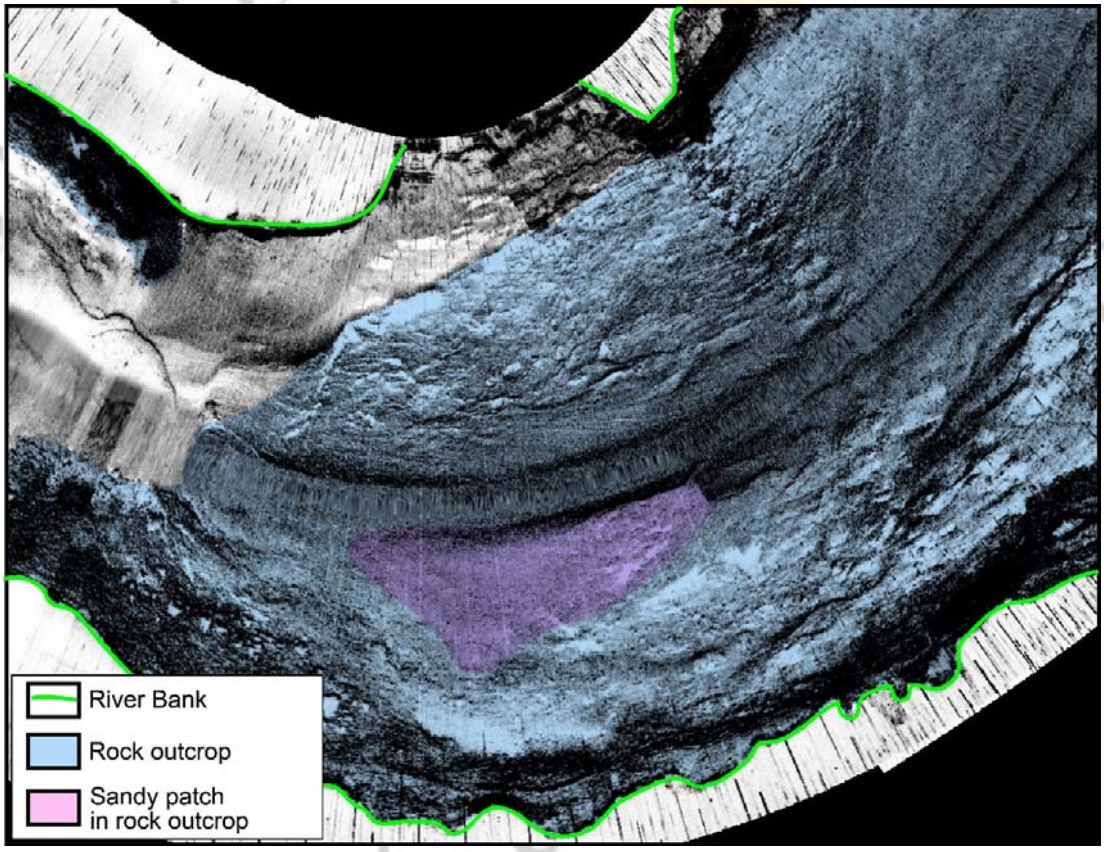


Figure 11. Sonogram showing patches of rock outcrops at Colvale

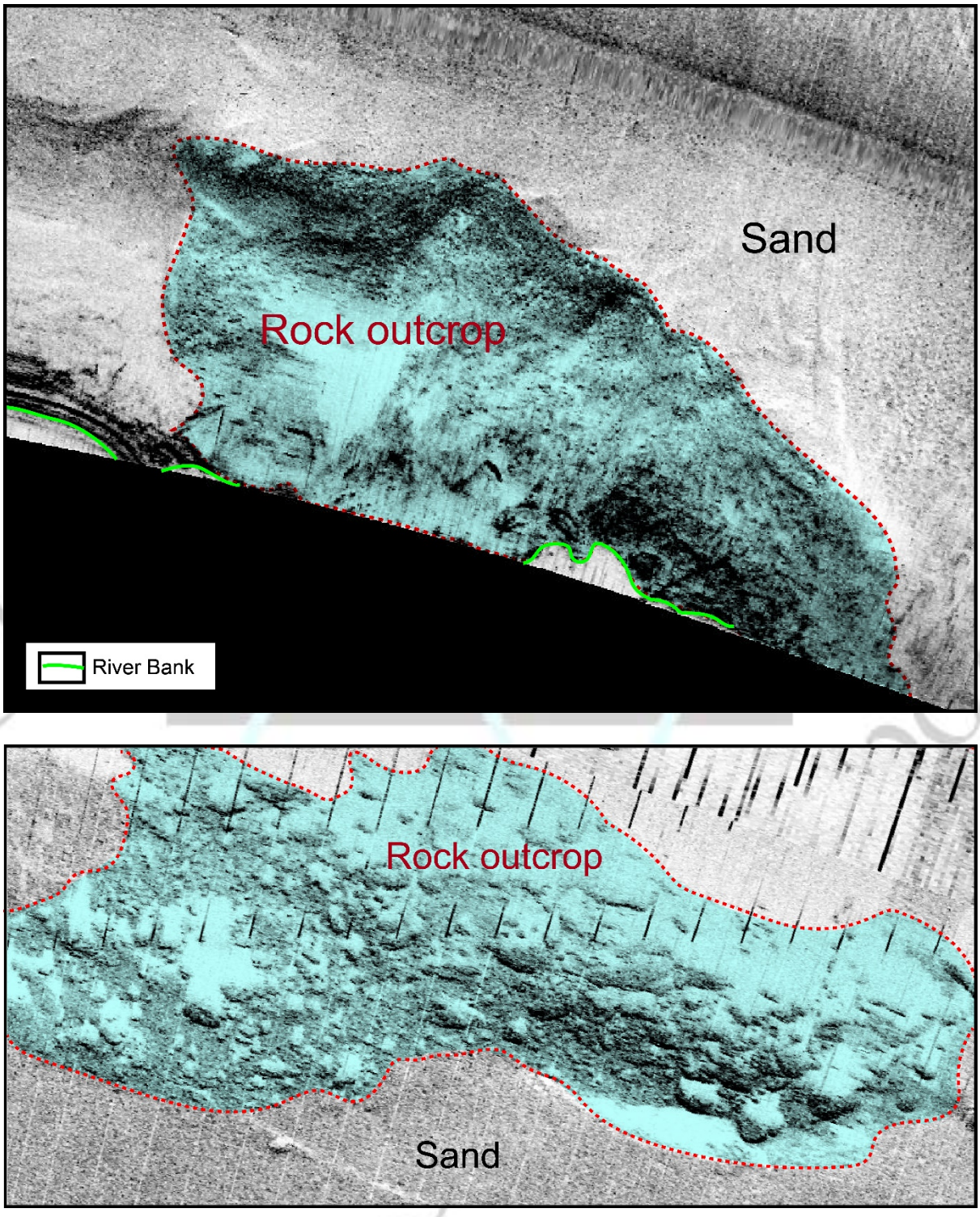


Figure 12. Sonogram showing rock outcrop and debris near the river bank Camurlim and Shirghalim

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Based on presence morphological features such as ripple marks and sand bar, along with tonal and textural variation in the backscatter, sand deposits on the riverbed are identified as shown in Fig.13. The riverbed, in the entire surveyed area, is predominantly comprised of sand. Sand boundaries in each sonogram have been delineated and presented in figures.17-28.

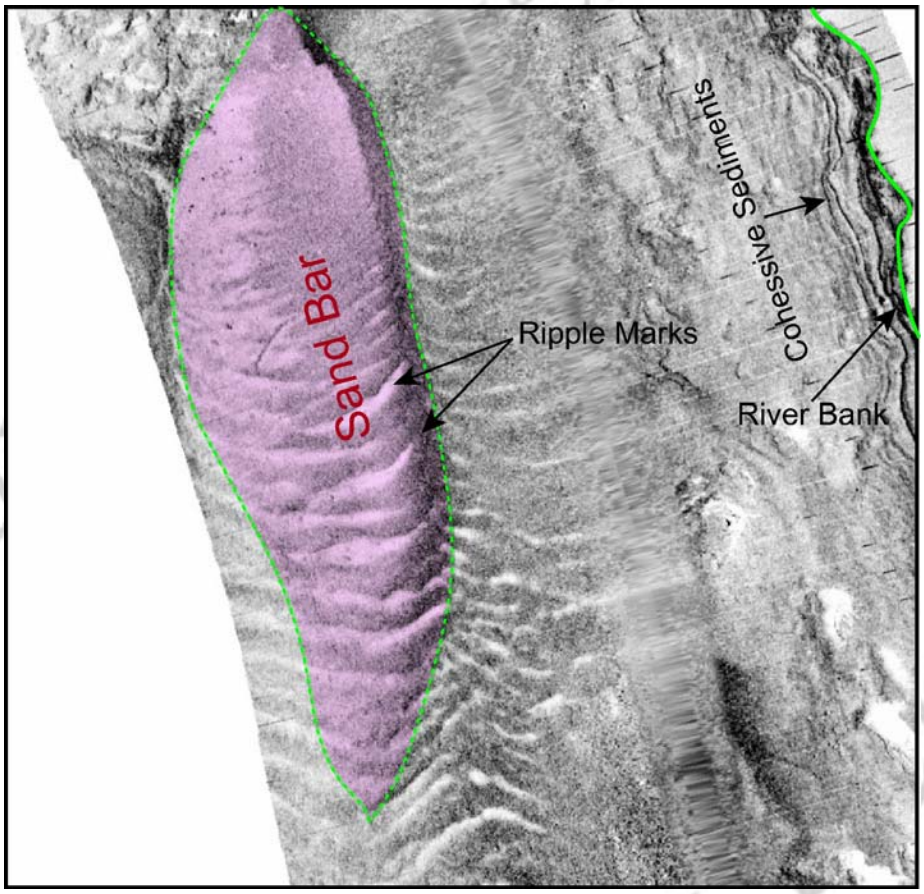


Figure 13. Sonogram showing sand bar and ripple marks near Ozorim, Mencurem-Dumashem VP.

At certain locations, side scan sonar images show zones with signatures of sediment excavation. These zones have been interpreted as active sand mining zones. Based on the appearances of excavation marks, these active sand mining zones are categorized in two types. In type-1 mining zone, excavation marks are generally elongated and one single excavation mark ~25 m long and ~4 m wide is shown in Fig.14.

In type-2 mining zone, the excavation marks are more rounded and a representative excavation mark of ~20-25 m diameter is shown in Fig. 15. Two different types of excavation marks signify variation in sand mining practice. Type-1 sand mining is predominant near Chikhli, Revora, Ozorim, and Mencurem whereas Type-2 sand mining zones are located near Ozorim, and Mencurem.

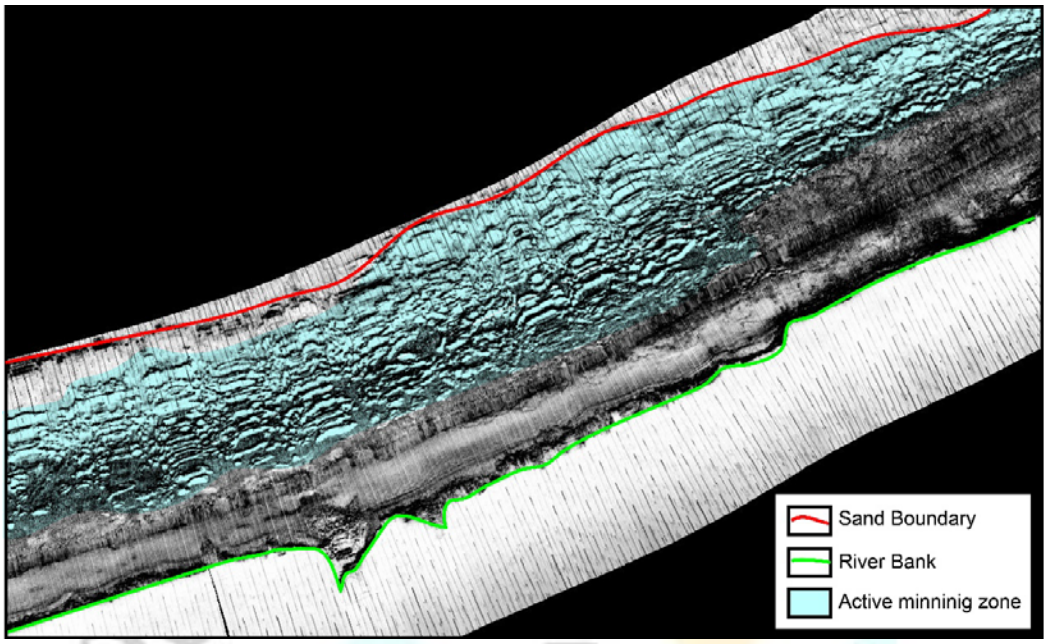


Figure 14. Sonogram showing type-1 sand mining zone at Bardez near Pirna-Ozorim bridge.

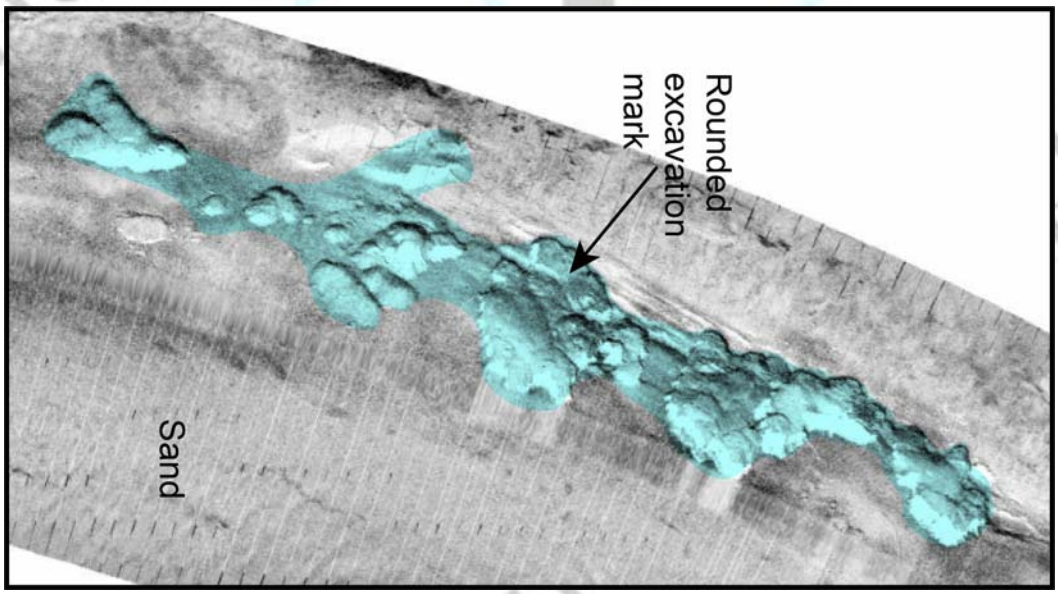


Figure 15. Sonogram showing type-2 sand mining zone

Apart from these between colvale and Revora, signatures similar to the signature of river migration have also have been observed (Fig.16 & Fig.17). These features need to be verified at present.

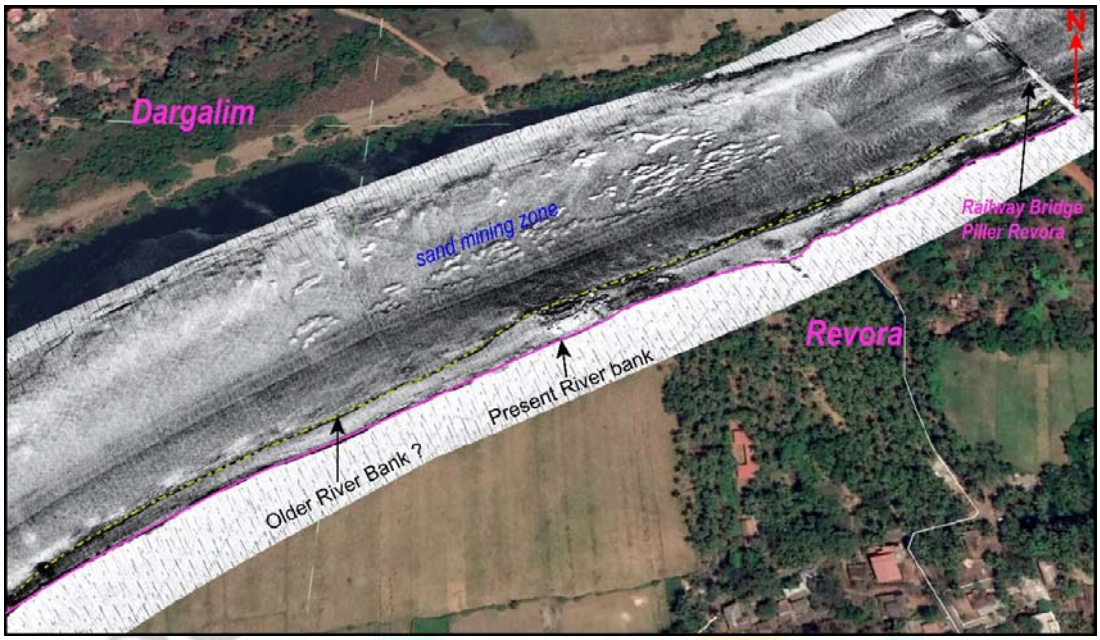


Figure 16. Sonogram showing river migration signature at Revora

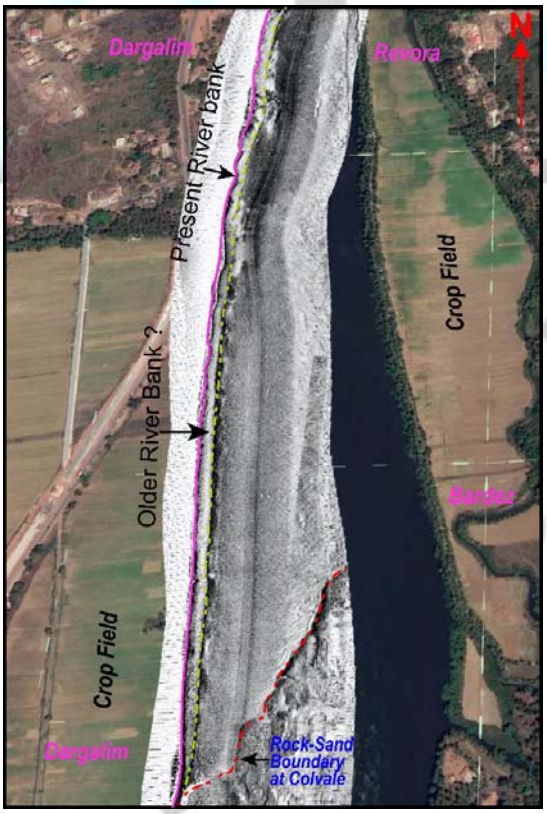


Figure 17. Sonogram showing river migration signature at Revora

Chapter Report

Color legends in Geophysical interpretation

Integrated geophysical plot highlighting the geomorphology based on side scan sonar (SSS) imaging, river bed bathymetry using single beam echo sounding and sediment thickness derived from high-resolution sparker seismic (HRS) is shown from Figures 17 to 28. The side scan sonar (SSS) image is referenced with WGS84 Universal Transverse Mercator (UTM) coordinate system and also in relative distance mode. Hereafter, the top X-axis is UTM-X, right Y-axis is UTM-Y and bottom and left axis show relative distance in m. The side scan sonar profile in Figures 17a-28a are interpreted with confirmed sand boundaries (red solid line), unconfirmed sand boundary (dotted red), outcrop (cyan), river bank (green), active mining region (pink solid), geological sample locations (green star) and the HRS seismic track is highlighted in solid blue line with the trace no. The bridges across the river are shown with Yellow and interpreted sand bars as solid black lines. Figures 17b-28b represent single beam echo sounder data (Solid blue) providing the river bed depth profile along survey line. Figures 17c-28c show interpreted riverbed (green) and bedrock (red) which are used for the calculation of sediment thickness.

The seismic data is acquired in time domain and is converted to depth by using a constant velocity of 1500 m/s and is also corrected with respect to tides. The sediment volumes are calculated as follows.

The difference between the bedrock and riverbed provide the sediment thickness along the seismic track. We assume that the sediment thickness goes to zero at the boundary of the sand zone. Assuming a linear sediment thickness between the seismic track line and boundary of sand zone, the cross section is calculated from the area of triangle as shown in Figure 16. The volume is calculated by multiplying the cross-section area with the incremental distance along the survey line.

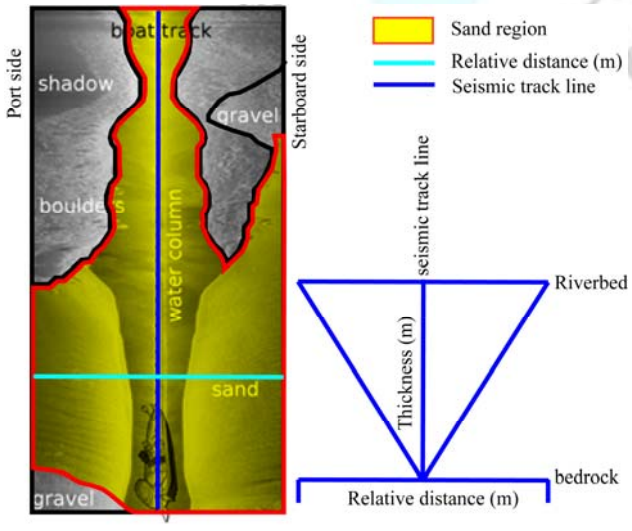


Figure 18. Schematic representing the calculation of sediment resource along the river profile

The total weight of sediment (sand) in tonnage is calculated by multiplying the volume with the bulk density of sediment of 1.6 g/cm^3 (equivalent to 1.6 Tonnes/m^3).

Estuary region (River Mouth)

The SSS data across the **Estuary region** covers an area of 200 m*1570 m area from the center of the navigation (blue track line), shows the sand boundary, and sand bar (black) side (Fig.19a). One geological sample location (**station 50**) is within the span of side scan sonar image at the bay (Fig.19a). Single beam bathymetry data shows the river bed depth varying between ~4.8-8 (Fig.19b). The sample analysis shows percentage (wt %) of sand is 98.43%, silt is 0.93 and clay is 0.05. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~3.75-8.5 m (green). bedrock is observed in the seismic data around depth of ~11.25-17m (Fig.18c). The sand volume estimated is **524283 m^3** equivalent to **1389350 tons** of sediment predominately of sand grain size.

Morjim jetty

The SSS data across the **Morjim jetty** covers an area of 200m*1850m area from the center of the navigation (blue track line), shows the sand boundary, rock outcrops and river bank on one side (Fig.20a). Single beam bathymetry data shows the river bed depth varying between ~2-4.5m (Fig.20b). One geological sample location (**station 54**) is within the span of side scan sonar image. The sample analysis shows weight percentage (wt.%) of sand is 99.62%, silt is 0.05 and clay is 0.05. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~3.75-7.5m (green) and bedrock (red) around ~11.25m (Fig.20c). The sand volume is **~1674221. cubic m** and **~2678753 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Wadji Supermarket

The SSS data across the **Wadji Supermarket** covers an area of 200m*1700m area from the center of the navigation (blue track line), shows the sand boundary, rock outcrops and river bank on one side (Fig.21a). Sand bar has been identified around the relative distance of 113 – 613 m. Single beam bathymetry data shows the river bed depth varying between ~2-8m. A deep valley like feature is identified from the single beam bathymetry (Fig.21b) and seismic data (Fig.21c) around relative distance of 613 where the depth of riverbed increase from 2 m to 8 m. Three geological sample location (**station 43,47, & 58**) are within the span of side scan sonar image, one at the slope of the valley (Fig.21a) the weight percentage variation (wt.%) of sand is 96.20-98.13%, silt is 1.38 – 3.54 and clay is 0.05-0.10. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~2-8m (green) and bedrock (red) between ~9.2-20m (Fig. 21c). The sand volume is ~**773160 cubic m** and **~1237057 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Sateri Temple

The SSS data across the Sateri temple covers an area of 200m*2300m area from the center of the navigation (blue track line), shows the sand boundary, rock outcrops and river bank on one side (Fig.22a). Single beam bathymetry data shows the river bed depth varying between ~2-12.5m. A deep valley like feature is identified from the single beam bathymetry (Fig.22b) and seismic data (Fig.22c). Two geological sample location (**stations 36, & 40**) are within the span of side scan sonar image, one at the slope of the valley (Fig.22a), the weight percentage (wt.%) of sand is 96-98%, silt is 0.10 and clay is 0.05-0.10. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~2-12.5m (green) and bedrock (red) between ~8.775-20m (Fig. 22c). The sand volume is **~1618575 cubic m** and **~2589720 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Camurlim Ferry Terminal

The SSS data across the **Camurlim Ferry Terminal** covers an area of 200m*2441m area from the center of the navigation (blue track line), shows the sand boundary, rock outcrops, river bank and active mining regions (pink) (Fig.23a). Single beam bathymetry data shows the river bed depth varying between ~2-9.8m. A deep valley like feature is identified from the single beam bathymetry (Fig.23b) and seismic data (Fig.23c). Two geological sample location (**stations 29, & 34**) are within the span of side scan sonar image (Fig.23a), the weight percentage (wt.%) of sand is 95.35-98%, silt is 0.12-3.47 and clay is 0.12-0.19. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~2-9.8m (green) and bedrock (red) between ~8.85-20m (Fig.23c). The sand volume is **~1988240 cubic m** and **~3181185 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Our Lady piety Chapel

The SSS data across the **Our Lady piety Chapel** covers an area of 200m*2170m area from the center of the navigation (blue track line), shows the sand boundary, unconfirmed sand boundary, rock outcrops, and river bank (Fig.24a). Single beam bathymetry data shows the river bed depth varying between ~2.5-7.8m. A deep valley like feature is identified from the single beam bathymetry (Fig.24b) and seismic data (Fig.24c). Two geological sample location (**stations 22, & 26**) are within the span of side scan sonar image (Fig.24a) the weight percentage (wt.%) of sand is 90.05-98.15, silt is 0.88-5.14 and clay is 0.88-4.82. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~2.5-7.8m (green) and bedrock (red) between ~9-20m (Fig.24c). The sand volume is **~1168952 cubic m** and **~1870323 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Sateri Temple Ambrewada

The SSS data across the **Sateri Temple Ambrewada** covers an area of 200m*950m area from the center of the navigation (blue track line), shows the sand boundary, unconfirmed sand boundary,

rock outcrops, and river bank (Fig.25a). Single beam bathymetry data shows the river bed depth varying between ~2.5-16m. A deep valley like feature is identified from the single beam bathymetry (Fig.25b) and seismic data (Fig.25c). Two geological sample location (**stations 5 & 21**) are within the span of side scan sonar image (Fig.25a) the weight percentage (wt.%) of sand is 94.55-94.93 silt is 0.84-1.80 and clay is 2.75-4.08. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~2.5-16m (green) and bedrock (red) between ~10-18.5m (Fig.25c). The sand volume is **~833393 cubic m** and **~1333429 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Railway Bridge Revora

The SSS data across the R**ailway Bridge Revora** covers an area of 200m*1644m area from the center of the navigation (blue track line), shows the sand boundary, unconfirmed sand boundary, rock outcrops, and river bank (Fig.26a). Single beam bathymetry data shows the river bed depth varying between ~9.8-19m. A deep valley like feature is identified from the single beam bathymetry (Fig.26b) and seismic data (Fig.26c). Two geological sample location (**stations 11 & 15**) are within the span of side scan sonar image (Fig.26a) the weight percentage (wt.%) of sand is 98.02-99.25 silt is 0.65-1.42 and clay is 0.09-0.10. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~9.8-19m (green) and bedrock (red) between ~16-26m (Fig.26c). The sand volume is **~610894 cubic m** and **~977431 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Raneache Zuem

The SSS data across the **Raneache Zuem** covers an area of 200m*1620m area from the center of the navigation (blue track line), shows the sand boundary, unconfirmed sand boundary, rock outcrops, and river bank and bridge across the river bank (Fig.27a). Single beam bathymetry data shows the river bed depth varying between ~1-10m. A deep valley like feature is identified from the single beam bathymetry (Fig.27b) and seismic data (Fig.27c). Two geological sample location (**stations 6 & 10**) are within the span of side scan sonar image (Fig.27a), the weight percentage (wt.%) of sand is 96.85-97.40%, silt is 1.4-2.30 and clay is 0.10-1.15. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~1-10m (green) and bedrock (red) between ~7-26m (Fig.27c). The sand volume is **~5753126 cubic m** and **~9205002 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Near Sati Devi Temple

The SSS data across the **Near Sati Devi Temple** covers an area of 200m*1900m area from the center of the navigation (blue track line), shows the sand boundary, two active mining regions (pink), rock outcrops, and river bank (Fig.28a). Single beam bathymetry data shows the river bed depth varying between ~5-16m. About three deep valleys like features are identified from the single beam bathymetry (Fig.28b) and seismic data (Fig.28c). One geological sample location

(**station 60**) is within the span of side scan sonar image on the rock outcrop is collected (Fig.28a) and the weight percentage (wt.%) of sand, silt and clay is 0 due to sample collected on the bedrock. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~1-17m (green) and bedrock (red) between ~9-21m. The sand volume is **~544284 cubic m** and **~870855 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

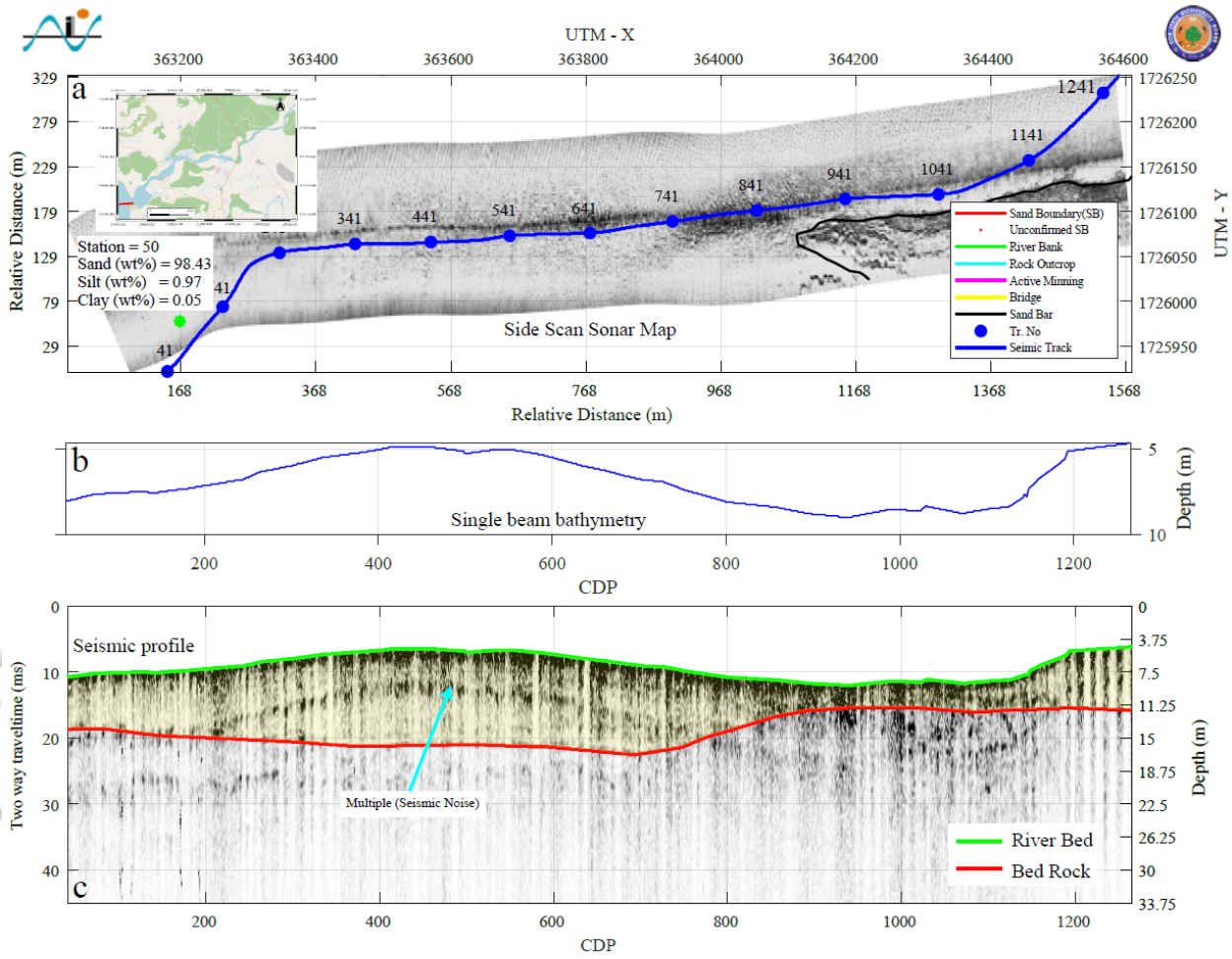
Pirna Ozarim bridge

The SSS data across the **Pirna Ozarim bridge** covers an area of 200m*1000m area from the center of the navigation (blue track line), shows the sand boundary, large part of active mining regions (pink), rock outcrops, river bank and base of Pirna Ozarim bridge (yellow) (Fig.29a). Single beam bathymetry data shows the river bed depth varying between ~3.85-16m. A valley like feature is identified from the single beam bathymetry (Fig.29b) and seismic data (Fig.29c). One geological sample location is within the span of side scan sonar image, collected (Fig.29a), the weight percentage (wt.%) of sand is 99.71, silt is 0.10 and clay is 0.05. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~3.85-17m (green) and bedrock (red) between ~7.6-18m (Fig. 29c). The sediment volume is ~ **216771 cubic m** and **~346835 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

Ozorim Tormas Bridge

The SSS data across the **Ozorim Tormas Bridge** covers an area of 200m*1250m area from the center of the navigation (blue track line), shows the sand boundary, unconfirmed sand boundary large part of active mining regions (pink), rock outcrops, river bank (Fig.30a). Single beam bathymetry data shows the river bed depth varying between ~2.5-11m (Fig.30b). A valley like feature is identified from the single beam bathymetry (Fig.30b) and seismic data (Fig.30c). One geological sample location (**station 63)** is within the span of side scan sonar image, collected (Fig.30a), the weight percentage (wt.%) of sand is 98.10, silt is 1.71 and clay is 0.05. The seismic data interpreted in both time and depth domain shows the riverbed depth varies between ~2.35-17m (green) and bedrock (red) between ~7-13m. The sediment volume is **~1028294 cubic m** and **~1645271 Tons** of sand is available. A substantial area is not covered during the present phase of SSS survey and will be covered in the next field season.

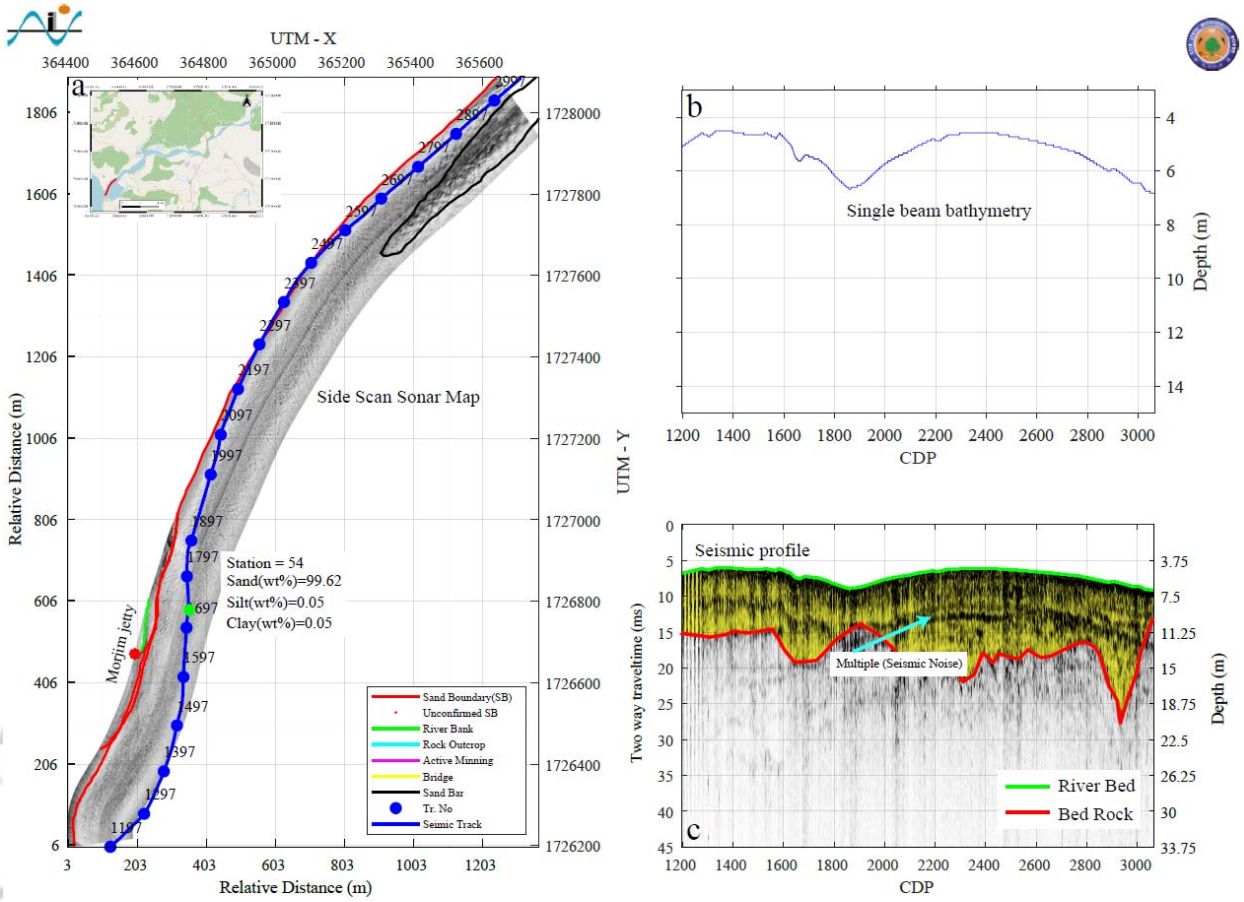
Chaliora River Survey Report



Total Volume across Estuary = 524283 Cubic metre
Total Weight (Tonne) = 1389350 Tons.

Figure 19. Estuary region (River Mouth) geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

Survey

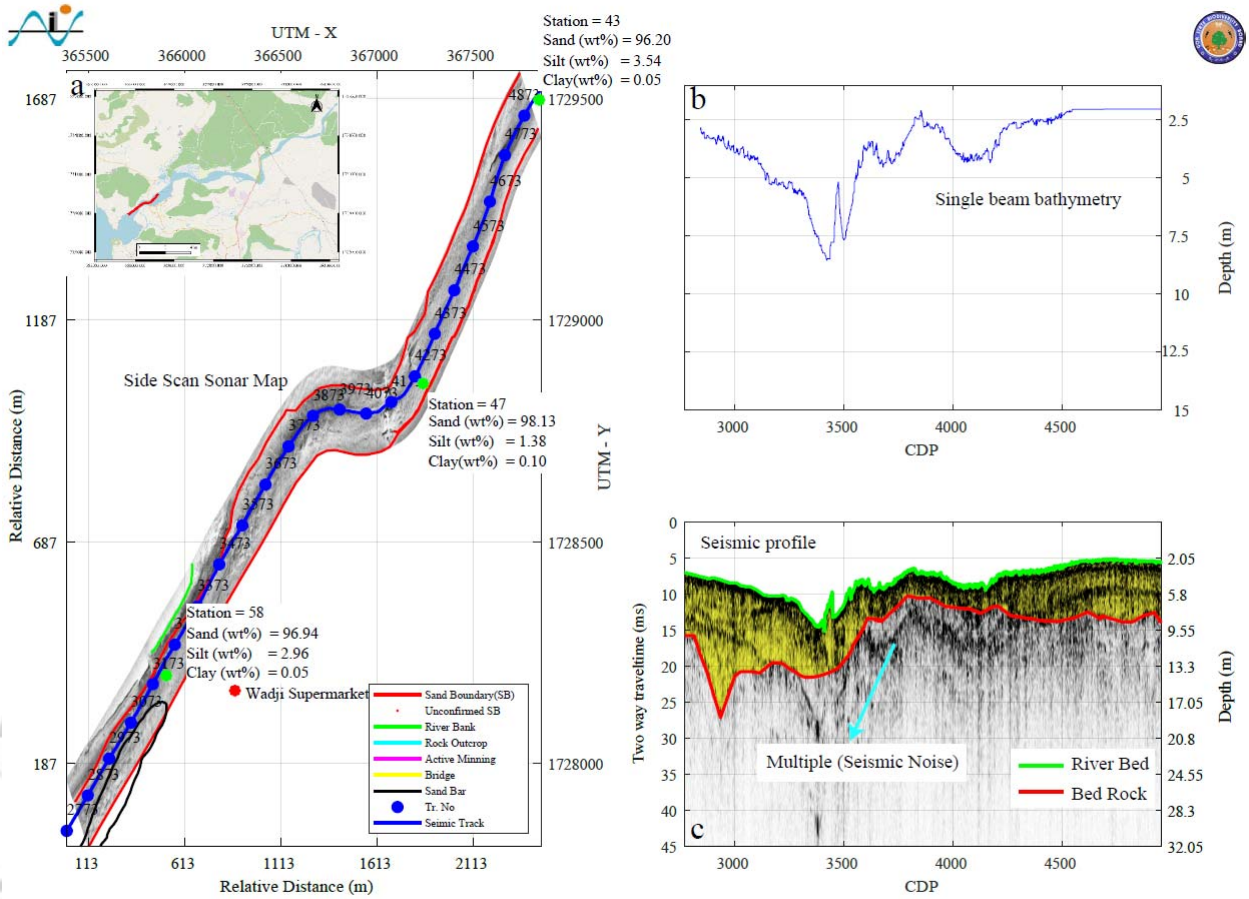


Total Volume across Morjim Jetty = 1674221 Cubic metre

Total Weight (Tonne) = 2678753 Tons.

Figure 20. Morjim jetty geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

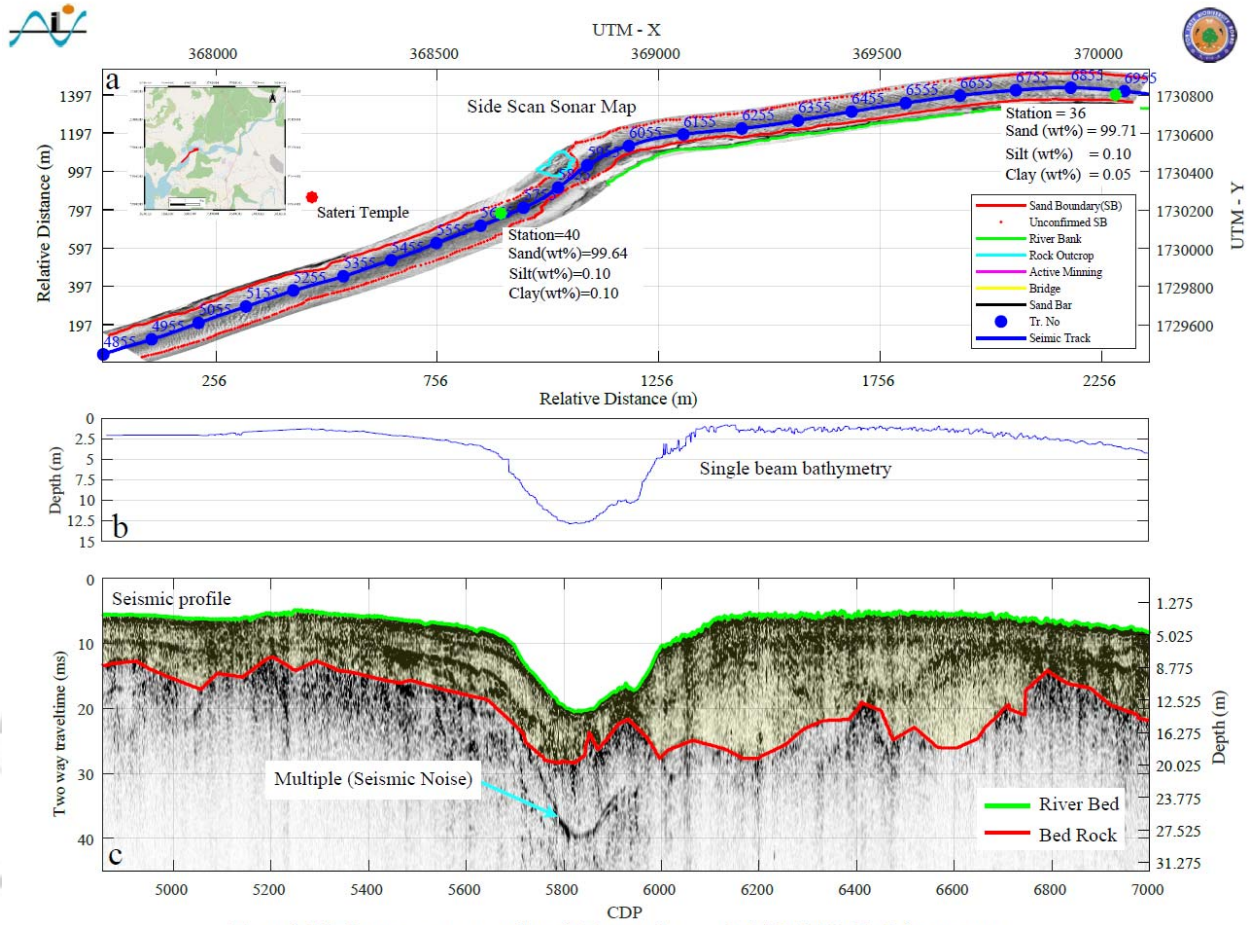
Survey Report



Total Volume across Wadji Supermarket = 773160 Cubic metre
Total Weight (Tonne) = 1237057 Tons.

Figure 21. Wadji Supermarket geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

Survey

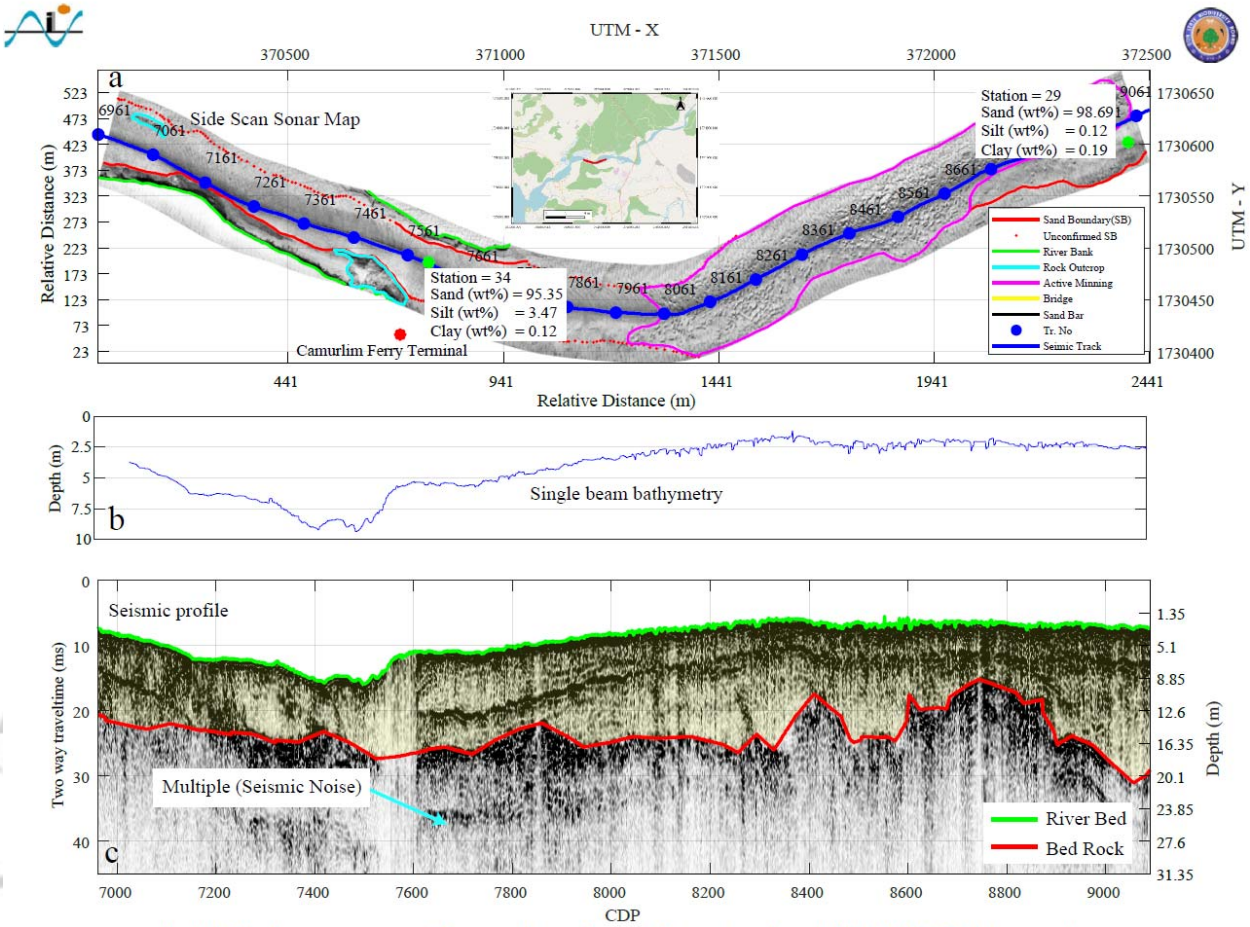


Total Volume across Steri Temple = 1618575 Cubic metre

Total Weight (Tonne) = 2589720 Tons.

Figure 22. Sateri Temple geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

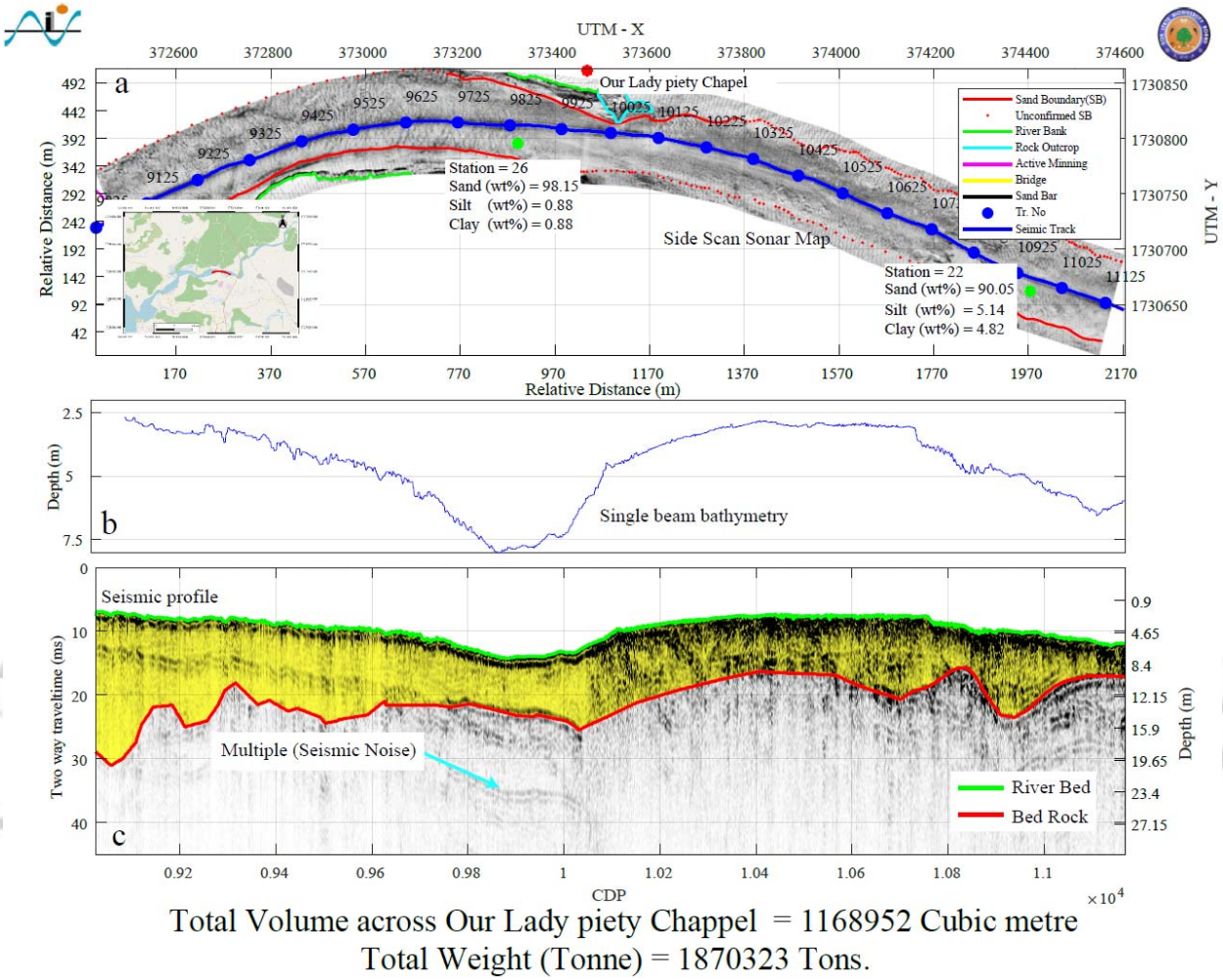
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Total Volume across Camurlim Ferry Terminal = 1988240 Cubic metre
Total Weight (Tonne) = 3181185 Tons.

Figure 23. Camurlim Ferry Terminal geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

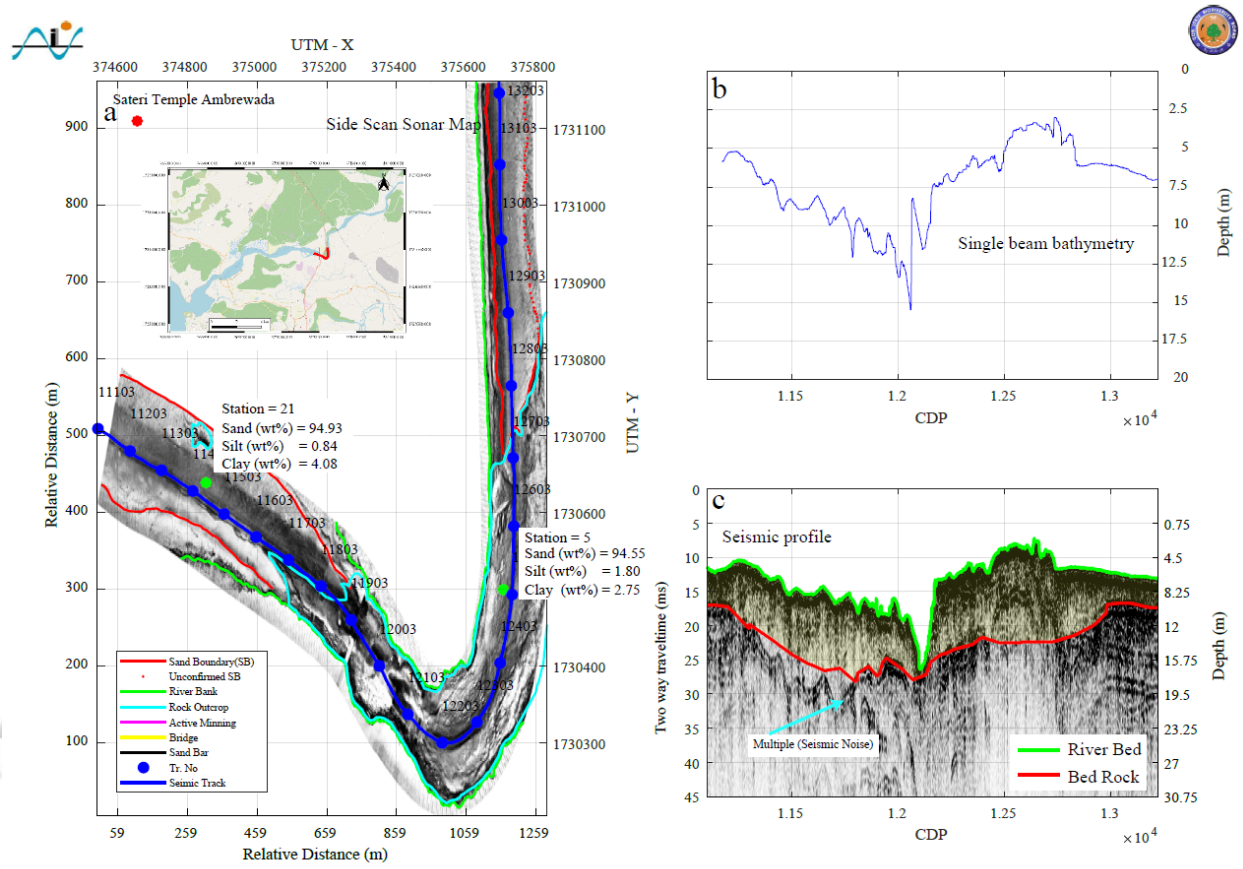
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Total Volume across Our Lady piety Chappel = 1168952 Cubic metre
Total Weight (Tonne) = 1870323 Tons.

Figure 24. Our Lady piety Chapel geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

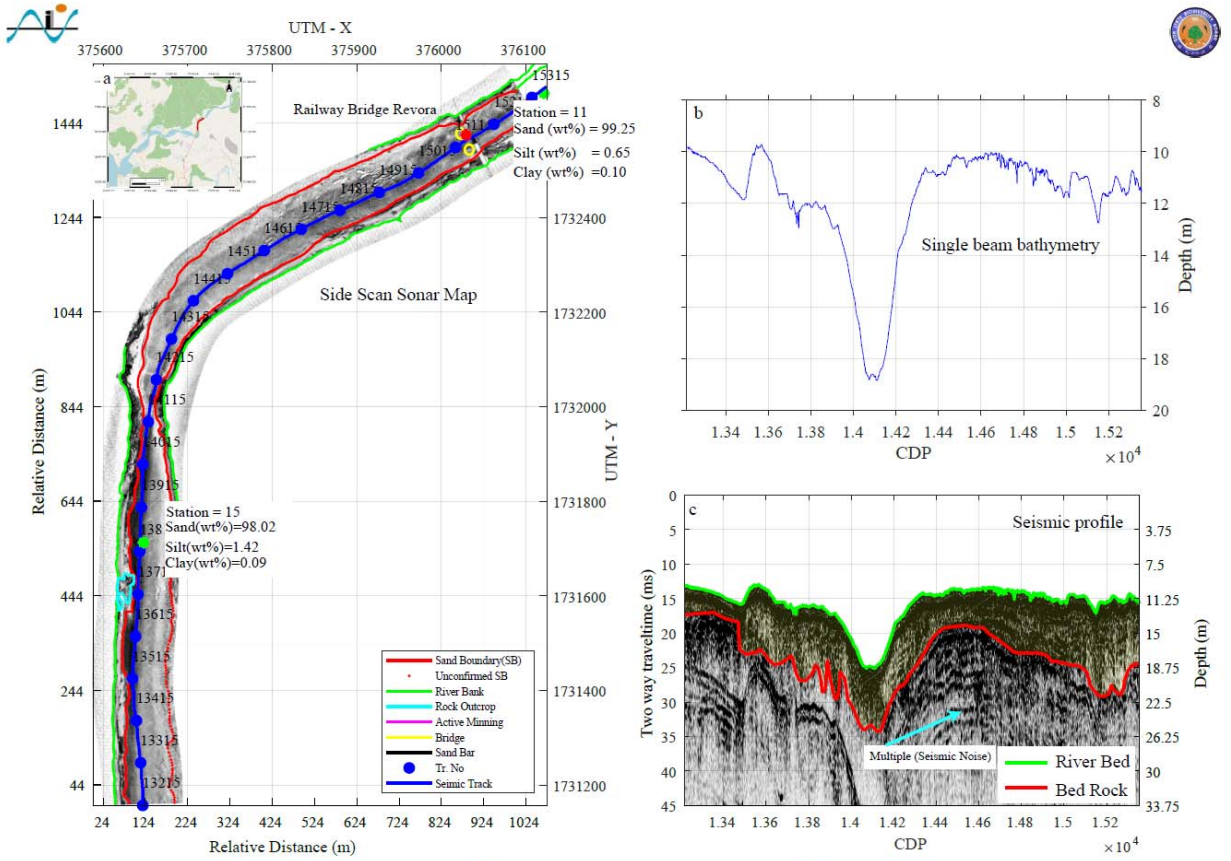
Survey



Total Volume across Ateri Tample Ambrewada = 833393 Cubic metre
Total Weight (Tonne) = 1333429 Tons.

Figure 25. Sateri Temple Ambrewada geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

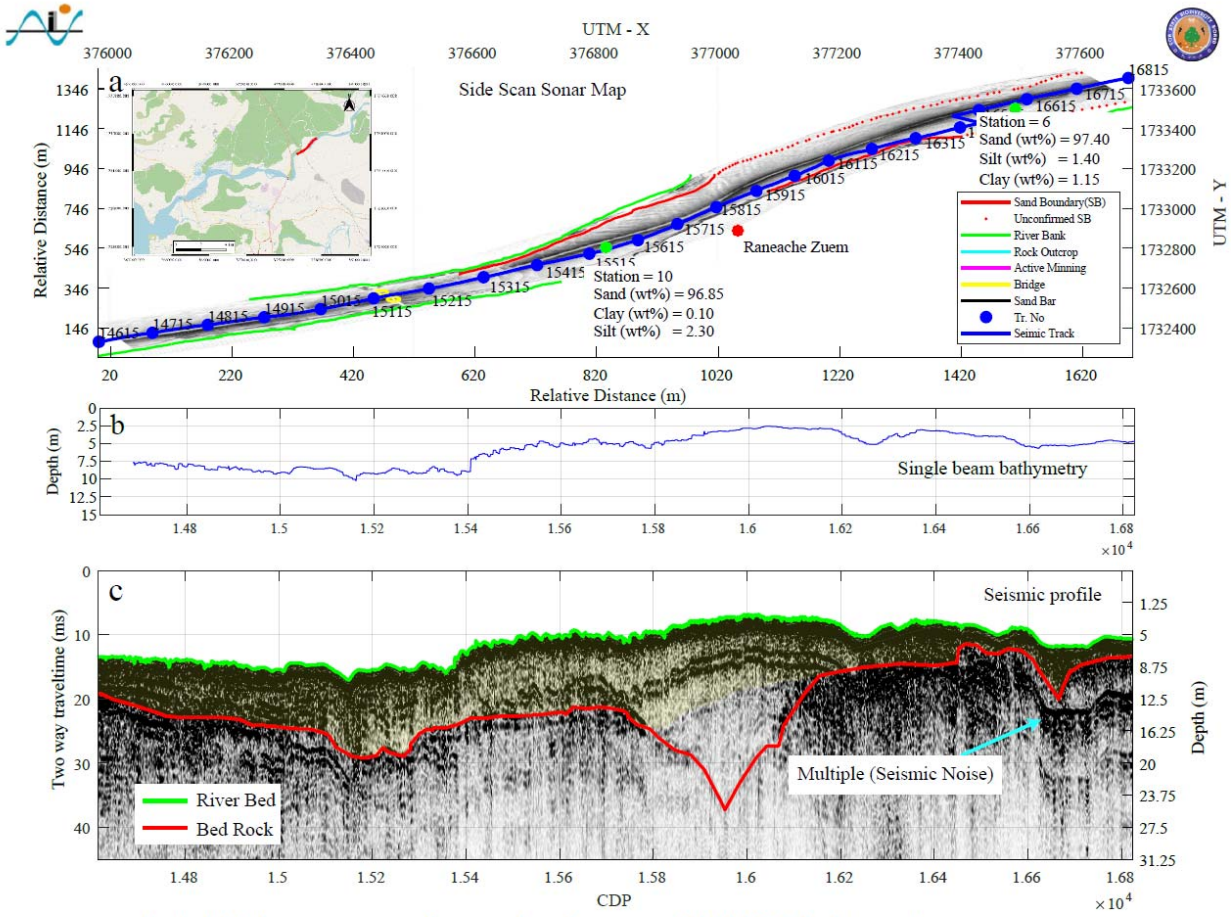
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Total Volume across Railway Bridge Revora = 610894 Cubic metre
Total Weight (Tonne) = 977431 Tons.

Figure 26. Estuary region (River Mouth) geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

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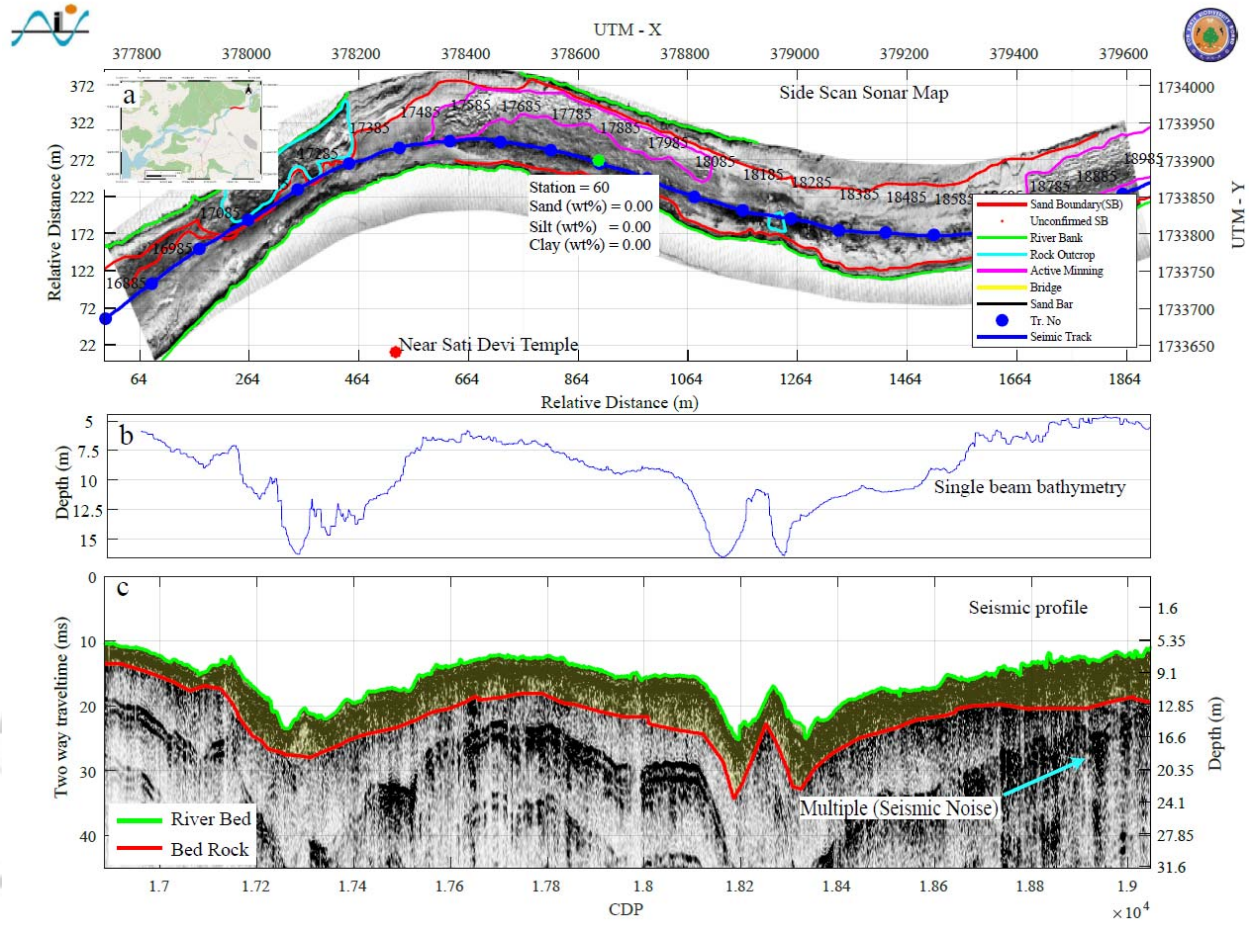


Total Volume across Raneache Zuem = 5753126 Cubic metre

Total Weight (Tonne) = 9205002 Tons.

Figure 27. Raneache Zuem geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

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Total Volume across Sati Devi Temple = 544284 Cubic metre
Total Weight (Tonne) = 870855 Tons.

Figure 28. Near Sati Devi Temple geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

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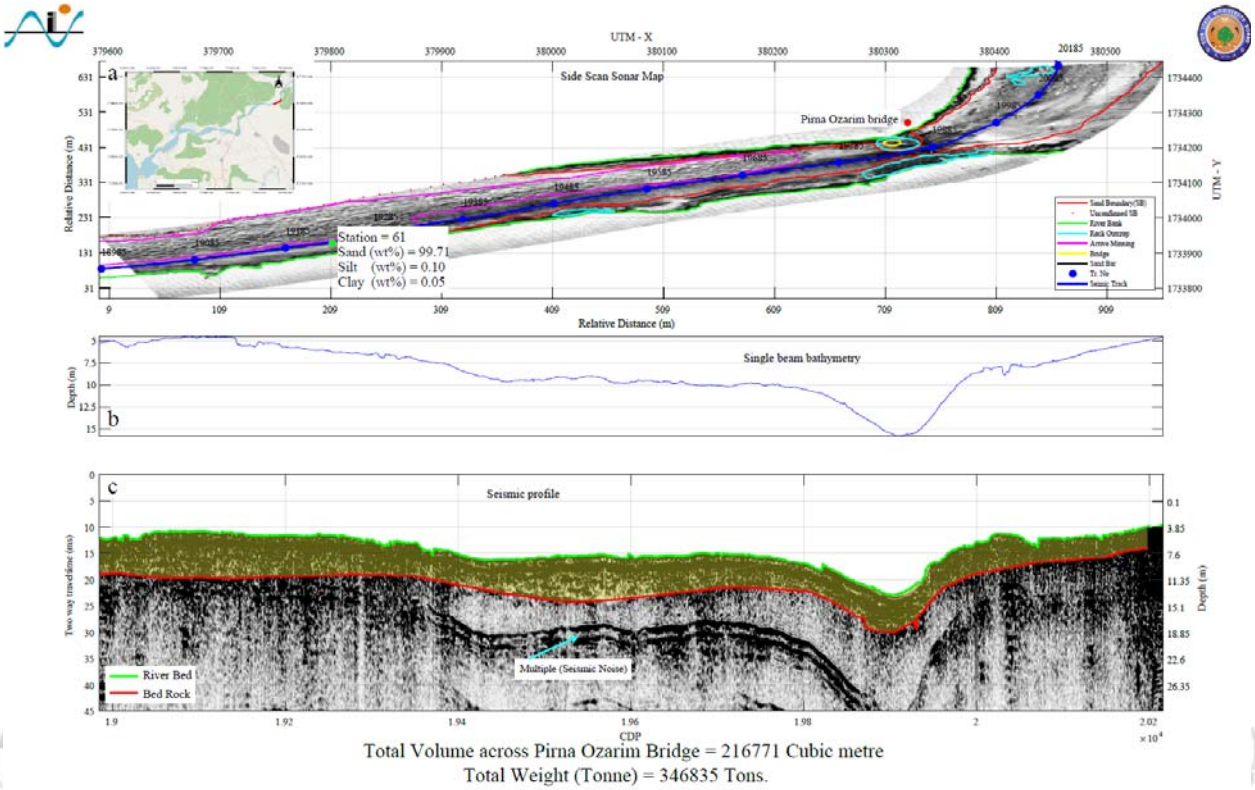
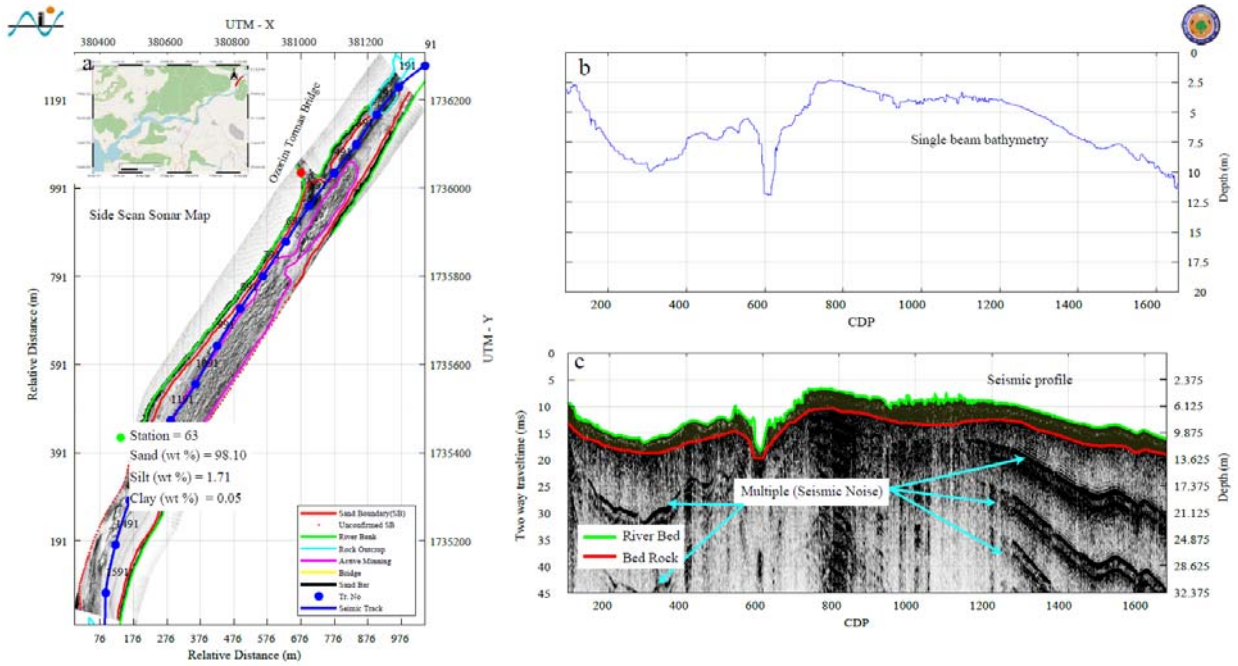


Figure 29. Pirna Ozarim bridge geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

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Total Volume across Ozorim Tormas Bridge = 1028294 Cubic metre
Total Weight (Tonne) = 1645271 Tons.

Figure 30. Ozarim Tormas bridge geophysical data. (a) Side scan sonar (SSS) image (b) single beam echosounder bathymetry. (c) high resolution seismic data

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Chapter 5. Geological Observations

Material and Methods

A total of sixty-five surface sediment samples (uppermost 5 cm) covering several parts of Chapora River were collected using a Van Veen grab sampler (Fig.31). Samples were packed in containers and stored at CSIR-NIO's sample storage repository. The samples are used for Salinity (PPT), pH, Chloride (PPM), sediment nomenclature (grain size through sieving analysis), and microscopic observations for grain sorting, mineral composition and grain angularity.

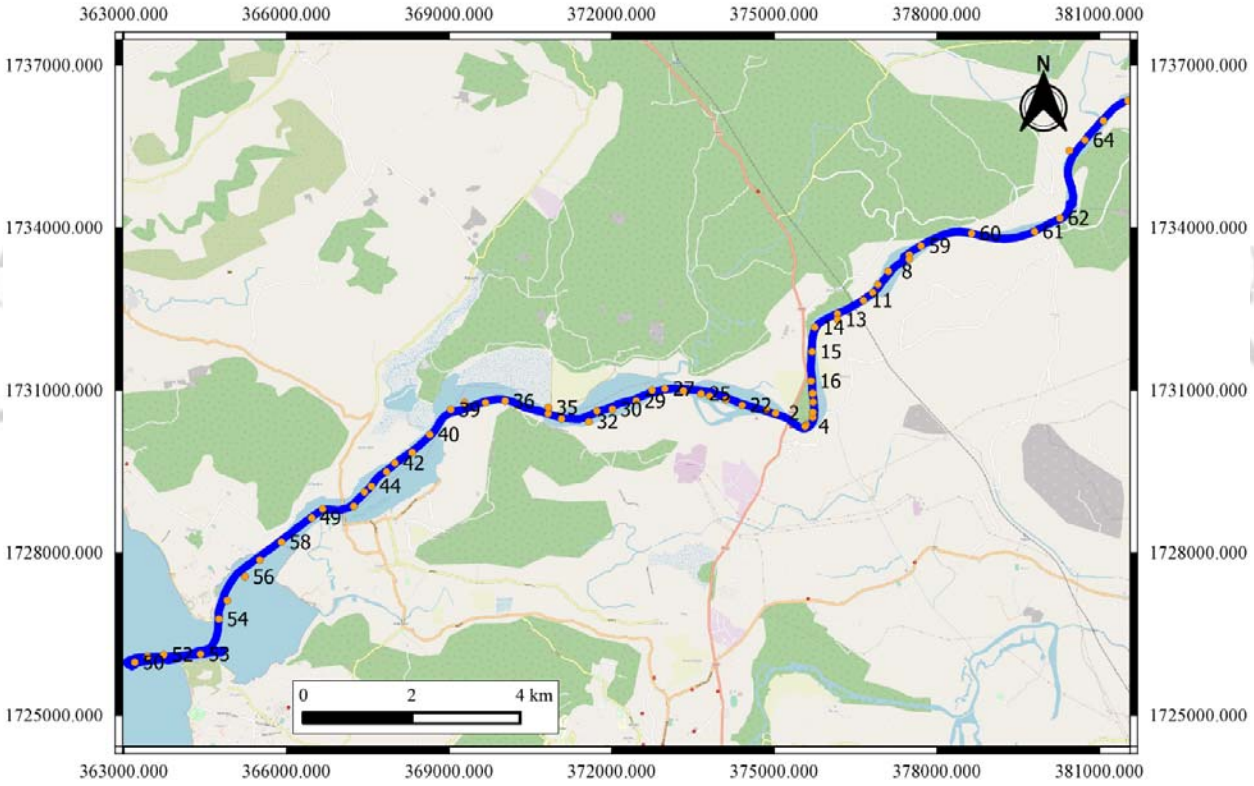


Figure 31. Geological Sample Locations

Sediment Nomenclature

Nomenclature of Chapora River sediment samples were done following standard Rock-Color Chart prepared by the Rock-Color Chart Committee (***representing the U.S. Geological Survey, GSA, the American Association of Petroleum Geologists, the Society of Economic Geologists, and the Association of American State Geologists***). The rock color chart for selected stations are provided in Table.5

Sieve Size analysis

As per IS 650 requirement, bulk sediment samples of about 50 g were dried, weighed, and wet-sieved for 20 mins with an automated sieve shaker (Fritsch Analysette) creating following sieved fractions > 2000 µm, 1600 -2000 µm, 1000 µm – 1600 µm, 850 µm – 1000 µm, 500 µm – 850 µm, 200 µm – 500 µm, and 90 µm - 200 µm. Cumulative percentage passing (%) for nine stations were calculated following ASTM standards. Weight percentage of sand (> 63 µm), silt (4 µm – 63 µm) and clay (< 4 µm) in Chapora river sediments are presented in Table.7

Results

Moderately – well sorted, fine-medium-coarse grained sand is found in majority of the sediment samples from Chapora River. The bulk sediment grain size in most of the samples is dominated by sand fraction. In general, sand content in Chapora River sediments ranges between 81.89 - 99.77 (wt %), silt content ranges between 0.05 – 13.13 (wt %), and clay content ranges between 0.04 – 17.70 (wt %).

SAMPLING STATION NO	COLOUR	ROCK COLOUR CHART	SORTING
6	Moderate yellowish brown	10YR 5/4	Moderately sorted
13	Moderate brown	5YR 3/4	Moderately sorted
19	Moderate brown	5YR 3/4	Well sorted
22	Dusky yellowish brown	10YR 2/2	Well sorted
32	Dark yellowish brown	10YR 4/2	Moderately sorted to well sorted
37	Moderate yellowish brown	10YR 5/4	Poorly sorted
45	Dark yellowish brown	10YR 4/2	Moderately sorted
56	Moderate yellowish brown	10YR 5/4	Moderately sorted
66	Dark yellowish orange	10 YR 6/6	Poorly sorted

Table 5. Nomenclature of Chapora River sand samples were done by following standard Rock-Color Chart prepared by the Rock-Color Chart Committee (representing the U.S. Geological Survey, GSA, the American Association of Petroleum Geologists, the Society of Economic Geologists, and the Association of American State Geologists).

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Stn. No	Latitude	Longitude	Sieve Size (mm)	Sieve Size (µm)	Cumulative percentage passing (%)
8	15°40'26.00" N	73°51'11.60" E	2	2000	94.22
			1.6	1600	94.12
			1	1000	78.26
			0.85	850	83.1
			0.5	500	82.46
			0.2	200	79.28
			0.09	90	95.12
13	15°39'56.91" N	73°50'40.21" E	2	2000	95.02
			1.6	1600	90.28
			1	1000	82.84
			0.85	850	80.24
			0.5	500	83.56
			0.2	200	82.06
			0.09	90	91.88
19	15°39'07.20" N	73°50'25.50" E	2	2000	98.94
			1.6	1600	98.08
			1	1000	97.34
			0.85	850	93.52
			0.5	500	88.78
			0.2	200	48.14
			0.09	90	82.66
22	15°39'05.10" N	73°49'41.50" E	2	2000	100
			1.6	1600	100
			1	1000	98.76
			0.85	850	97.56
			0.5	500	92.9
			0.2	200	49.28
			0.09	90	69.92
32	15°398'54.42"N	73°48'60.821" E	2	2000	99.88
			1.6	1600	97.78
			1	1000	97.7
			0.85	850	94.64
			0.5	500	83.22
			0.2	200	52.12
			0.09	90	81.56

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45	15°38'11.654" N	73°45'47.830" E	2	2000	100
			1.6	1600	100
			1	1000	99.58
			0.85	850	98.18
			0.5	500	97.26
			0.2	200	49.32
			0.09	90	61.06
56	15°37'20.449" N	73°44'34.073" E	2	2000	100
			1.6	1600	100
			1	1000	99.22
			0.85	850	94.92
			0.5	500	89.28
			0.2	200	26.74
			0.09	90	91.72
57	15°37'30.489" N	73°44'43.272" E	2	2000	98.38
			1.6	1600	97.96
			1	1000	94.9
			0.85	850	93.74
			0.5	500	58.8
			0.2	200	69.28
			0.09	90	98.5
66	15°42'9.23" N	73°53'39.649" E	2	2000	12.96
			1.6	1600	97.64
			1	1000	96.2
			0.85	850	98.66
			0.5	500	98.94
			0.2	200	99.24
			0.09	90	99.06

Table 6. Cumulative percentage passing (%) of Chapora River sediment samples as per IS 650 requirements

Stn. No	Latitude	Longitude	Sand (Wt.%)	Silt (Wt.%)	Clay (Wt.%)
1	15°38'59.20" N	73°50'05.00" E	92.67	3.64	3.13
2	15°39'00.50" N	73°50'02.21" E	96.10	3.69	0.10
3	15°38'53.60"N	73°50'21.30" E	93.89	1.31	4.37
4	15°38'52.60"N	73°50'20.60" E	93.05	2.75	3.65

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5	15°38'58 .20" N	73°50'25.30" E	94.55	1.80	2.75
6	15°40'36.00" N	73°51'24.60" E	97.40	1.40	1.15
7	15°40'33.40" N	73°51'24.60" E	99.13	0.15	0.10
8	15°40'26.00" N	73°51'11.60" E	95.66	0.68	3.27
9	15°40'18.12" N	73°51'05.23" E	95.53	1.16	2.37
10	15°40'13.20" N	73°51'02.10" E	96.85	2.30	0.10
11	15°40'08.57" N	73°50'56.320" E	99.25	0.65	0.10
12	15°40'00.28" N	73°50'40.21" E	92.17	7.51	0.27
13	15°39'56.91" N	73°50'40.21" E	95.13	1.90	2.31
14	15°39'52.12" N	73°50'26.30" E	96.53	1.12	1.81
15	15°39'37.50" N	73°50'24.70" E	98.02	1.42	0.09
16	15°39'19.89" N	73°50'24.501" E	97.16	1.20	1.07
17	15°39'19.89" N	73°50'24.01" E	98.20	1.55	0.25
18	15°39'12.50" N	73°50'25.12" E	93.58	2.00	3.79
19	15°39'07.20" N	73°50'25.50" E	97.51	1.66	0.44
20	15°39'01.13" N	73°50'25.40" E	96.42	2.18	0.79
21	15°39'02.40" N	73°49'56.60" E	94.93	0.84	4.08
22	15°39'05.10" N	73°49'41.50" E	90.05	5.14	4.82
23	15°39'08.50" N	73°49'31.40" E	83.13	6.87	9.95
24	15°39'10.51" N	73°49'21.30" E	81.89	0.23	17.70
25	15°39'11.90" N	73°49'16.00" E	93.72	1.16	4.83
26	15°39'13.60" N	73°49'05.10" E	98.15	0.88	0.88
27	15°39'14.80" N	73°48'53.60" E	84.73	13.13	1.53
28	15°39'13.90" N	73°48'45.70" E	92.80	6.73	0.09
29	15°39'07.35" N	73°48'35.859" E	98.69	0.12	0.19
30	15°39'02.30" N	73°48'21.18" E	92.88	3.95	1.30
31	15°39'01.20" N	73°48'11.60" E	97.98	0.10	0.99
32	15°398'54.42"N	73°48'60.821" E	98.93	0.92	0.05
33	15°38'56.346" N	73°47'49.667" E	99.76	0.10	0.05
34	15°38'59.512" N	73°47'41.391" E	95.35	3.47	0.12
35	15°39'03.114" N	73°47'41.391" E	99.30	0.14	0.14
36	15°39'06.816" N	73°47'14.662" E	99.71	0.10	0.05
37	15°39'05.747" N	73°47'02.423" E	99.45	0.20	0.05
38	15°39'005.69" N	73°46'49.584" E	99.15	0.15	0.15
39	15°39'01.560" N	73°46'41.032" E	99.56	0.10	0.10
40	15°38'46.419" N	73°46'28.151" E	99.64	0.10	0.10
41	15°38'35.612" N	73°46'17.246" E	97.58	0.84	0.05
42	15°38'29.158" N	73°46'06.612" E	92.17	7.09	0.04
43	15°38'23.941" N	73°46'01.376" E	96.20	3.54	0.05

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44	15°38'15.174" N	73°45'52.141" E	98.91	0.88	0.05
45	15°38'11.654" N	73°45'47.830" E	99.69	0.05	0.05
46	15°38'03.010" N	73°45'41.239" E	98.63	1.10	0.11
47	15°38'03.010" N	73°45'41.239" E	98.13	1.38	0.10
48	15°38'01.385" N	73°45'21.953" E	98.94	0.05	0.77
49	15°37'55.975" N	73°45'15.216" E	99.38	0.17	0.22
50	15°36'28.557" N	73°43'26.145" E	98.43	0.97	0.05
51	15°36'32.154 N	73°43'34.047" E	99.69	0.15	0.05
52	15°36'33.34" N	73°43'44.025" E	99.40	0.55	0.05
53	15°36'33.819" N	73°44'06.850" E	99.62	0.14	0.05
54	15°36'54.91" N	73°44'18.110" E	99.62	0.05	0.05
55	15°37'06.10"7 N	73°44'23.122" E	99.73	0.09	0.04
56	15°37'20.449" N	73°44'34.073" E	99.77	0.09	0.05
57	15°37'30.489" N	73°44'43.272" E	99.76	0.10	0.10
58	15°37'41.330" N	73°44'56.574" E	96.94	2.96	0.05
59	15°40'41.402" N	73°51'31.863" E	99.02	0.49	0.09
60	15°40'48.998" N	73°52'03.097" E	--	--	--
61	15°40'50.328" N	73°52'42.188" E	99.71	0.10	0.05
62	15°40'58.488"N	73°52'57.846" E	94.18	3.09	2.22
63	15°41'39.15" N	73°53'03.503" E	98.10	1.71	0.05
64	15°41'45.487" N	73°53'13.078" E	97.26	2.37	0.27
65	15°41'57.134" N	73°53'24.410" E	91.78	6.65	1.52
66	15°42'9.23" N	73°53'39.649" E	97.66	0.12	2.14

Table 7. Weight percentage of sand, silt and clay fractions in Chapora River sediments.

Microscopic Analysis of geological samples

Methadology

Sand samples collected from the different locations of Chapora river were treated with 20 ml oxalic acid to remove iron coating and subsequently washed in distilled water and air dried before microscopic observation. The dried samples observed under Leica EZ4 D (Fig.32).

Major findings

1. From the upper reaches of the river till sampling zone 30-31, the grains show relatively poorer sorting than the sampling zone 31-32 to 58.
2. Throughout the river channel quartz grains remain highly angular compared to the highly rounded iron oxide grains/pebbles. The lithic fragments (fragments of source rocks) show moderate to good roundness.

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3. The grain size analyses data may be compared with the microscopic data which suggest reduced fraction of sand size component from river mouth to the sampling zone 30-31.
4. The iron oxide and lithic fragment comprise substantial and highly variable component (qualitative) of the total sediment.
5. Silt-Mud rich pockets are recorded at sampling point 20, 60 and 65.
6. Calcareous shell fragments are observed.

Detailed observation

Chapora	Large grain size(mm)	Small grain size(mm)	Remarks
Station 1	1.85	0.10	Large grains are combined with small grains, angular grains quartz, rounded iron oxide
Station 2	0.70	0.10	Angular grains, quartz, lithic fragments, rounded iron oxide
Station 3	No Sand	No Sand	
Station 4	No Sand	No Sand	
Station 5	20.00	0.10	Different size of grains, more iron oxide, quartz and shell fragments
Station 6	1.00	0.10	Shell fragments, lithic fragments, quartz, iron oxides
Station 7	1.75	0.10	Shell fragments, lithic fragments, quartz, iron oxides
Station 8	1.25	0.10	Shell fragments, lithic fragments, quartz, iron oxides and wood fragments
Station 9	2.00	0.20	Angular grains, Shell fragments, lithic fragments, quartz, rounded iron oxides
Station 10	3.60	0.30	Angular grains, Shell fragments, lithic fragments, quartz, rounded iron oxides
Station 11	1.60	0.20	Angular grains, Shell fragments, lithic fragments, quartz, rounded iron oxides
Station 12	3.50	0.20	Shell fragments, lithic fragments, quartz, rounded iron oxides, muscovite

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Station 13	0.50	0.20	Angular grain, Shell fragments, lithic fragments, quartz, rounded iron oxides
Station 14	1.60	0.20	Angular grains, Shell fragments, lithic fragments, quartz, rounded iron oxides
Station 15	0.50	0.20	Angular grains, Shell fragments, lithic fragments, quartz, rounded iron oxides, muscovite
Station 16	2.00	0.20	Iron oxides most of them are rounded lithic fragments, quartz
Station 17	1.25	0.10	Quartz, iron oxides, rock and wood fragments, muscovite
Station 18	2.30	0.10	Quartz, iron oxides, rock and wood fragments, muscovite
Station 19	1.00	0.10	Quartz, iron oxides, rock and wood fragments, muscovite
Station 20	3.14	0.20	Mud
Station 21	0.50	0.10	Angular grains, quartz, lithic fragments, rounded iron oxide, biotite, much improved sorting.
Station 22	0.40	0.05	Angular grains, quartz, lithic fragments, rounded iron oxide, biotite, improved sorting.
Station 23	0.30	0.02	Angular grains, quartz, lithic fragments, rounded iron oxide, biotite, improved sorting.
Station 24	0.50	0.05	Angular grains, quartz, lithic fragments, rounded iron oxide, biotite, improved sorting.
Station 25	0.70	0.10	Quartz, Iron oxides, lithic fragments, biotite
Station 26	0.57	0.10	Quartz, Iron oxides, lithic fragments, biotite
Station 27	0.10	1.00	Quartz, Iron oxides, lithic fragments, biotite
Station 28	0.10	0.80	Quartz, Iron oxides, lithic fragments, biotite

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Station 29	0.10	0.60	Quartz, rounded iron oxides, lithic fragments, biotite
Station 30	0.10	1.00	Quartz, rounded iron oxides, lithic fragments, biotite
Station 31	0.05	0.50	Quartz, rounded iron oxides, lithic fragments, biotite, angular grains
Station 32	0.05	0.60	Quartz, rounded iron oxides, lithic fragments, biotite, angular grains
Station 33	0.10	0.70	Quartz, rounded iron oxides, angular grains
Station 34	0.10	1.00	Quartz, rounded iron oxides, lithic fragments, biotite, angular grains, shell fragments
Station 35	0.10	0.50	Quartz, rounded iron oxides, lithic fragments, angular grains, shell fragments
Station 36	0.10	0.50	Quartz, rounded iron oxides, lithic fragments, angular grains, shell fragments
Station 37	0.10	1.25	Quartz, rounded iron oxides, lithic fragments, angular grains, shell fragments
Station 38	0.10	0.65	Quartz, pink quartz rounded iron oxides, lithic fragments, angular grains, shell fragments
Station 39	0.10	0.50	Iron oxides quartz lithic fragments, angular grains, muscovite
Station 40	0.10	0.40	Rounded iron oxide, quartz, shell fragment and well sorted
Station 41	0.10	0.40	Rounded iron oxide, quartz, shell fragment and well sorted
Station 42	0.10	0.40	Rounded iron oxide, quartz, shell fragment and well sorted
Station 43	0.15	0.50	Rounded iron oxide, quartz, shell fragment and well sorted
Station 44	0.10	0.65	Angular grains, coating shell fragments, quartz

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Station 45	0.10	1.00	Shell fragments, angular grains, muscovite, iron oxide, biotite and lithic fragments
Station 46	0.10	0.50	Angular grains, rounded iron oxide, quartz
Station 47	0.16	2.03	Varying grains of iron oxides, lot of shell fragments, quartz
Station 48	0.25	1.25	Small shell fragments, poor sorting compare to station 50
Station 49	0.25	0.50	Rounded iron oxide particle is more and highly angular quartz
Station 50	0.10	0.25	Rounded to semi rounded iron oxide, highly angular quartz, broken CaCO3 shell, muscovite, well sorted
Station 51	0.10	0.25	Rounded to semi rounded iron oxide, highly angular quartz, broken CaCO3 shell, muscovite, well sorted
Station 52	0.10	0.50	Rounded to semi rounded iron oxide, highly angular quartz, broken CaCO3 shell, muscovite, well sorted
Station 53	0.25	0.50	Rounded iron oxide, highly angular quartz, broken CaCO3 shell, muscovite, biotite well sorted
Station 54	0.25	0.40	More iron oxide particles compared to station 50
Station 55	0.20	0.50	Biotite, muscovite rounded iron oxide, CaCO3 shell and heavy minerals
Station 56	0.50	1.25	Lithic fragments, white and pink quartz present
Station 57	0.50	1.20	High calcareous fragments, lot of shell
Station 58	0.25	1.00	Calcareous shells are present, large grains better rounding than 50
Station 59	20.00	3.30	iron oxide pebbles
Station 60	Mud	Mud	Mud

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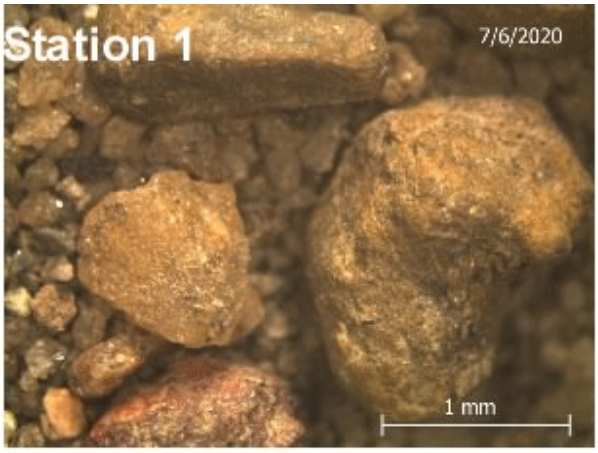
Station 61	12.00	0.20	Iron oxide pebbles, lithic fragments and quartz
Station 62	13.00	0.10	Mixture of very large grains (and pebbles) and small grains (quartz, Iron Oxide)
Station 63	13.00	0.10	Mixture of very large grains and small grains (quartz, iron oxide)
Station 64	1.30	0.15	Shell and wood fragments, iron oxide and quartz
Station 65	Mud	Mud	Mud
Station 66	13.00	0.50	Large grains of lithic fragments, iron oxide and quartz

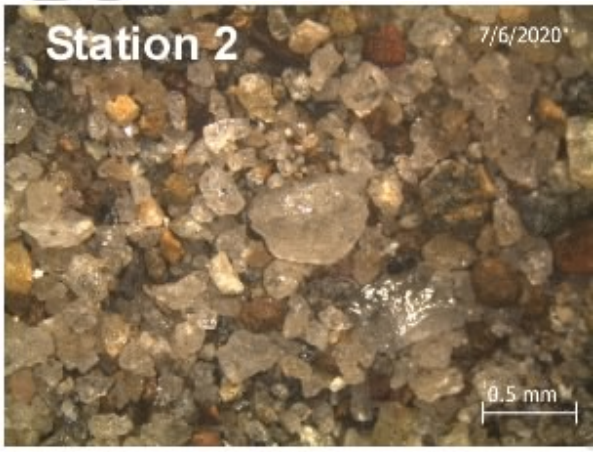
Table 8. Detailed microscopic observation of sand samples

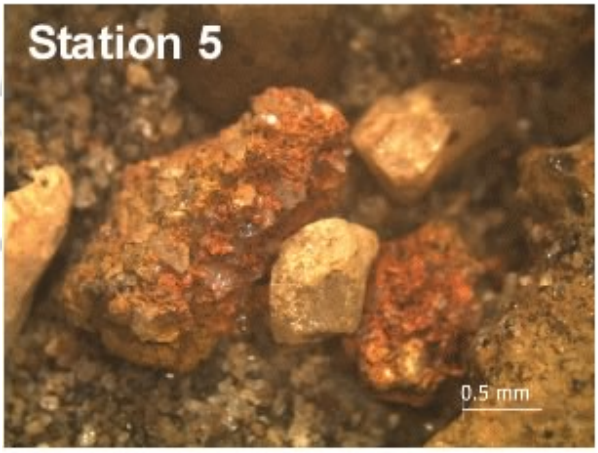
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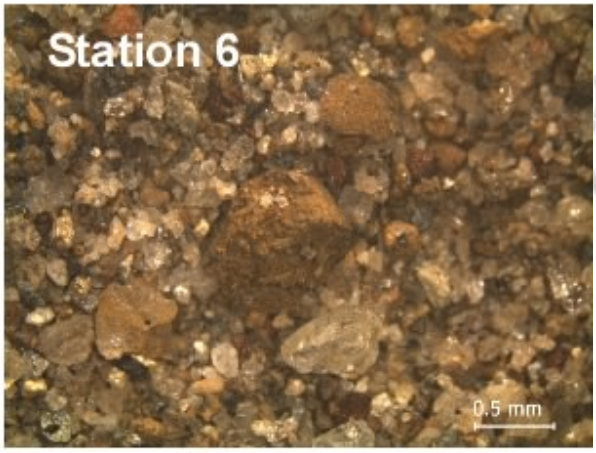
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Microscopic observation





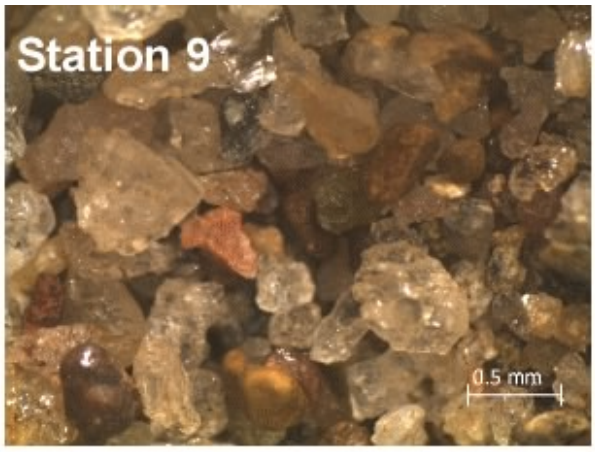


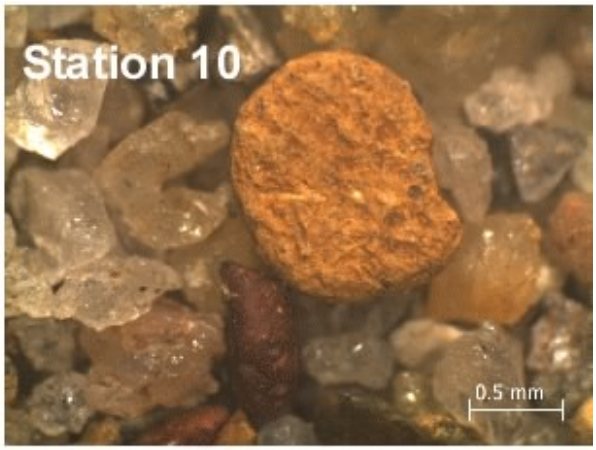


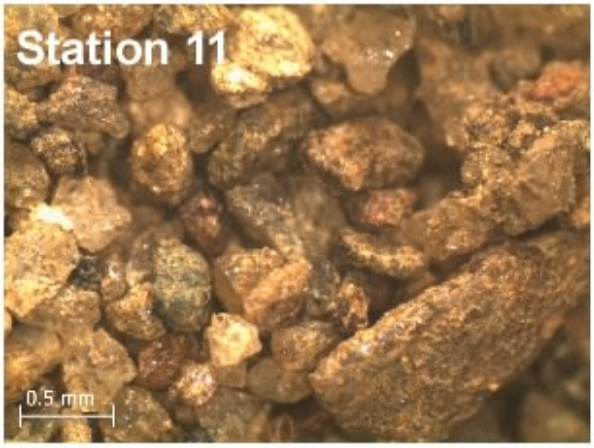


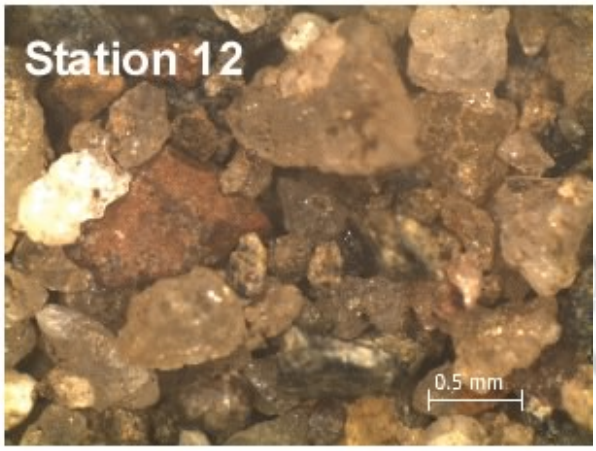


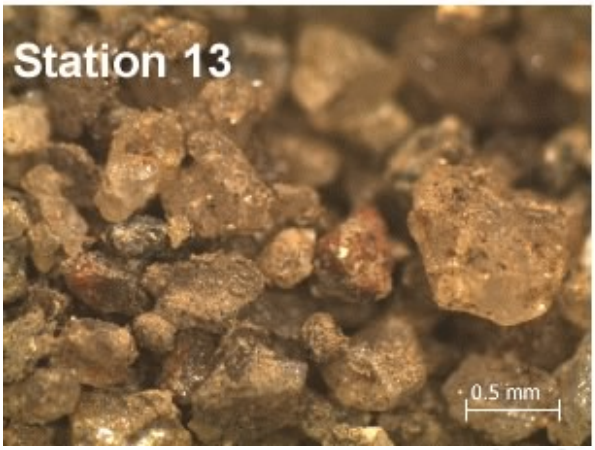
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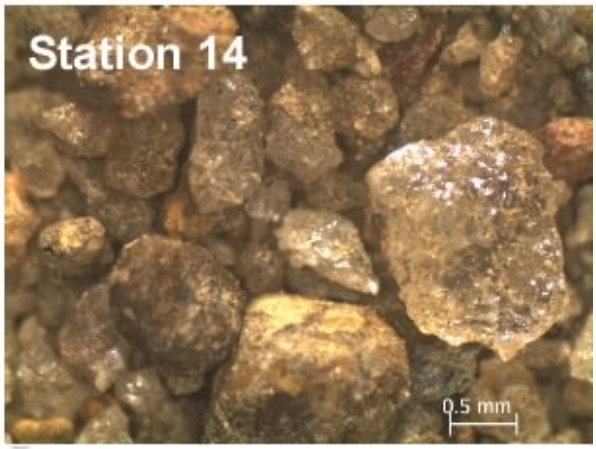




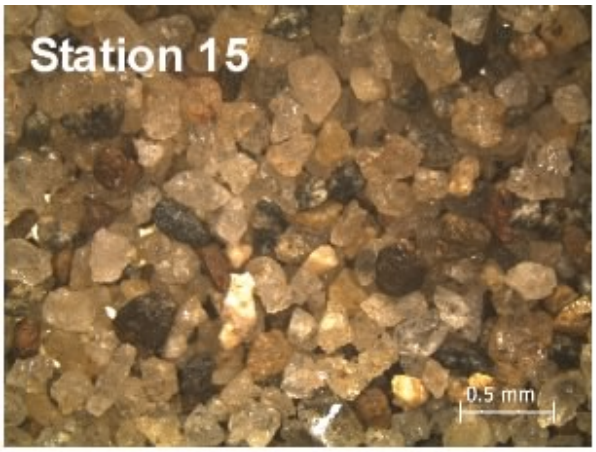


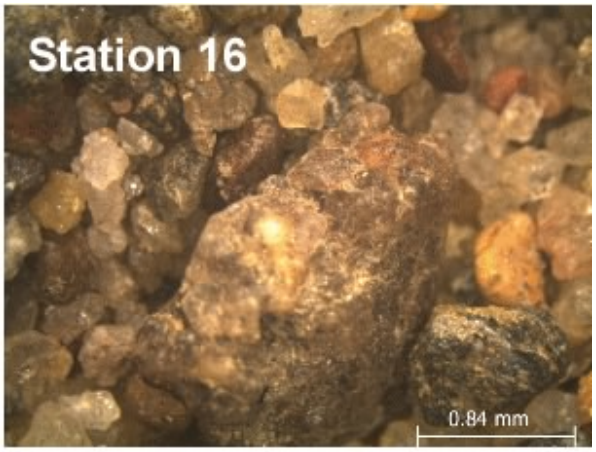


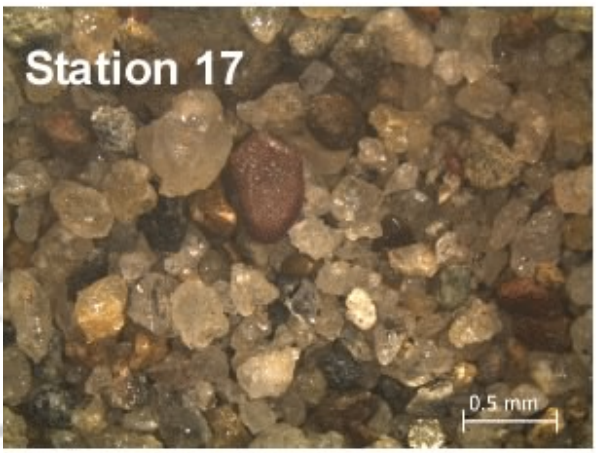


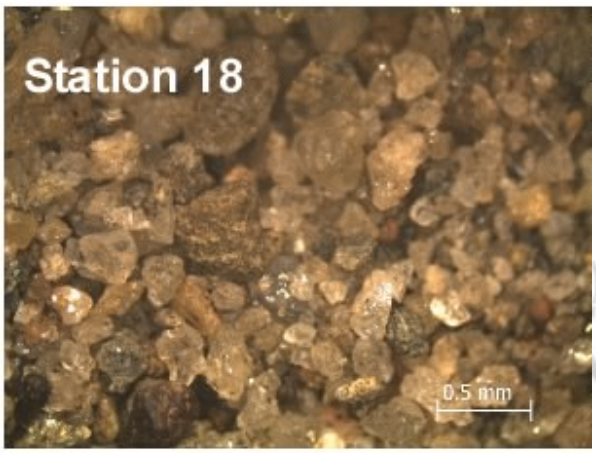


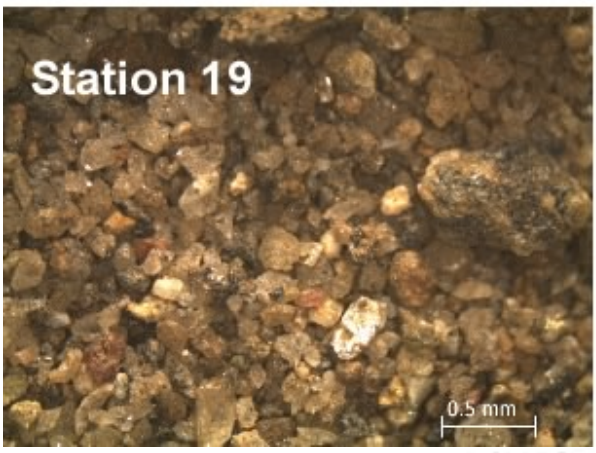
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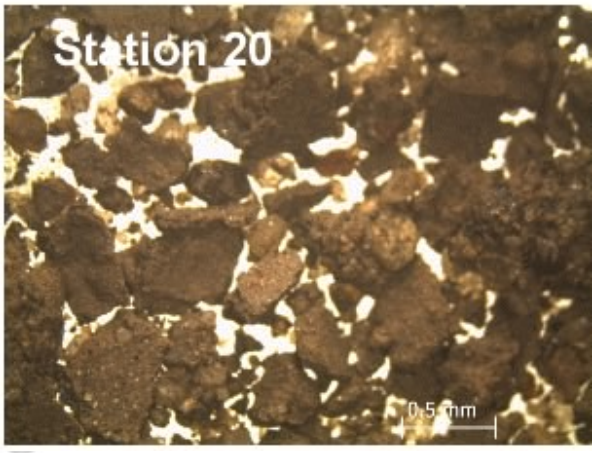




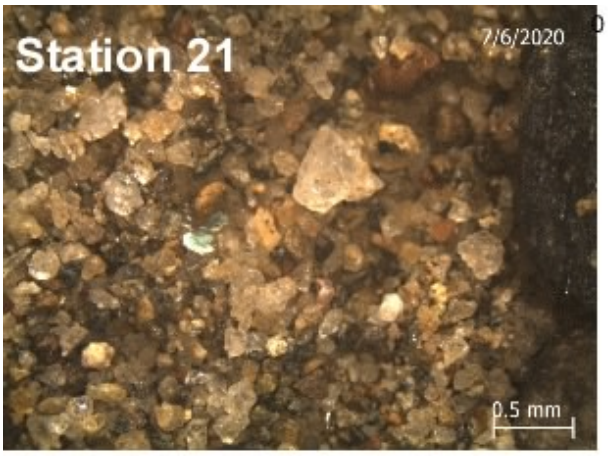


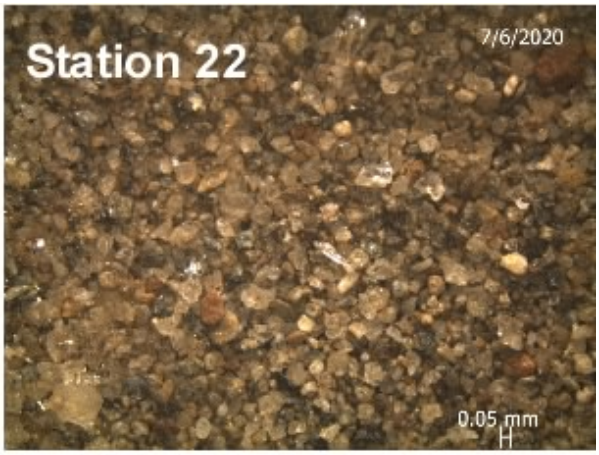




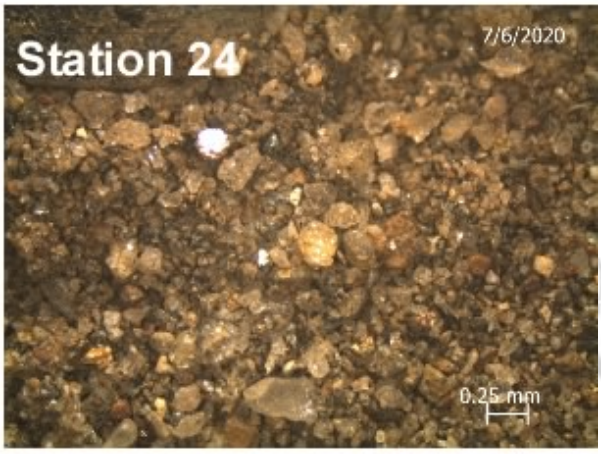


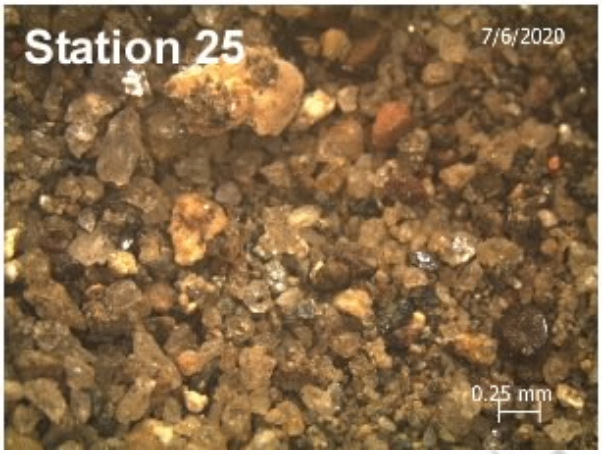
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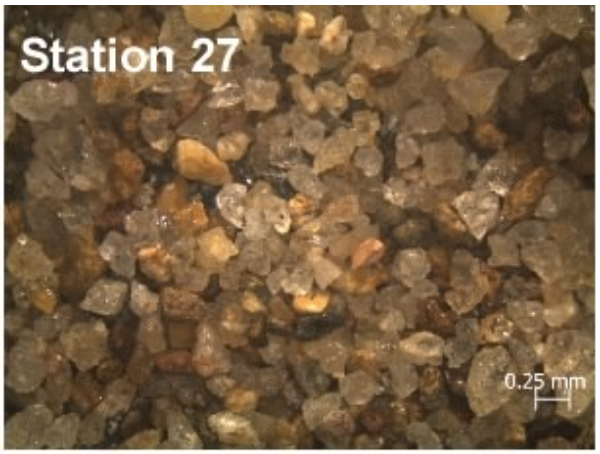


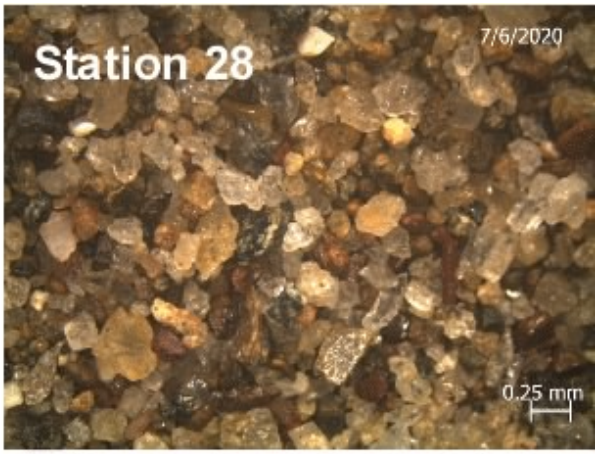




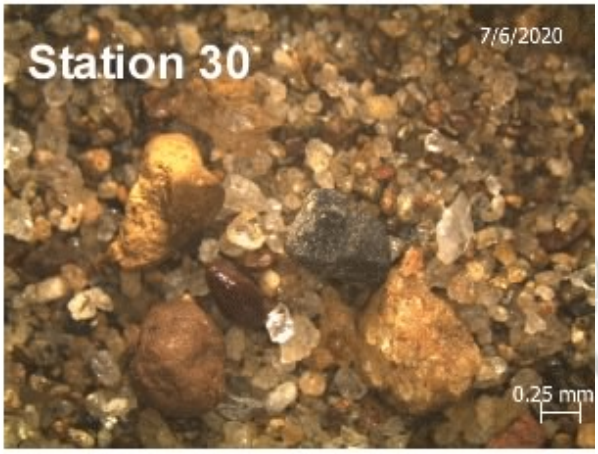


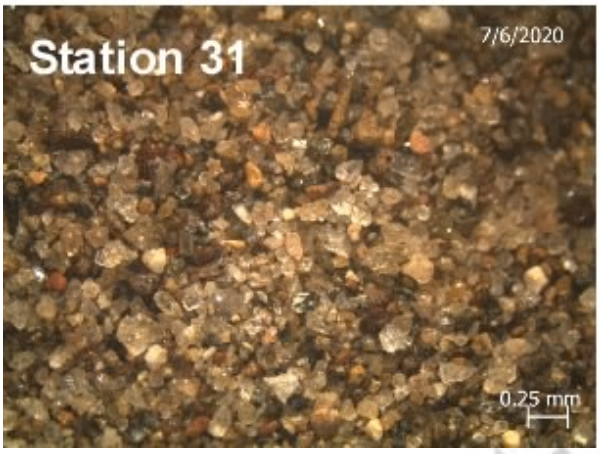
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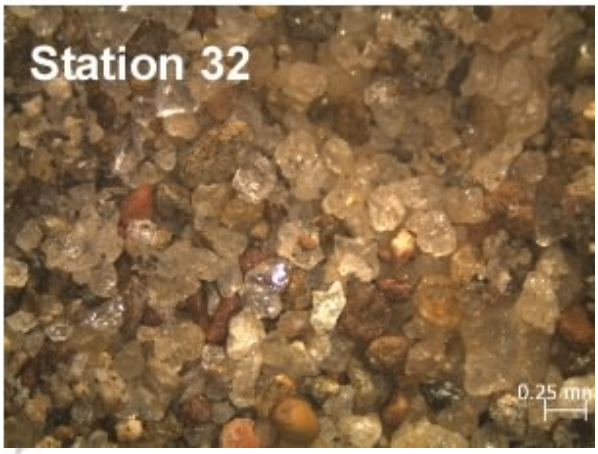




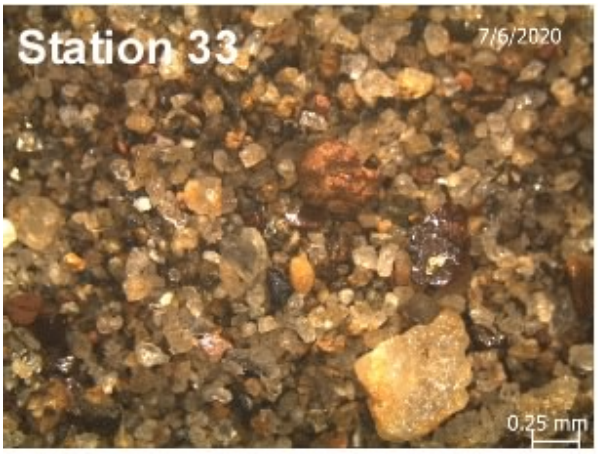




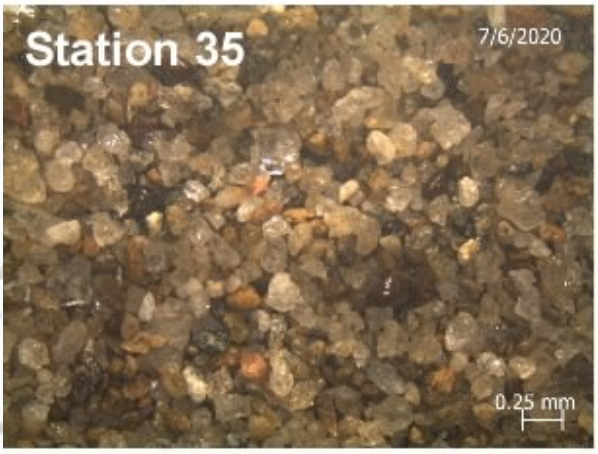


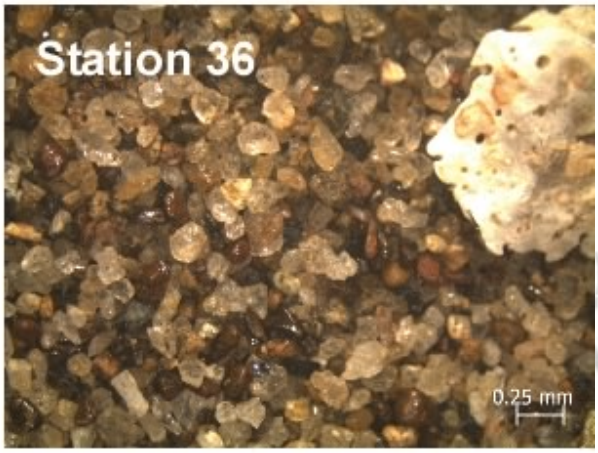


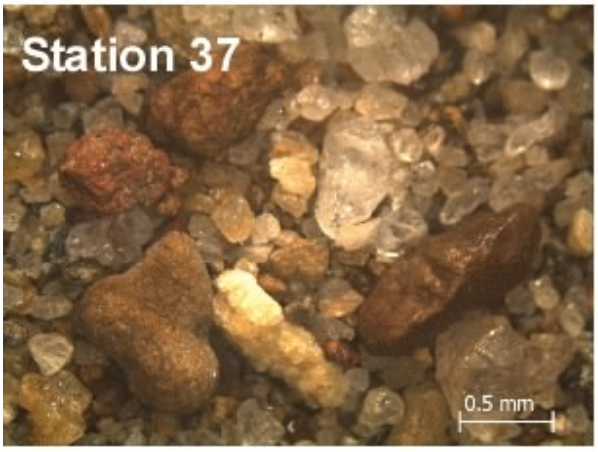
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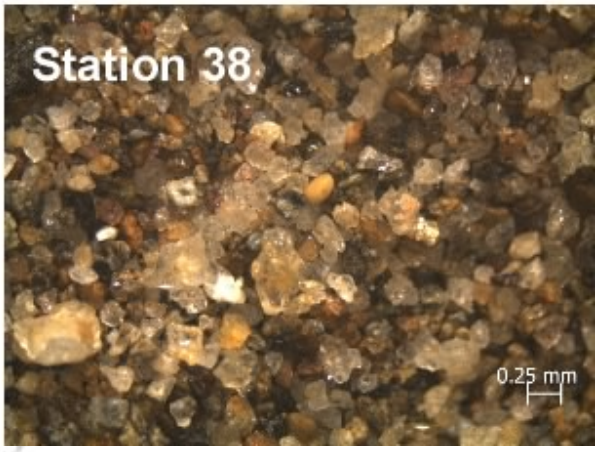




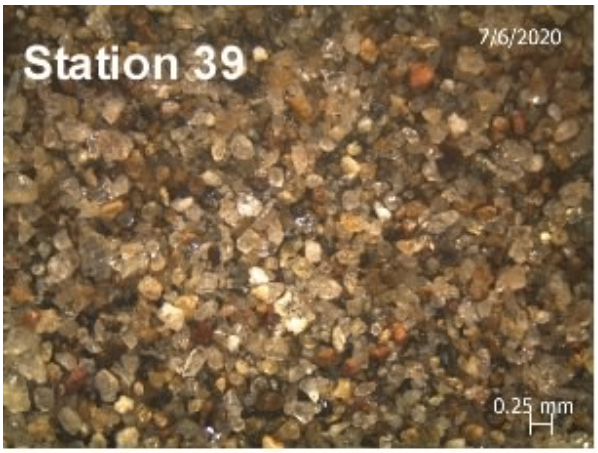


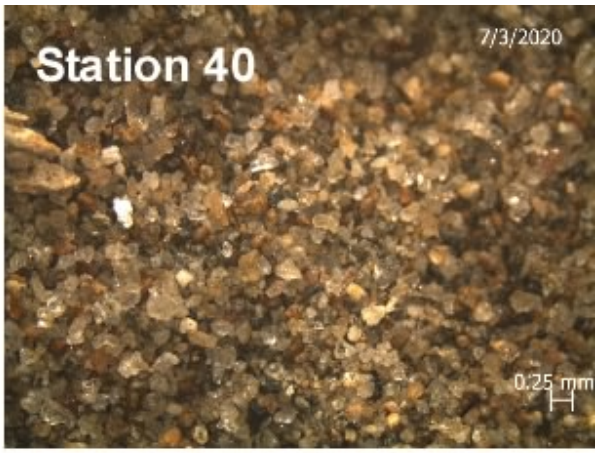


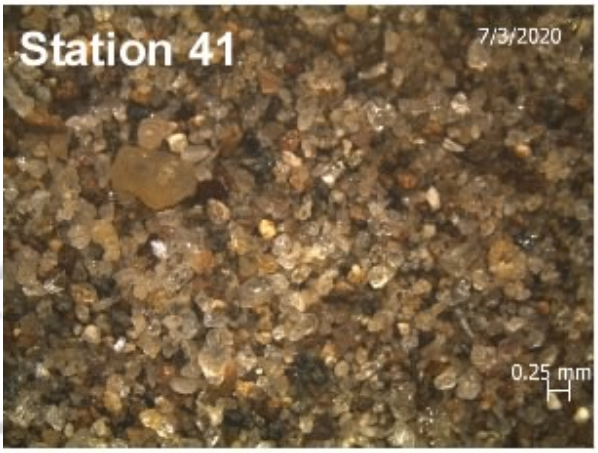




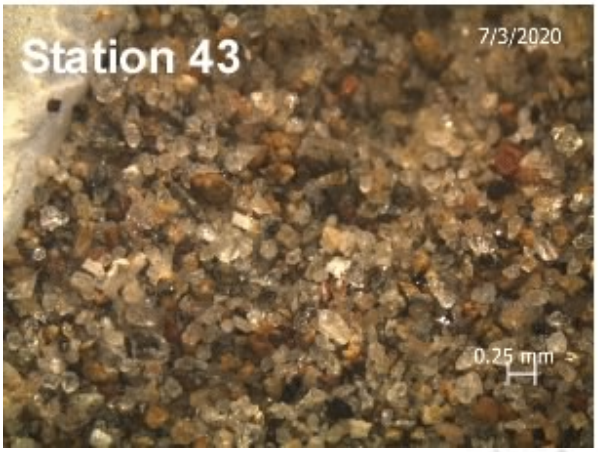
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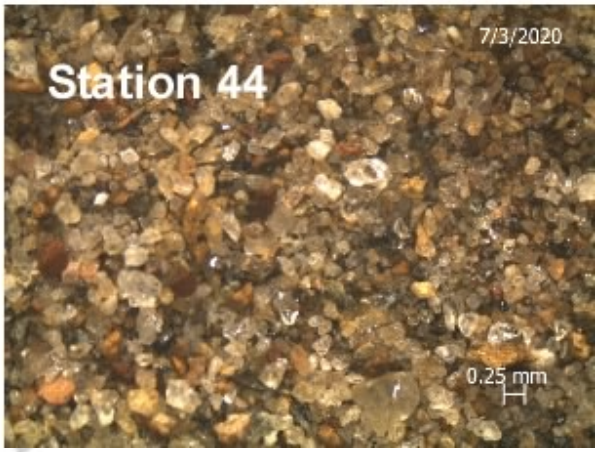




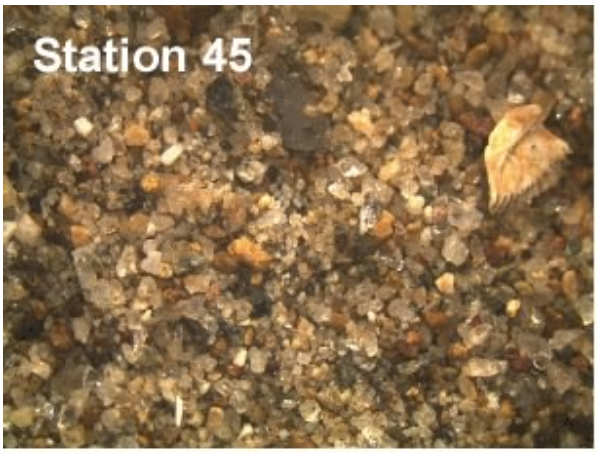


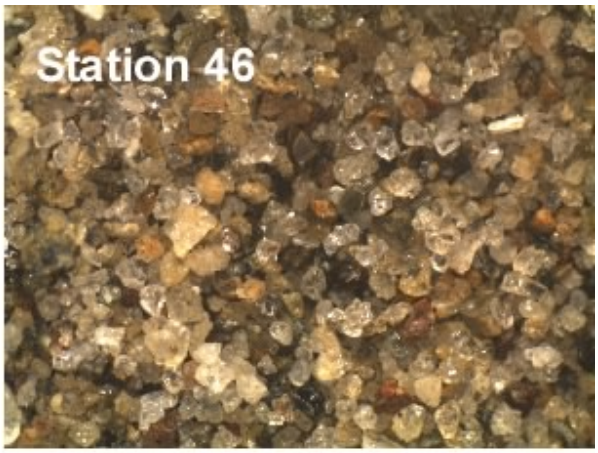


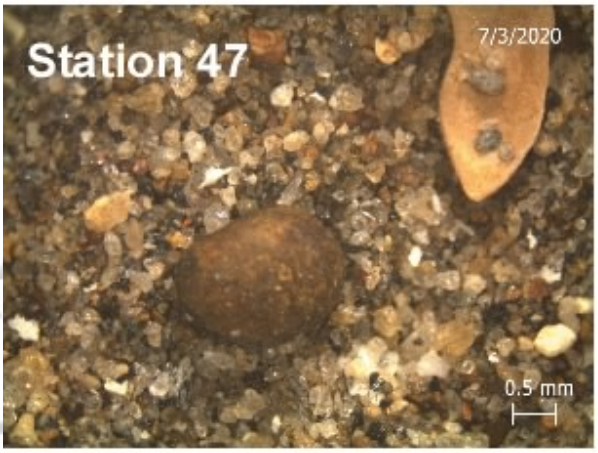


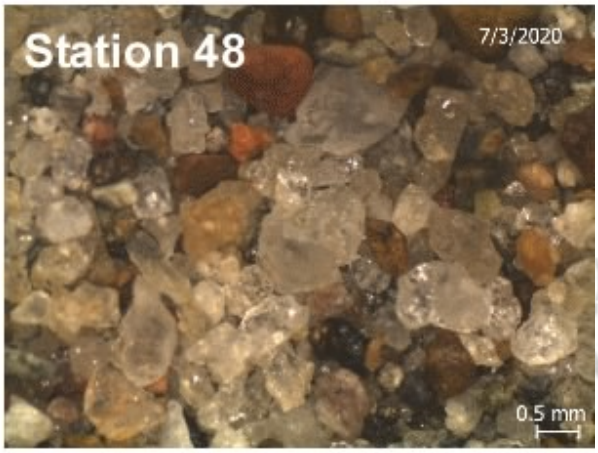


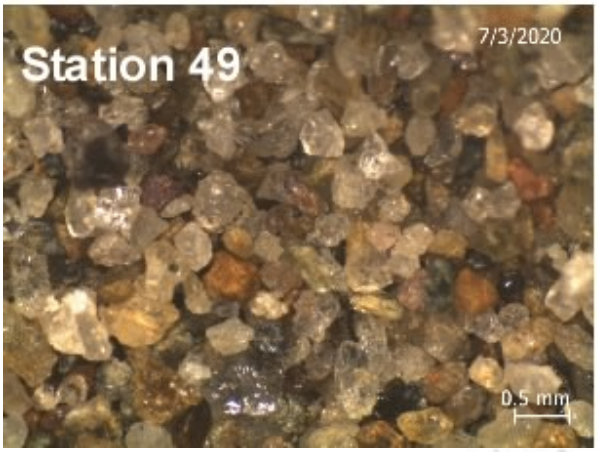
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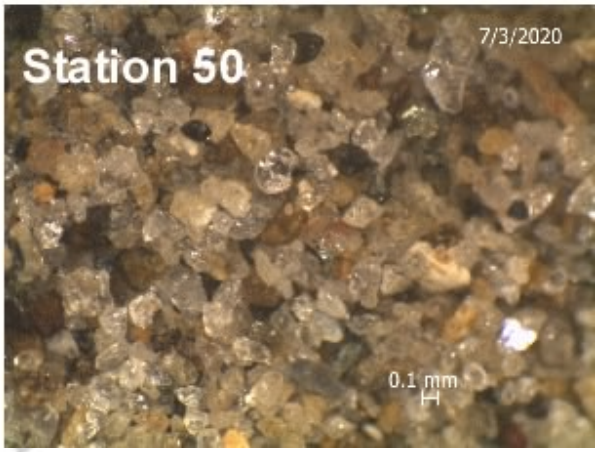




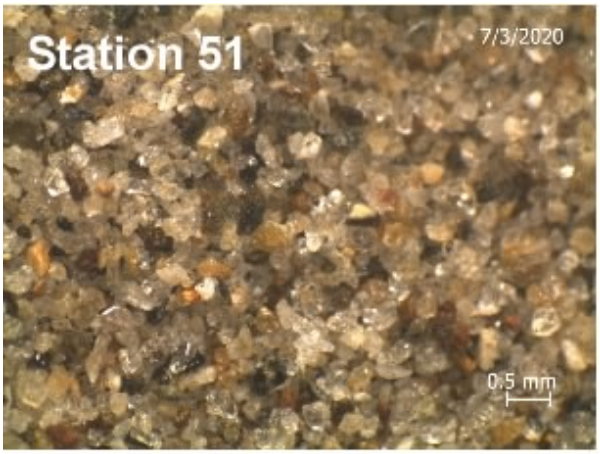


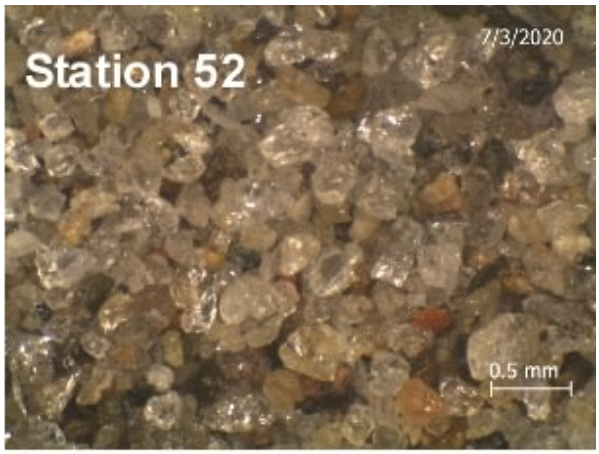


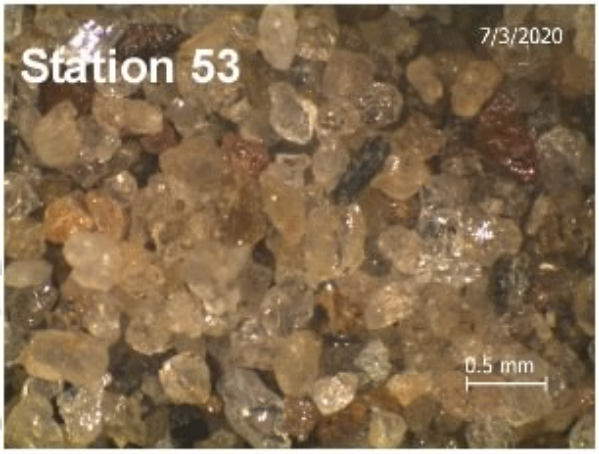


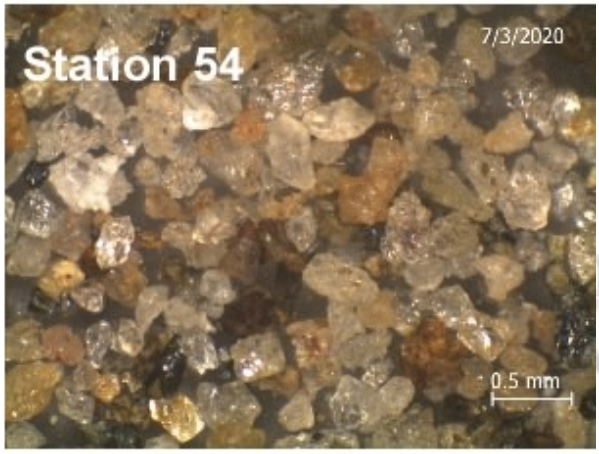


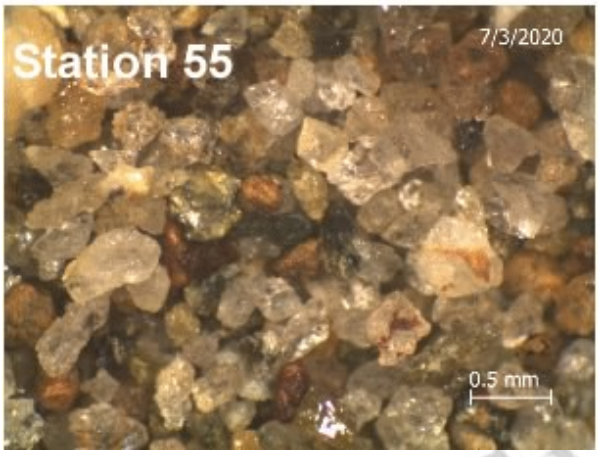
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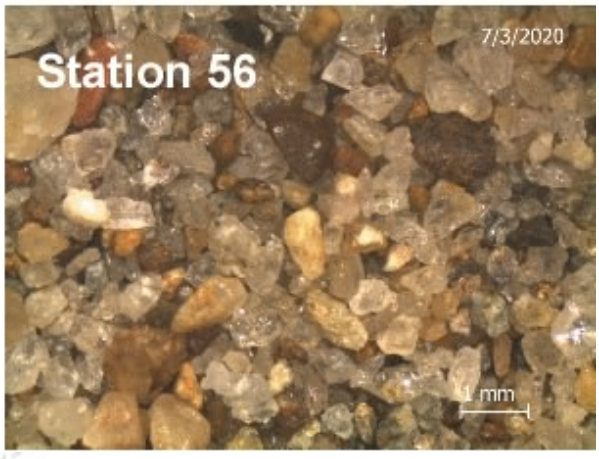








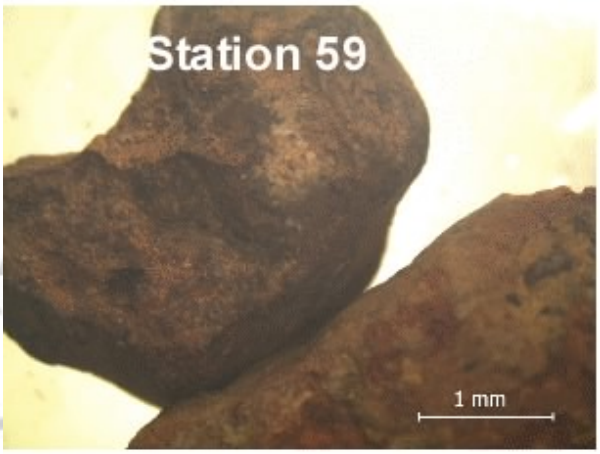


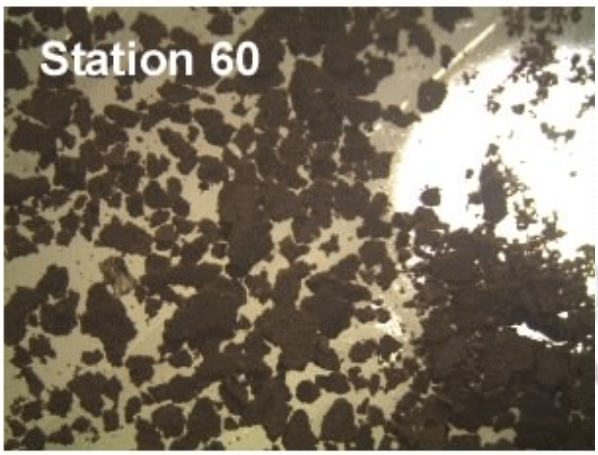


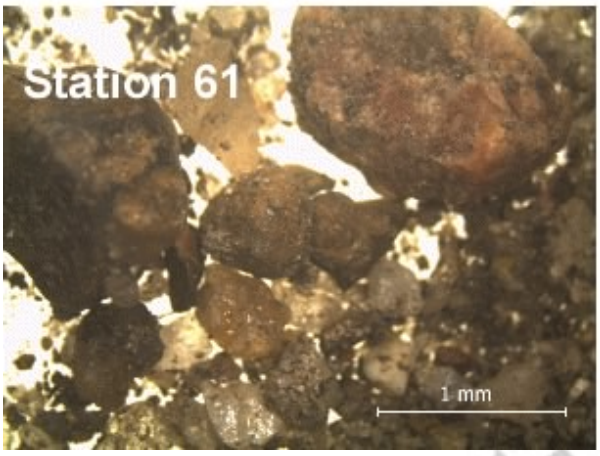
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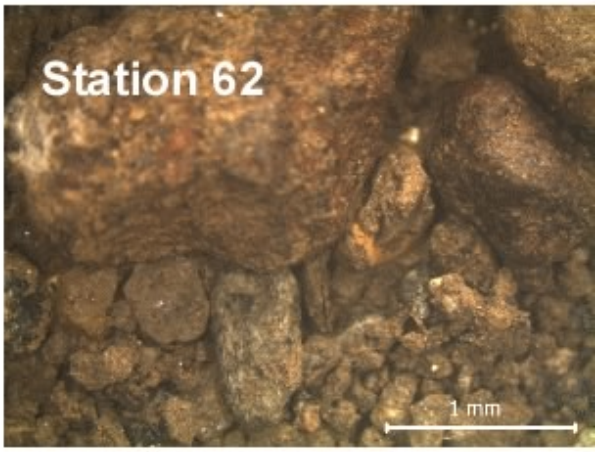












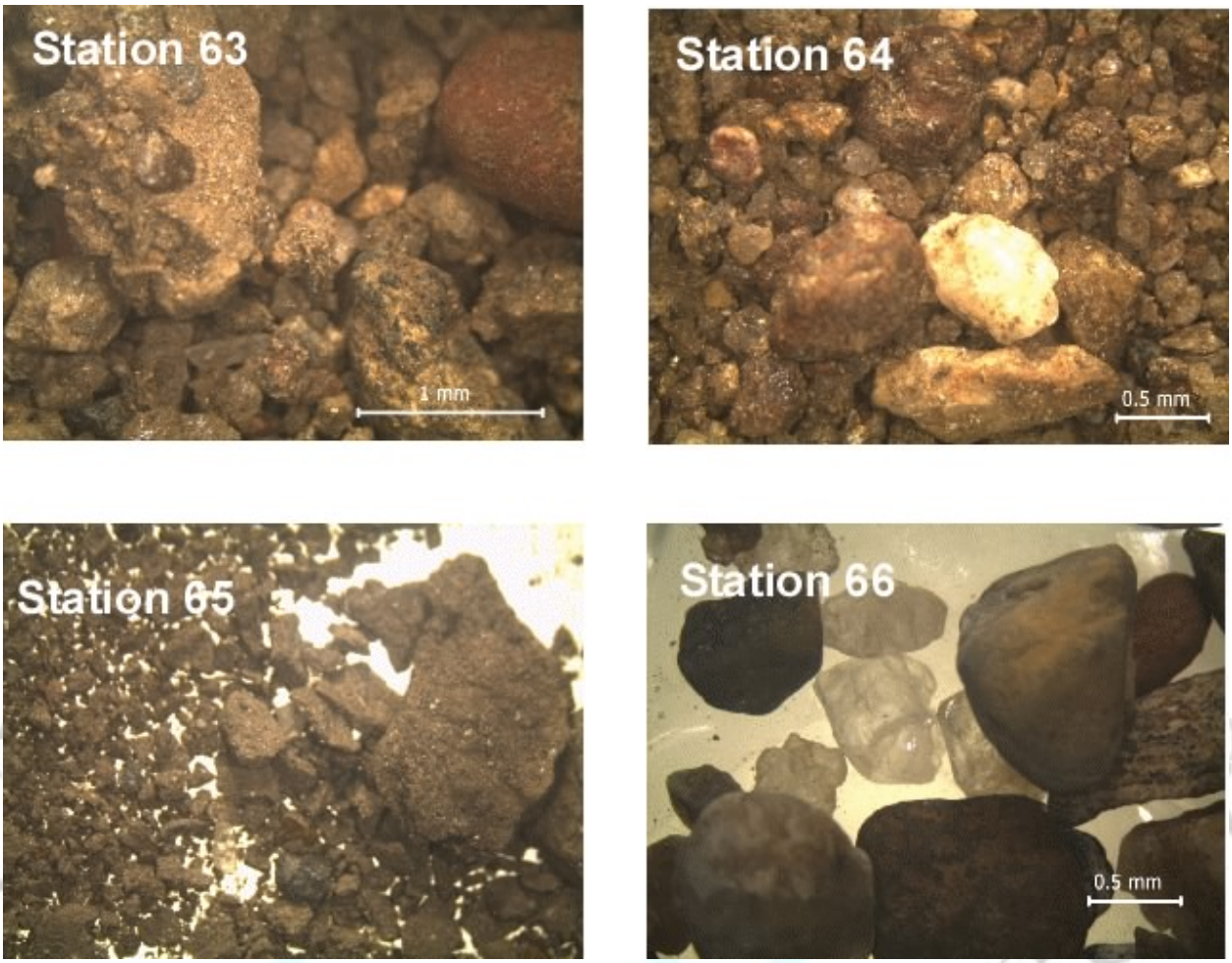


Figure 32. Microscopic Images of Geological Samples

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Chapter 6. Post Monsoon Geophysical Survey

Geophysical data acquisition:

Chapora River is a river in northern Goa, India. It runs westward into the Arabian sea at Chapora and demarcates the border between the North Goa talukas of Pernem and Bardez. The river originates at Ramghat in the neighboring state of Maharashtra enters Goa and flows into the Arabian Sea. Vagator Beach, a tourist destination, is located at the estuary to the south, and to the north is the village of Morjim (Fig.1).

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The post monsoon geophysical data acquisition is carried out in Chapora river, north Goa to understand the post monsoon changes like, new deposition or erosion and replenishment. In this process we have acquired multi geophysical data like, side scan sonar, high resolution sparker seismic (HRS) and Single beam bathymetry data to study the post monsoon geomorphological and subsurface variations.

Major features identified from the side scan sonar (SSS) imaging and high resolution seismic (HRS):

Riverbed morphology through the side scan sonar images have been carefully analyzed in order to infer the river bed geomorphological changes after the monsoon, and high-resolution seismic imaging is carried out to study the river bed depth changes after monsoon. We have analyzed the side scan sonar and seismic data and compared with the same data that was collected during March 2020 for any major changes like new deposition or erosion and replenishment pits after monsoon.

Seismic Data Interpretation:

The seismic data collected post monsoon is compared with the pre-monsoon data across the Chapora River. The river bed and basement interpreted from the pre-monsoon and post monsoon high resolution seismic data are compared to see any change in the river bed depth changes across the Chapora river. In the present report we have highlighted few regions for representing the pre- and post-monsoon studies. Fig.33a-b highlights the pre- and post-monsoon seismic data across the mouth of the Chapora river and Fig.33c highlights the interpreted river bed from pre- and post-monsoon seismic data, which doesn't show any significant variations in the river bed depth. Fig.34a-b highlights the pre- and post-monsoon seismic data

across the Pernem village and Fig.34c highlights the interpreted river bed from pre- and post-monsoon seismic data, which doesn't show any significant variations in the river bed depths. Fig.35a-b highlights the pre- and post-monsoon seismic data across the Camurlim Jetty and Fig.35c highlights the interpreted river bed from pre- and post-monsoon seismic data, which doesn't show any significant variations in the river bed depth. Fig.36a-b highlights the pre- and post-monsoon seismic data across the Revora Village and Fig.36c highlights the interpreted river bed from pre- and post-monsoon seismic data. The depth difference between pre- and post-monsoon shows a noticeable localized depth difference of ~30-40 cm across the region possibly due to exposed rock outcrop.

Side Scan Sonar Interpretation:

The side scan sonar data that provides the regional geomorphology across the river was collected post monsoon and compared with the pre-monsoon data across the Chapora River. A comparative analysis of the pre-monsoon and post-monsoon side scan sonograms have been carried out to identify morphological changes of the river bed.

Fig.37. highlights the pre- and post-monsoon side scan sonar data across Ozorim-Tormas which shows intense mining signatures during pre-monsoon time (Fig.37a) and post-monsoon side scan imaging shows old and new mining signatures are observed in the post-monsoon data (Fig.37b). Fig.38. highlights the pre- (Fig.38a) and post-monsoon (Fig.38b) side scan sonar data across Revora railway bridge and Zuem Island which shows intense mining signatures during pre-monsoon time and post monsoon deposits are observed; the localized sediment thickness as estimated from the seismic data (Fig.36.) is ~30-40 cm and few mining signatures are obliterated. The pre-monsoon (Fig.39a) side scan sonar data within Colvale region highlights absence of ripple marks near the rock boundary and a linear feature on the rock outcrop and post-monsoon side scan sonar within the same region highlights presence of ripple marks near the rock boundary and disappearance of linear feature on the rock outcrop (Fig.39b). Fig.40. highlights the pre- (Fig.40a) and post-monsoon (Fig.40b) side scan sonar data across Colvale bridge do not show any significant change in the river bed morphology. Fig.41. highlights pre- (Fig.41a) and post-monsoon (Fig.41b) side scan sonogram acquired near Chikhli depicts slight local adjustment of sand boundary channel-ward and sand mining activity. Side scan sonogram acquired between Camurlim-Chikhli highlights the change in locations of the sand mining activity (Fig.42a and 42b).

The pre- and post-monsoon side scan data acquired in proposed CC1 (sand mining zone 1) do not show any significant change in the river bed morphology except few sediment erosion and rock outcrop (Fig.43a, b).

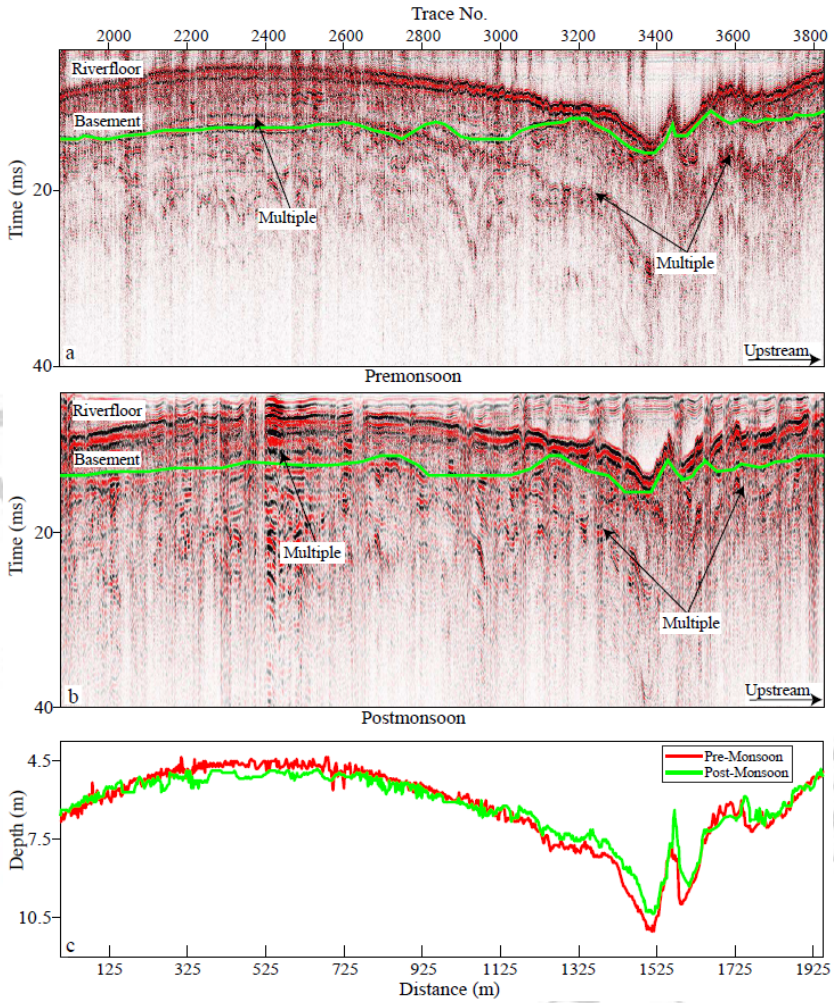


Figure 33. High resolution seismic data. a) Pre-monsoon seismic data, b) Post-monsoon seismic data, c) Interpreted river bed depth from the pre- and post-monsoon seismic data across the mouth of the Chapora river

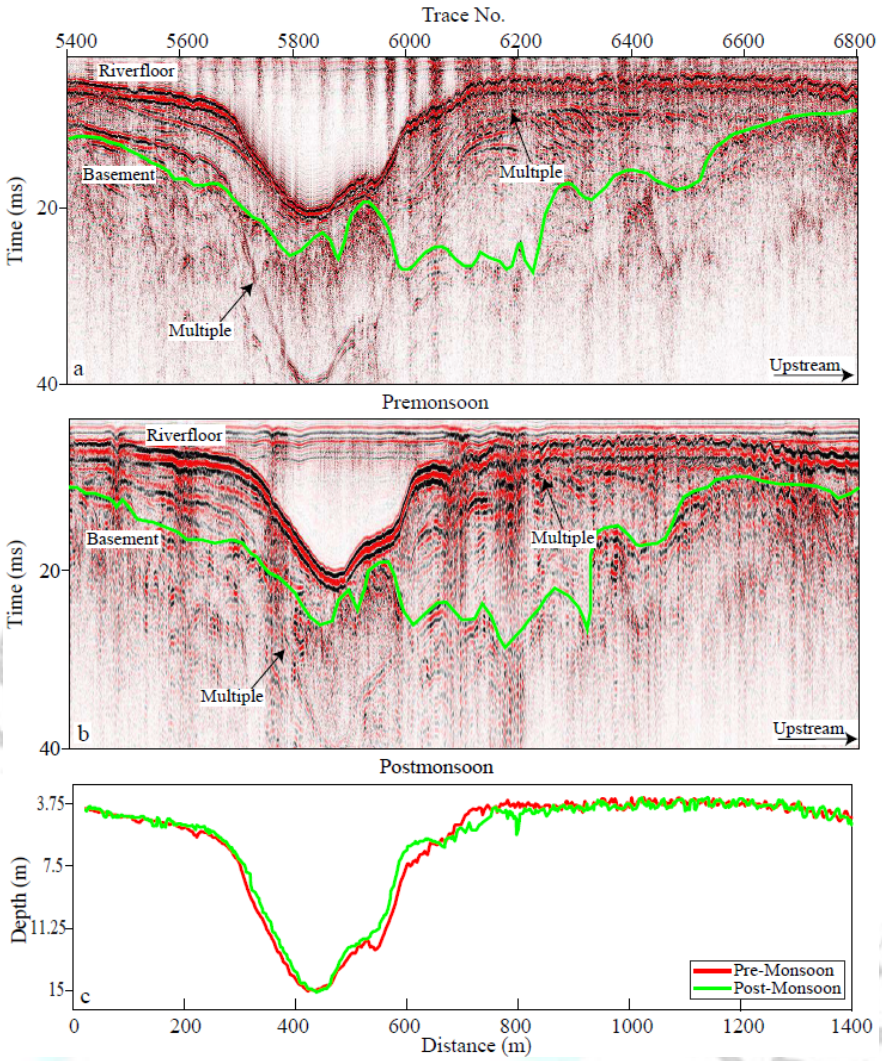


Figure 34.High resolution seismic data. a) Pre-monsoon seismic data, b) Post-monsoon seismic data, c) Interpreted river bed depth from the pre- and post-monsoon seismic data across the mouth of the Pernem village

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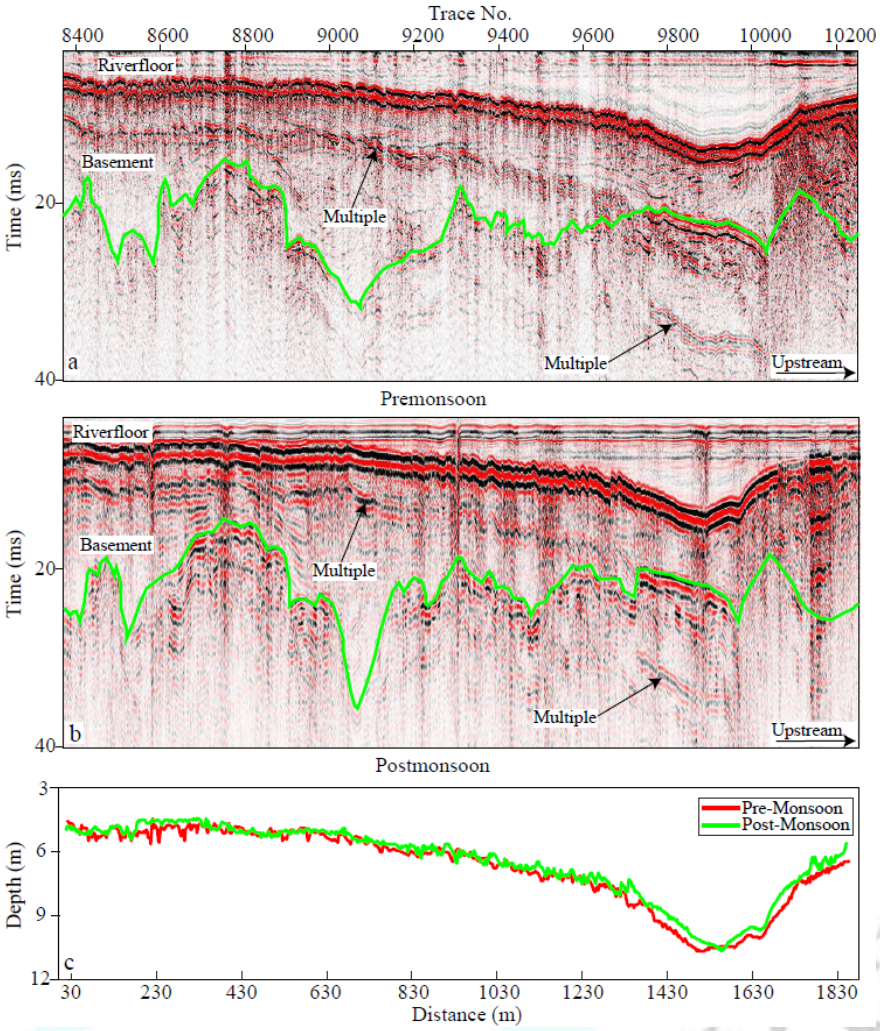


Figure 35. High resolution seismic data. a) Pre-monsoon seismic data, b) Post-monsoon seismic data, c) Interpreted river bed depth from the pre- and post-monsoon seismic data across the mouth of the Camurlim Jetty

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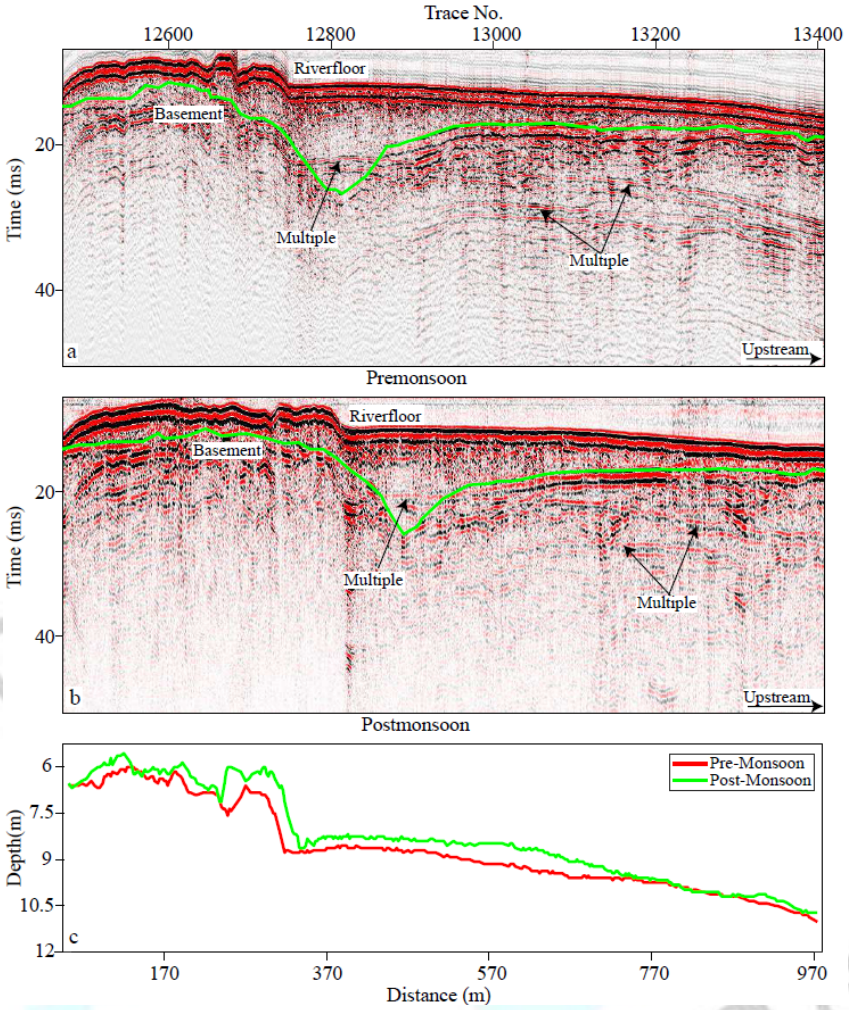


Figure 36.High resolution seismic data. a) Pre-monsoon seismic data, b) Post-monsoon seismic data, c) Interpreted river bed depth from the pre- and post-monsoon seismic data across the mouth of the Revora Village

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Comparative analysis of the Side Scan Sonar data:

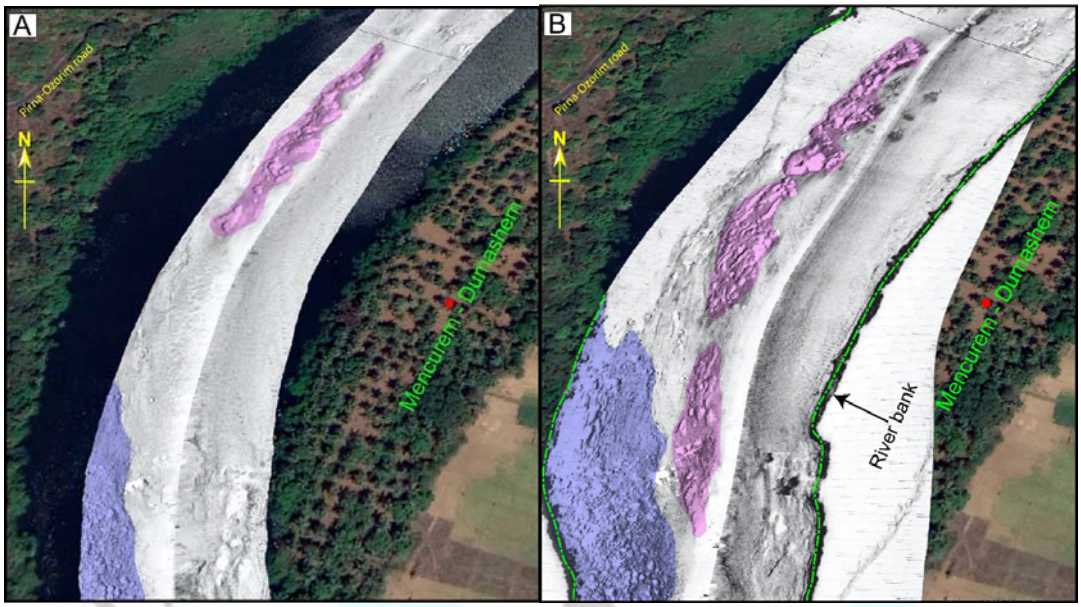


Figure 37. Side Scan Sonograms acquired near Ozorim during (A) pre-monsoon and (B) post-monsoon seasons. (A) and (B) both show the presence of sand mining signature of type-2.

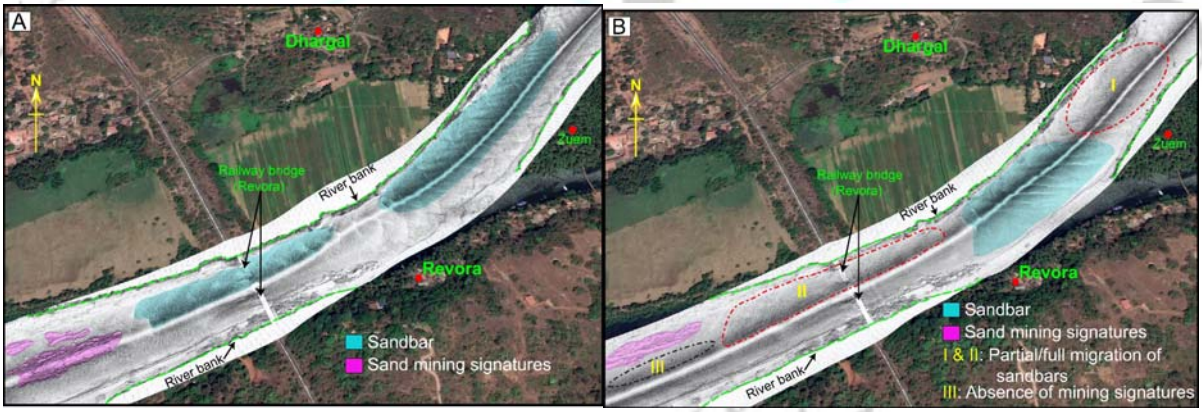


Figure 38. Side Scan Sonograms acquired near Revora railway bridge and Zuem Island during (A) pre-monsoon and (B) post-monsoon seasons. (A) and (B) primarily highlight; (1). migration of sandbars along the course of river, and (2). Filling of sand mining signature

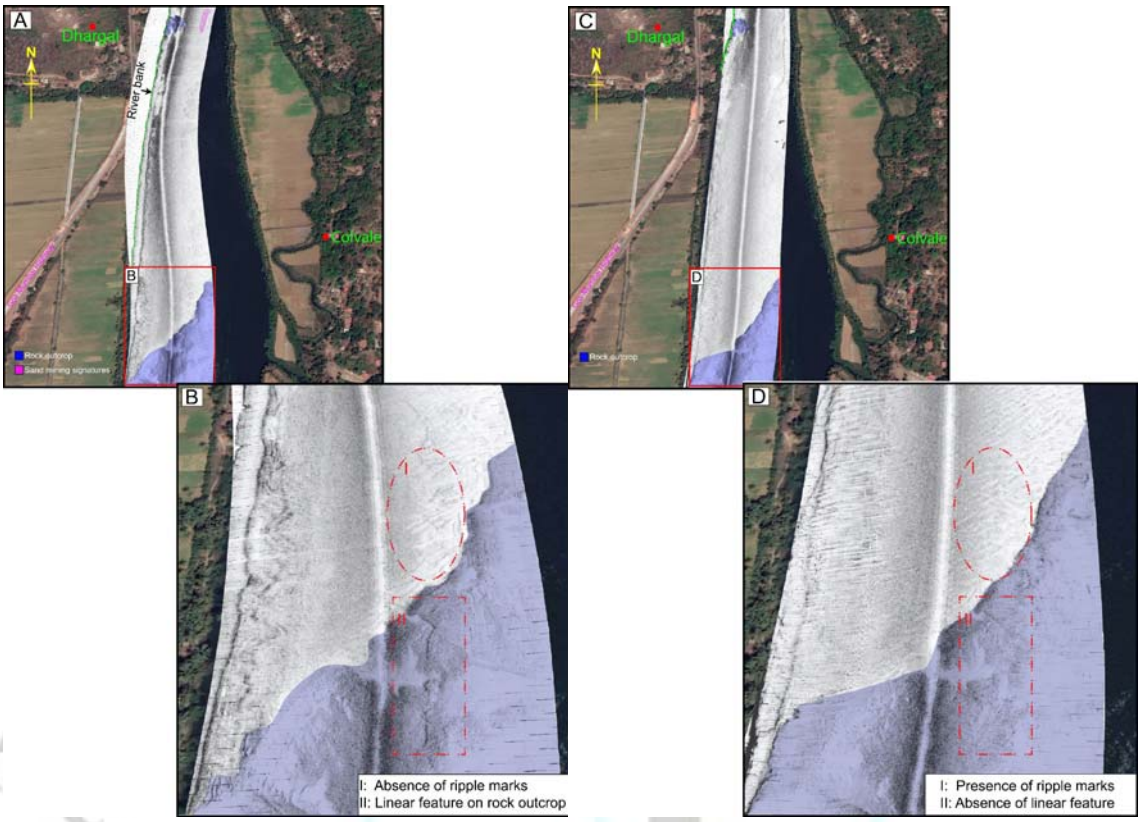


Figure 39.Side Scan Sonogram acquired near Colvale during pre-monsoon season. (A) shows the river bed morphology, (B) highlights absence of ripple marks near the rock boundary and a linear feature on the rock outcrop, (C) shows the river bed morphology correspond

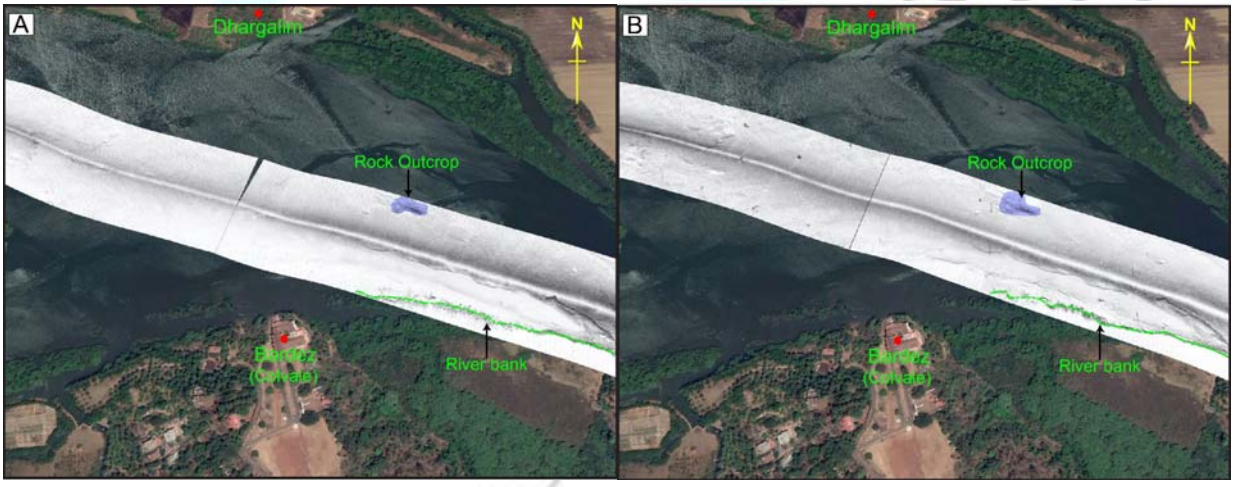


Figure 40.Side Scan Sonogram acquired near Colvale Bridge during (A) pre-monsoon and (B) post-monsoon seasons. (A) and (B) do not show any significant change in the river bed morphology

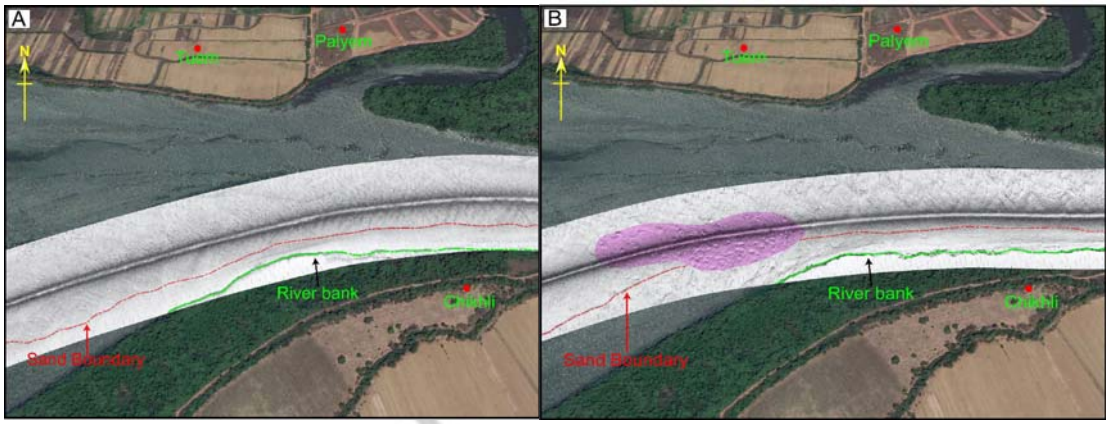


Figure 41.Side Scan Sonogram acquired near Chikhli during (A) pre-monsoon and (B) post-monsoon seasons. (B) depicts slight local adjustment of sand boundary channel-ward.

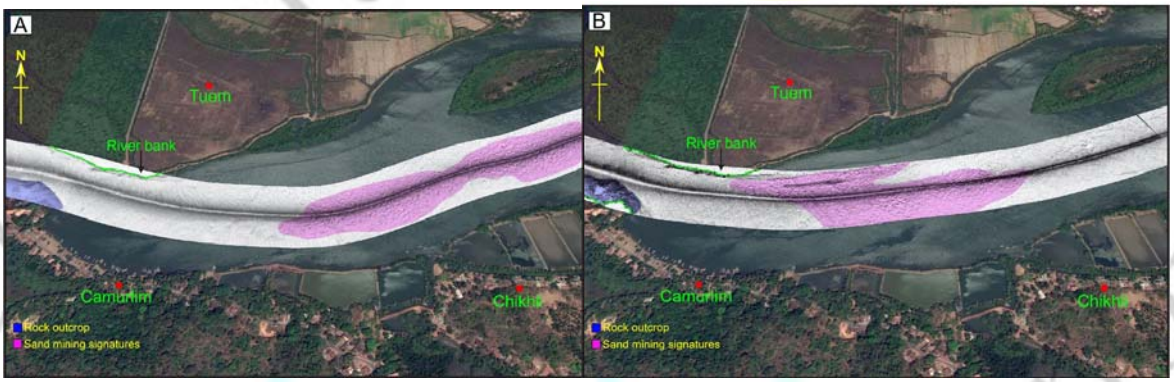


Figure 42.Side Scan Sonogram acquired between Camurlim-Chikhli during (A) pre-monsoon and (B) post-monsoon seasons. (A) and (B) highlights the change in locations of the sand mining activity.

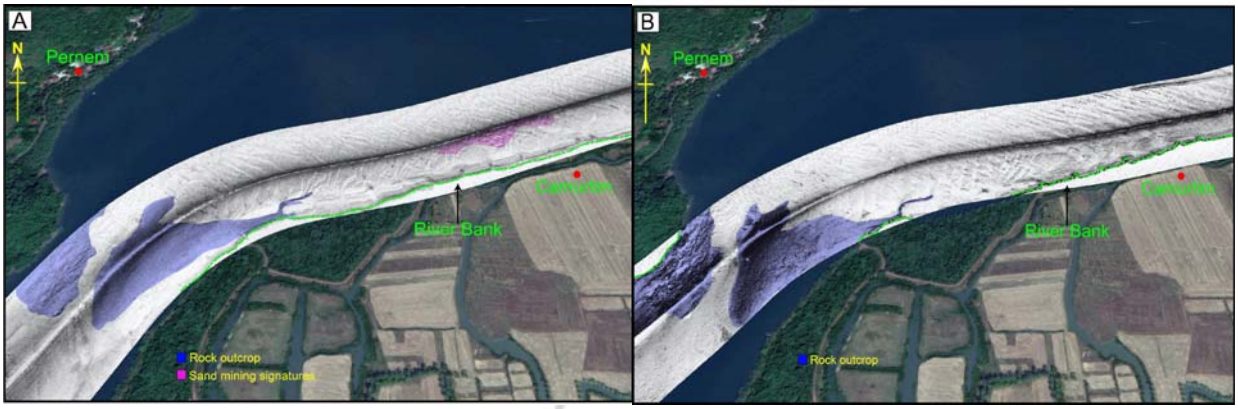


Figure 43.Side Scan Sonogram acquired in proposed CC1 (sand mining zone 1) during (A) pre-monsoon and (B) post-monsoon seasons. The sonograms do not show any significant change in the river bed morphology.

Chapter 7. Conclusions

Pre-Monsoon Executive Summary:

Based on the side scan sonar imaging, single beam echosounder bathymetry and high resolution seismic (HRS) across the stretch of 28km of Chapora river we have interpreted morphological features of river bed. The side scan sonar image shows various geomorphological features like ripple marks (sand), rock out crops, river banks, present and older river banks, erosional features, mud zones and shadow zones of the roads, bridges and railway bridges across the Chapora river. We have also observed active mining zones in different regions of Chapora river where the mining is almost reaching very close to the bridges (~70m close). The single beam echo sounding data is used for estimating the depth of the river bed and the high-resolution seismic data is utilized for the estimating the sediment thickness.

The total volume and total weight of sand availability in Chapora river are given in Table 9.

S. No	Region	Length	Volume (Cubic m)	Weight (Tons)
1	Estuary region	1570	524283	1389350
2	Morjim jetty	1850	1674221	2678753
3	Wadji Supermarket	1700	773160	1237057
4	Sateri Temple	2300	1618575	2589720
5	Camurlim Ferry Terminal	2441	1988240	3181185
6	Our Lady piety Chapel	2170	1168952	1870323
7	Sateri Temple Ambrewada	950	833393	1333429
8	Railway Bridge Revora	1644	610894	977431
9	Raneache Zuem	1620	5753126	9205002
10	Near Sati Devi Temple	1900	544284	870855
11	Pirna Ozarim bridge	1000	216771	346835
12	Ozorim Tormas Bridge	1250	1028294	1645271
	Total =	**20395**	**16734193**	**27325211**

Table 9. Total Volume and weight estimated from Chapora River

The total sand volume is estimated using the sediment thickness derived from the seismic river bed to bed rock thickness and width of the sand distribution region based on the side scan sonar image interpretation based on the river bed characteristics like ripple marks, high and low

Chapora River Survey Report

amplitude features that differentiate between the sand and rock out crops along the length of the river. By consider the effect bulk density of the sediment we have estimated the total weight of sediment (sand) available in the Chapora river.

Based on the grain size analysis and microscopic studies the region is divided into three zones based on the sorting. Zone1: sampling point 59-66 characterised by pebbles and cobble size sediment along with silt clay pockets; Zone2: sampling point 33-58 characterised by moderate to well sorted sediments and Zone3: sampling points 1-32 characterised by poor to moderately sorted (Fig.33).

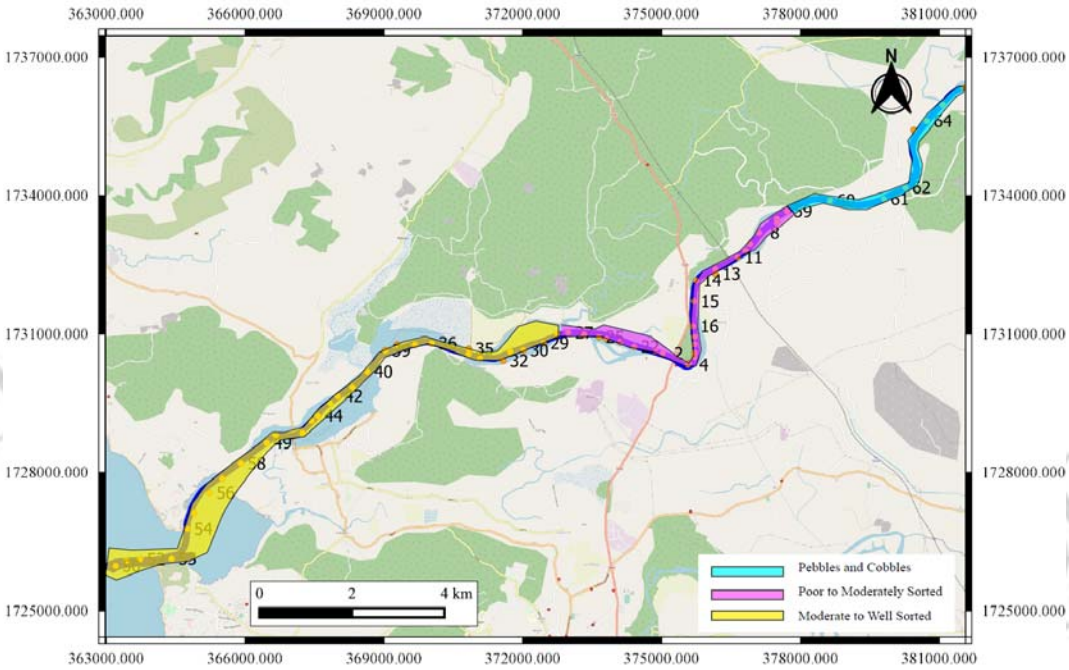


Figure 44.Sand sediment grain size distribution from upstream to river mouth

Based on the EIA/EMP study by NIO in Chapora river, we have identified six feasible sand mining regions which can be evaluated based on further detail studies of impact on the environment and biodiversity in the identified regions (Fig.45).

Based on the selection of regions we have estimated the sand volumes and weight of total sand availability and also the total sand that is available for sustainable mining (3-meter mining) is provided in table 10.

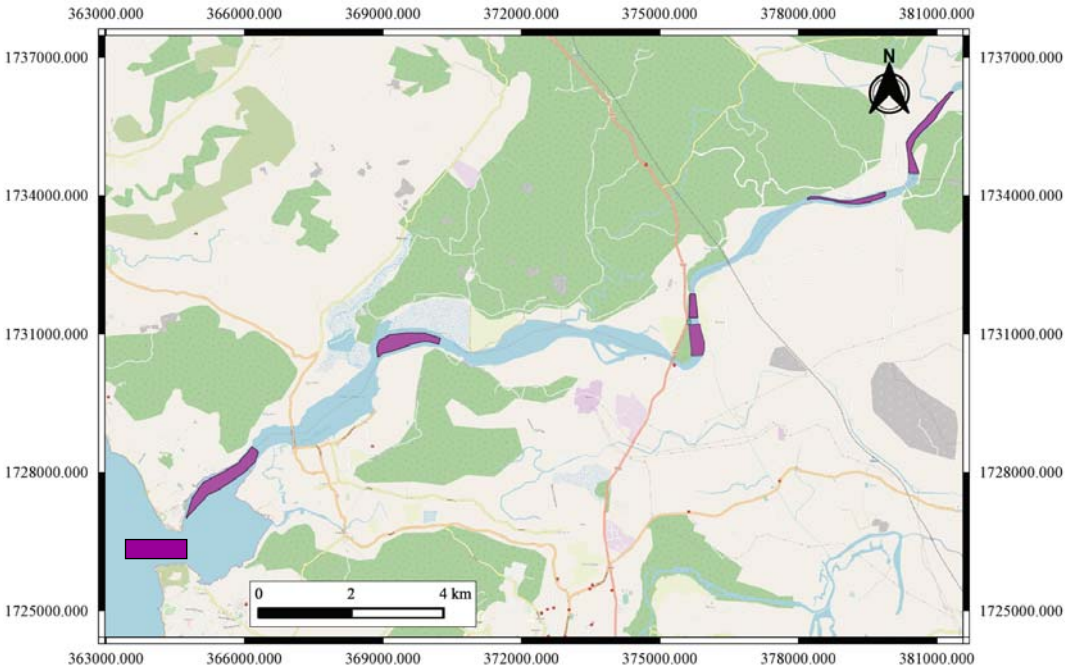


Figure 45.Possible Sand mining regions after considering EIA/EMP studies

S. No	Region	Length	Volume (Cubic m)	Weight (Tons)	Volume for 3-meter Thickness (Cubic m)	Weight (Tons) for 3-meter thickness
1	Estuary region	1570	524283	1389350	357072	571316
2	Morjim jetty	1850	1674221	2678753	1037146	1659434
3	Sateri Temple	2300	809287	1294860	254245	406791
4	Railway Bridge Revora	1644	610894	977431	302923	484676
5	Near Sati Devi Temple	1900	544284	870855	341031	545650
6	Ozorim Tormas Bridge	1250	1028294	1645271	1028294	1645271
	Total =	**10514**	**5191263**	**8856520**	**3320711**	**5313138**

Table 10. Total Volume (Cubic m) and Weight (Ton) in selected regions and volume (cubic m) and weight (ton) within 3meter mining depth

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Pre- and Post-Monsoon comparative executive Summary:

1. The pre- and post-monsoon high resolution seismic data survey across the Chapora river is carried out to study the post monsoon changes like new deposition or erosion and replenishment pits after monsoon.
2. The difference between the pre- and post-monsoon seismic data doesn't show any 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 ~30-40cm.
3. The difference between the pre- and post-monsoon side scan sonar data doesn't show any significant changes in the river bed and even the pre monsoon mining pits are not completely filled. In few regions localized changes in the river bed morphology and spatial adjustment of sand bar are observed.
4. Type -1and Type - II mining signatures as observed from the side scan sonar data are mostly obliterated but no significant aggradation is observed in the seismic data.
5. Identical signatures in side scan sonar data are observed in the vicinity of rock outcrop, indicating no significant deposition.

Chapora River Survey Report

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

Report on Mandovi Estuary

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31st Aug 2021

Report submitted by:

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EXECUTIVE SUMMARY

Mandovi River is one of the nine major rivers flowing from the east (Western Ghats) to the west (Arabian Sea) in the state of Goa. It is located between the latitudes ($15^0$09' and $15^0$33'N) and longitudes ($73^0$45' and $74^0$14'E). The river originates in central western ghats and flows in Goa, where it is known as Mahadayi River in the up-streams, and enters into Goa where it is popularly known as Mandovi. The present study was undertaken to study the following aspects of the Mandovi 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 estuarine ecology and biodiversity and to calculate the biodiversity index of the estuary.

The results of all the above aspects have been incorporated in the chapters of this report as baseline study. The overall biological results suggest moderate to poor conditions, possibly several parts of the estuary 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 Mandovi 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 estuary show bank erosion and breaching of bunds, due to non-maintenance. Hence, the banks are vulnerable and may experience erosion in the future.

Spatial variations observed in the backscatter sonar intensity and ripple patterns. The Side Scan Sonar images of Mandovi river shows varying smooth to rippled to heavily rugged riverbed morphology between off Miramar to Khandepar. Point and mid-channel bars are more frequent in upstream region of the river.

Sparker system achieved a subsurface penetration of ~3-25 m in the survey area. Due to the shallow depth of riverbed, multiples (up to second-order) are observed in the study area. Sand volume are estimated using side scan sonar image zonation of sand features, sediment thickness from seismic data. Sand dominates the sediments followed by silt.

Considering the physical baseline parameters, modelling studies have been carried out. The Hydrodynamic simulations is carried out using MIKE21 Flow Model FM. 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 to I 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, the Mandovi estuary has been impacted by cumulative anthropogenic activities and natural riverine and costal processes.
- Based on the studies eight feasible sand mining regions are identified.
- In the Mandovi estuary the bed level changes for the post-mining scenario are mostly around -0.15 m to 0.25 m during both simulated monsoon (August-November, 2020) and non-monsoon period (November, 2020 - May, 2021). The changes in bed morphology in the post-mining scenario at different sections of the river are highly dynamic and patchy in nature.

- A higher salinity regime influences the lower stretches of the estuary; 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, riparian zones and mudflats into mangrove areas.
- Based on the SSMG (2016) & Hon'ble NGT recommendations, certain areas in the estuary stretches have been demarcated where sand extraction from the estuary bed cannot be carried out. These sites identified as "sensitive" include islands, bridges-piers, embankments, eroded and erosion prone banks, ecologically sensitive areas viz; mangroves.
- No sand is available in the upper stretches of the Mandovi estuary, which is non saline region of the estuary. In contrast, the majority of sand deposits are in the salinity influenced areas.
- The stretches with 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 a conflict of interest.
- Once the lease areas are issued, then the delineated "Environmental Conservation and Management Plan" needs implementation. The plan also describes the team/committee, which should be capable of addressing, executing, and monitoring all 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. The ordinary sand is brought by the river originating from the Western Ghats and flowing west to join the Arabian Sea. The process of weathering helps the deposition of sand. Sand is extracted mainly from the river Mandovi, Zuari, Terekhol, Chapora and its tributaries. Where the water column is deep, sand is extracted with the help of canoes and buckets attached to bamboos. Sand is mostly used in construction activities.

The extraction of sand is a traditional activity being carried out in Goa before the Portuguese regime. The extraction was manually carried out and some 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 after that, the Goa Minor Mineral Concession Rules, 1985 were notified. In 1979 various references are available in the form of application from traditional extractors, letters from cart owners, village panchayats etc.

The extraction of sand from the rivers beds in Goa is governed by the Goa Minor Mineral Concession Rules, 1985 and permission was granted yearly. 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 the Ministry of Environment, Forests & Climate Change, Government of India for permission to remove 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, Forests & Climate Change was issued which carved out an exception to the CRZ notification. 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 licence 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/stretches 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 informed 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 1 October 2017 to 31st May 2018. As per one of the conditions 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 was forwarded by 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. MCA application was filed before the Hon'ble High Court seeking a time frame of 8 weeks as the Directorate of Environment was in the 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 as stacking point of sand, installation of weigh bridges, etc. Subsequently, in the order dated 4th April 2019, eight weeks were granted to the State Government to decide on renewal of sand permits. The directorate of Environment has agrred to incorporate Environment Management Plan for an individual cluster to capture all possible externalities before the renewal of the licences. A proposal for the 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 in the Mandovi Estuary.

1.2 Mandovi Estuary

Mandovi river is one of the nine major rivers flowing from the east (Western Ghats) to the west (Arabian Sea) in the state of Goa. It is located between the latitudes ($15^0$09' and $15^0$33'N) and longitudes ($73^0$45' and $74^0$14'E). The river originates in central western ghats and flows in Goa, where it is known as Mahadayi River in the up-streams, and in downstreams is popularly known as Mandovi (Figure 1.1). Mandovi is one of the most important rivers of the state of Goa and is the largest among all the rivers. The Mandovi and Zuari (two major rivers of the state) are joined / interlinked by a canal, called Cumbarjua canal. The river Mandovi and Zuari meets at a common point at Cabo Rajniwas opposite to Mormugao Harbour. The total flowing distance of the river is 70 km in the State of Goa. The total basin area of the Mandovi river is 1530 km^2 and it runs amidst a typical tropical setting along the Midwest coast of India. Mandovi is remarkably influenced by monsoon maritime climate with its three distinct seasons, namely pre-monsoon (February-May), monsoon (June-September), and post-monsoon (October-January).

The annual freshwater runoff of the Mandovi River is approximated to be 16 km^3 with a small pre-monsoon runoff of approximately 0.06 km^3. The river carries drainage from 435km^2 of forestland. The Goa State Pollution Control Board (GSPCB) monitors the water quality of River Mandovi at 5 locations (i.e., Tonca, Hotel Marriott, IFFI Jetty, Mandovi Bridge, Amona Bridge & Marcel) under the National Water Monitoring Program (NWMP) of CPCB. The polluted

stretch identified for the Mandovi River is 9.00 kms i.e., from Marcel to Volvoi, whereas the stretch from Panjim to Marcel is 20 kms (action plan as per Hon. NGT order in original application No. 486 / 2018 in Feb. 2019). This stretch of the River Mandovi between Volvoi to Marcel is classified as SW-II (for bathing, contact water sports and commercial fishing). On the basis of GSPCB reports, Central Pollution Control Board (CPCB) has classified Mandovi River (Volvoi to Marcel) under Priority IV, as it has the BOD level range between 3.3 to 6.2 mg/l.

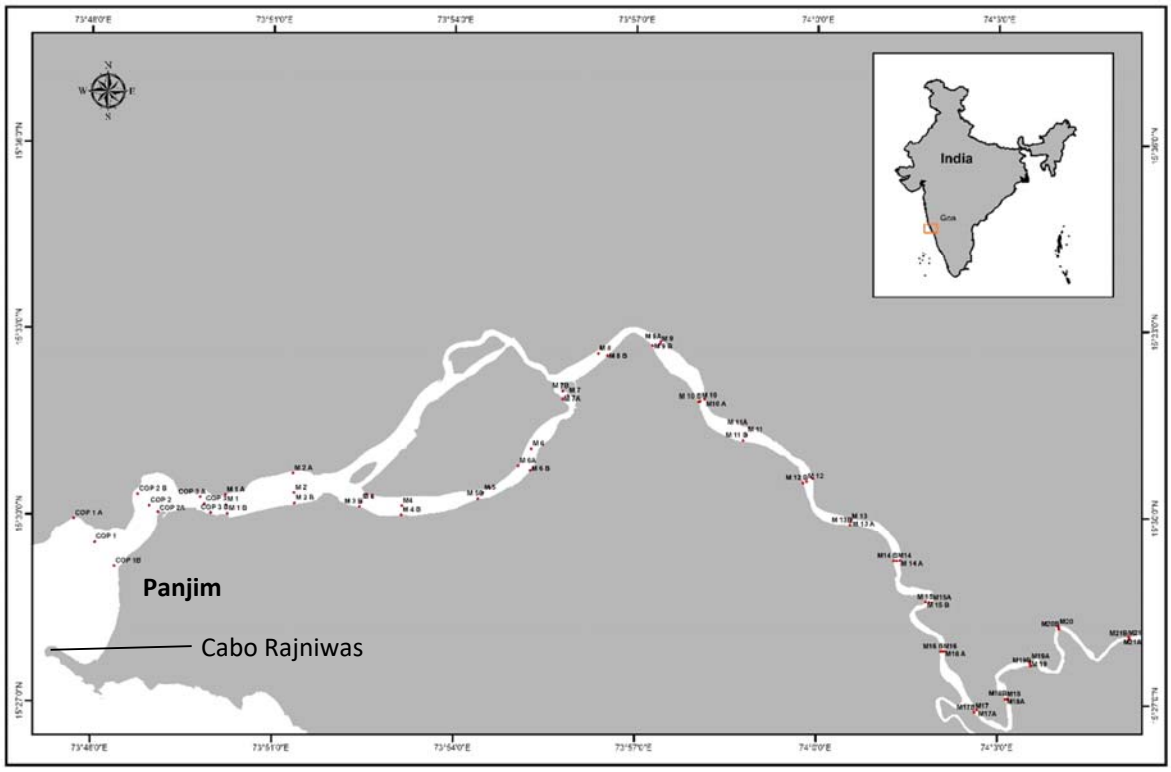


Figure 1.1: Map showing sampling stations in the Mandovi Estuary

1.3 Constraints in adopting SSMMG (2016) for the state of Goa

Goa is a small state located on India's central west coast, part of the rich and biodiverse 'Western Ghats'. There are numerous west flowing rivers in the state of Goa which originate mostly in the hilly regions of the Western Ghats and meet the Arabian sea, forming a major estuarine expanse. The upper stretches of the rivers in Goa are mostly small rivulets, numerous streams that collectively join to form tributaries which further join to form the

major rivers. Heavily influenced by south-west monsoon, the rivers bring sedimentary material by regular processes such as denudation and erosion of top soil and rocky material of the Western Ghat formations (Barcem, Sanvordem, Bicholim, Vagheri Formation) shown in Figure 1.2. The average distance of the rivers in the state of Goa from the origin to the Sea is about 25 km or less. With this short distance and the amount of geogenic material brought to its lower reaches by typical process of sediment erosion and denudation the overall process of sand and gravel formation is deficient and truncated. Considering the topography, river velocity and the quantum of riverine flow from each watershed, the magnitude and scale of the rivers in Goa are smaller by an order, as compared to the other Indian rivers such as Ganga, Yamuna, Bramhaputra, Krishna, Cauveri, Mahanadi and Pennar. Additionally, the estuarine complexes in the state of Goa cover a major area of the state. A significant influence of coastal hydrodynamics and salinity intrusion upto several kilometers upstream is a typical characteristic of all the rivers in the state of Goa. Therefore, a majority of riverine expanse is under the influence of salinity.

The second important aspect critical in deciding the sand budget for the rivers in Goa is the dams, barrages and bandaras built on the rivers as the source of important freshwater supply for the state. The lower stretches of these rivers are the major sites of sand extraction but the restricted supply of eroded/denuded material coming downstream makes the riverbeds impoverished due to manmade structures. Indeed, the preliminary studies for replenishment of sand material have revealed very low rate (a few centimeters) of sand deposition after each monsoon season. Furthermore, this replenishment is mostly 'local adjustment' that is redistribution of already existing sand from nearby areas, which is shifted mainly due to flow velocity and tidally influenced hydrodynamics.

These unique traits of rivers in Goa make it difficult to apply the SSMMG which is generically designed considering the diverse nature of rivers in the entire country. Understandably, the SSMMG fits well for important and large river basin that are major sand producing sites contributing a significant percentile of the national requirement. Therefore, at times it becomes difficult to follow all the guidelines delineated in the SSMMG, although this report tries to adopt all relevant plans and implement them for the greater interests of the state of Goa.

It is recommended to consider few additional aspects in the SSMMG (2016) so as to accommodate the small estuarine rivers which exist in the States like Goa. The norm of 3 meters may be explicitly reviewed as it may not fit few of the estuarine regions on the west coast. The guidelines may also mention a mechanism to include capital dredging and maintainance dredging activities which are sectors (or part of coastal projects) requiring MoEFCC clearance. These acticvites demand proper disposal of dredged material at designated offshore locations, with large volumes, if feasible, dredged material can be well utilized as 'commercial sand' instead of dumping in the offshore locations resulting in additional impacts. Coastal hydro-dynamics and bathymetry studies are vital to understand the fate of sedimentary material and its repleninshment in the saline influenced riverine stretches. Inclusion of such baselines can be used to evaluate the vulnerability of banks as well as salinity intrusion pertaining to sand extraction activity.

The present scope also includes a study on the 'river biodiversity index' delineated along with methodology (CPCB, 2002). This index categorically uses freshwater benthic species as indicators for calculating the diversity indices. The values derived from application of these index denotes the status of the river/stretch in terms of pollution/degradation. As mentioned earlier, the rivers in the state are influenced by salinity. A significant span of these rivers can be categorized as estuarine zone and the majority of sand available areas overlap this zone. Estuaries predominantly represent marine biodiversity adopted to low saline conditions and most of the freshwater species tend to perish with any small spike in salinity. Therefore, freshwater indices are not applicable to estuarine communities (benthic or pelagic) and because of this inapplicability the present report uses other standard diversity indices that are used by the scientific community globally.

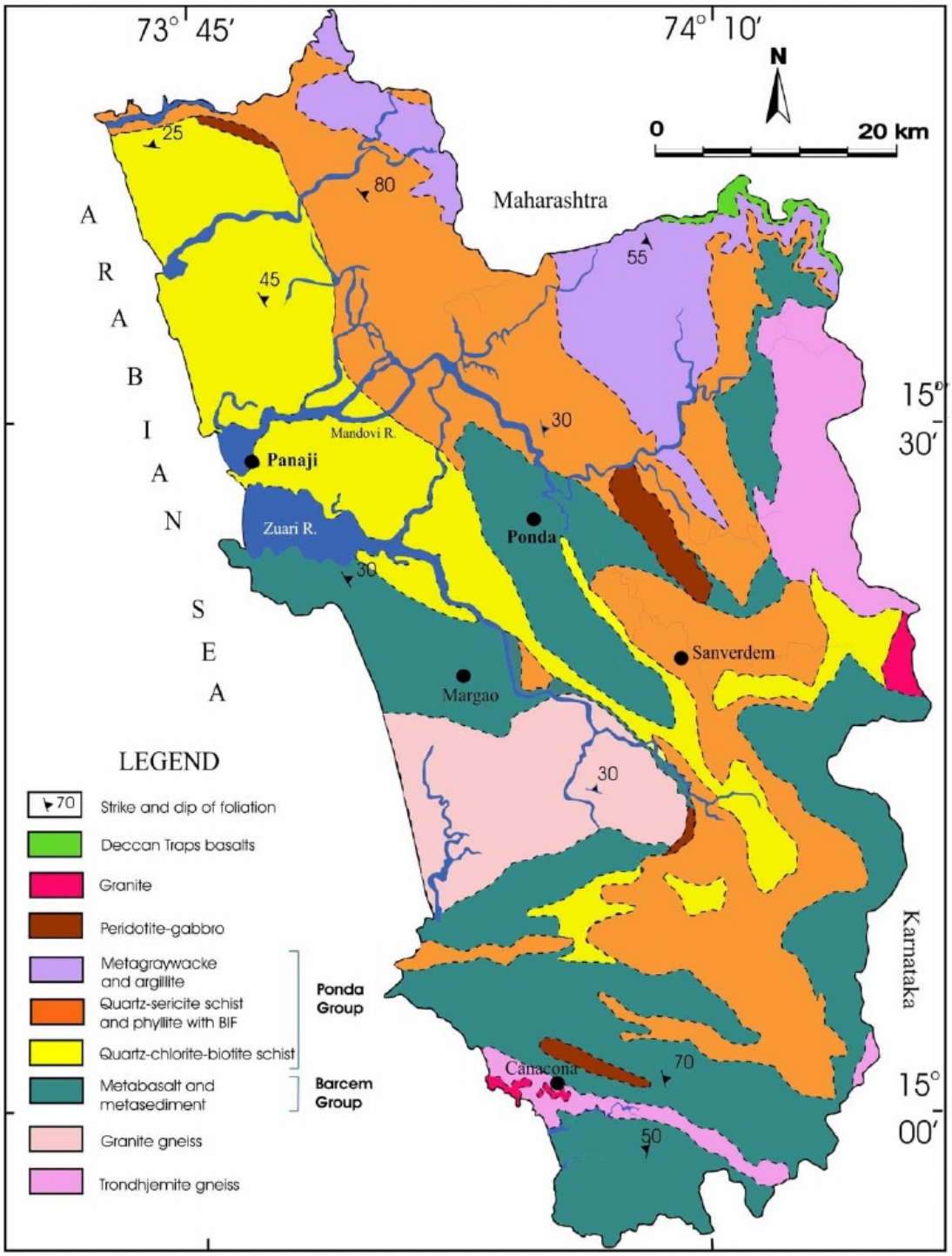


Figure 1.2: Geological map of Goa (Dessai, 2011).

CHAPTER 2-METHODOLOGY:

Following table represents the work plan and the steps involved in Assessing and executing the EIA studies. Which involves surveys, water and sediment parameters and collection and identification of fauna which represents the ecosystem in which the base line study is conducted. All the biotic and abiotic studies those includes Biological, Physical, chemical and geological studies are taken into consideration and a base line report is prepared which includes impacts on the environment, mitigation measures and recommendations for monitoring and conservation and management aspects.

Steps involved in EIA	Particulars
Baseline data collection	• Surveys for all the parameters and measurements as per the requirement • Baseline data collection as per the scope of work. All the baseline data collection has to be as per the plan. • The baseline data collection / monitoring is from primary and secondary sources and field monitoring studies.
Laboratory analysis	• Sample preparation, processing and analysis using various concerned instruments. Calibration and standardisation of all the parameters/ instruments is carried out prior to sample analysis.
Data analysis	• All data generated via direct measurements and laboratory analysis is pooled, outliers are eliminated and data analysis and processing is carried out using standard software to generate Graphical Representations, maps, trends and indices etc.
Preparation of report	• Input of all the experts are given for each of parameters analysed reports in the EIA study • Final compilation of the report (following standard methodology) with the basic requirements for each aspect. Standard report is designed with the following format with analysis and synthesis for decision making. o EXECUTIVE SUMMARY o INTRODUCTION: Sand Mining Scenario in the State of Goa, About specific study area. o METHODOLOGY: Study Area and sampling locations, Water sample collection and processing, Sediment Sample Collection, Meiofaun, Macrobenthos, Diversity indices,

	Biotic indices, AMBI index, M-AMBI index, BENTIX index, AMBI and M-AMBI index, BENTIX Index. o Methodology for Modelling- Climatology & Meterology and Methodology for Numerical Modelling Studies o RESULTS: Physico- Chemical And Biological Parameters, Temperature and Salinity, pH and Turbidity. Phytoplankton biomass, Chlorophyll a (Chl a), Phytoplankton, species composition and abundance of phytoplankton, Phytoplankton Diversity, o Zooplankton, Biomass of Mesozooplankton, Total abundance of Mesozooplankton, Distribution of taxonomic groups of Mesozooplankton, Species Diversity, Sediment Characteristics, Total suspended matter (TSM). o Meio-benthos , Foraminifera, Macro benthos, Land Use Land Cover (LULC), Fishery, Reptiles & Mammals, Avifauna, Riparian Vegetation, Seaweeds & Grass (Halotolerant), Mangrove. o MODELLING- CLIMATOLOGY & METEOROLOGY o NUMERICAL MODELLING STUDIES o ANTICIPATED IMPACT: Quantification of impacts wherever possible, Clear difference between prediction modelling, identification of pollution and narration of impacts (Impacts are always on common or sensitive receptors) o Prediction & Assessment of impacts, Impact on all the paramters, Positive anticipated impacts, Mining Sensitive Areas. o MITIGATION MEASURE Protection of river embankment, Annual replenishment of sand, Maintenance of flood capacity, Seasonal ban on sand mining activity, Limiting sediment impact, Prevention and mitigation of pollution, Protection and management of groundwater, Soil management, Alternative resource generation. o ENVIRONMENTAL CONSERVATION AND MANAGEMENT PLAN: Strategy for the management plan, Development of green belts and Nursery, Mangrove management and conservation, Embankment protection and restoration, Biodiversity conservation & management plan, Conservation plan for fauna, Conservation & natural resource utilization, Community participation, Floodplain management (saline marshlands), Development of sustainable integrated aquaculture, Development of eco-tourism, Development of team and funds for the plan,

	Funds for the plan, Role and responsibility of the team, Corrective action/contingency plan, Documentation and record keeping, Complaint handling procedures, Incident and non-conformance reporting. o ENVIRONMENTAL MONITORING PLAN o RECOMMONDATIONS

2.1 Study Area and sampling locations

Table 2.1: Coordinates, depth and sediment texture of Mandovi Estuary

Sampling stations	Location		Depth (m)	Sediment Texture
	Latitude (°N)	Longitude (°E)		
COP1	15°29'21.0"	73°48'24.3"	7	Sandy
COP2	15°30'08.6"	73°48'57.9"	5	Sandy
COP3	15°30'10.4"	73°49'52.9"	2	Silty clay
M1	15°30' 9.84"	73°50' 14.16"	8	Clayey silt
M2	15°30'21.66"	73°51'21.6"	4	Sandy
M3	15°30' 13.02"	73°52' 28.5"	3	Silty sand
M4	15°30'11.3"	73°53'25.2"	2.5	Sandy
M5	15°30'22.7"	73°54'28.8"	5.5	Sandy
M6	15°31'05.1"	73°55'16.9"	3.5	Sandy
M7	15°31'56.1"	73°55'52.9"	8.5	Silty sand
M8	15°32'37.0"	73°56'22.9"	10	Rocky
M9	15°32'46.6"	73°57'24.5"	5.5	Sandy
M10	15°31'51.8"	73°58'04.3"	9.5	Sandy
M11	15°31'26.6"	73°58'53.0"	5	Sandy+gravel
M12	15°30' 34.9"	73°59' 50.4"	6	No data
M13	15°29' 56.28"	74°0' 34.14"	10	Silty sand
M14	15°29'17.94"	73°01'19.92"	2.5	No data
M15	15°28' 38.22"	74°1' 52.08"	8.5	Sandy gravel
M16	15°27'51.3"	74°02'5.52"	7.5	No data
M17	15°26'54.12"	74°02'37.56"	5	Pebbles
M18	15° 45'3.3"	74°05'17.7"	4	Clayey silt
M19	15°27'39.9"	74°3' 32.82"	8.5	Pebbles and sand
M20	15°28'15.3"	73°04'0.72"	7	Sandy
M21	15°28'4.98"	73°05'10.8"	1.5	Pebbles



Plate 2.1: Study area– the Mandovi Estuary

2.2 Water sample collection and processing

Mandovi Estuary was sampled (at eqi-distant locations from mouth to upstream) during November 2020 with the objective to understand the hydrography and productivity pattern on a spatial scale based on biological parameters such as chlorophyll *a* concentration and analyses of phytoplankton and zooplankton composition (see below). The phytoplankton and zooplankton form the bases of the aquatic food web. Since phytoplankton production depends on the availability of nutrients, nutrients such as nitrate, phosphate, and silicate acid were also simultaneously measured.

Sample collection, preservation, and processing were done following the standard protocol mentioned in the project proposal. The samples were collected from 21 stations (surface and near the bottom) starting from near mouth to upstream (M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13, M14, M15, M16, M17, M18, M19, M20, and M21; Table 2.1, Plate 2.1).

2.3.1 Sediment Sample Collection:

The sediments from the margins of the estuary were manually collected from 1 m deep waters, by scrapping the top 2 cm of the sediments with a spatula. The surface sediments from the middle of the estuary were collected by using a grab sampler. The top 2cm of the grab sediment was scrapped with a sterile spatula and transferred to zip-lock bags. A part of the sediment was transferred to plastic containers and immediately stained with ethanol Rose-Bengal solution (2g Rose-Bengal in 1L of 70% ethanol) to identify the living benthic foraminifera. The samples were stored in cool-dry storage boxes. The surface water samples were collected in clean sterile plastic containers for the total suspended matter measurements.

2.3.2 Sediment Sample Processing:

For grain-size analysis, sediments were freeze-dried, weighed and washed by using 63 µm sieve. The material retained on the sieve (sand, coarse fraction) was dried and stored in plastic vials. The water passing through the sieve containing the clay and silt fraction was collected. The fine fraction solution volume was made to 1000 ml in a glass measuring cylinder, stirred vigorously and left undisturbed for a pre-determined duration, as per the ambient

temperature. After the passage of pre-determined time, 25 ml of the solution was siphoned and transferred to pre-weighed glass beakers and dried. The beaker with dried clay was weighed again to get the clay weight. The silt weight was estimated by subtracting the weight of the sand plus clay from the weight of the dry sediment. A part of the freeze-dried sediment was powdered and used for total carbon, nitrogen and inorganic carbon analysis. The total carbon and nitrogen were analysed by using a CN analyser and the inorganic carbon was measured by coulometer. The organic carbon was estimated by subtracting the inorganic carbon from the total carbon.

The stained sediments were stored for a couple of weeks for proper staining. The sediments were then directly washed by using a 63 µm sieve. The material retained on the sieve was stored in plastic vials.

2.3 Meiofauna methodology

The sediment samples were collected from 72 stations across the Mandovi Estuary. Sampling was carried out from a mechanized boat during 4th, 5th and 6th November 2020 using an acrylic core of 4.5 cm in diameter. The sampling stations were represented as MA and MB indicating the peripheral regions of Mandovi estuary upstream of the Mandovi bridge. Similarly, COPA and COPB was used to indicate peripheral stations downstream of the Mandovi bridge. Stations at the center of the estuary were labelled M and COP upstream and downstream of the Mandovi bridge respectively. The sand is mainly extracted from the center of the estuary while the peripheral regions generally contain sensitive areas like mangroves and embankments. The samples were collected in duplicates at the stations. Samples were not collected at stations M21, M20, M18, M17, M16 and M14 due to hard substratum All samples were preserved in 10% buffered formalin mixed with Rose-Bengal solution and stored in polythene bags.

2.3.1 Laboratory analysis

The meiobenthos samples were sieved by using a 0.3 mm mesh to remove larger macrofauna and then through a 0.04 mm sieve for smaller fauna. The fauna retained on the 0.4 mm mesh was considered as meiofaunal which was collected in a 100 ml sample container and preserved in 5% buffered formalin. The fauna was identified and enumerated up to the group

level under the stereo-zoom microscope (Nikon SMZ18 and Nikon Eclipse Ci) using the guide "Introduction to study of meiofaunal" (Robert P. Higgins et al., 1988).

2.4 Macrobenthos methodology

Total 72 stations were sampled for benthic study in the Mandovi Estuary. The stations at the center were represented as M where there is extraction of sand and peripheral area by MA and MB, where there are mangroves and other sensitive areas. Central stations of the estuary showed sandy texture and peripheral stations showed silty clayey texture. Sediment samples could not be retrieved from stations M17, M18, M19, M20 and M21 due to hard/rocky bottom. Sampling was carried out on a mechanised boat in November 2020 using Van veen grab (0.0410 m^2) for the central stations and Metal Quadrat (0.0625 m^2) at the periphery of the estuary. All the sediment samples were washed separately through 300µm nylon mesh in the field and then transferred to polythene bags and preserved in 10% formaldehyde containing Rose-Bengal stain.

2.4.1 Laboratory analysis

In the laboratory, all the sediment samples were again washed on a 300 µm 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 (Nikon SMZ 18) and compound microscope (Nikon Eclipse Ci). Faunal abundance was calculated as number/m^2. Polychaete was identified to the highest taxonomic level using available identification keys (Day, 1967; Fauvel, 1953; Fauchald, 1977). Abundance of other fauna such as Oligochaeta, Crustacea, Bivalvia, Gastropoda, Platyhelminthes, Nemertea, Nematoda, Bryozoans, Chyronomidae larvae, Fish juveniles were recorded group-wise. Station wise biomass (wet weight) was done and expressed as g/m^2.

2.4.2 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 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 $\log_2$ scale at each station (Clarke & Gorley, 2001).

Shannon-Wiener index of diversity:

Shannon-Wiener index of diversity (information index), a measure derived from information theories developed by Shannon & Wiener (1949), 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.

$$D = -\Sigma^{s}{}_{i} p_i \log p_i$$

Where (D) is the number of species within a tropic level or community
(S) is the total number of species in the sample,
(i) Is the total number of individuals in one species,

(P_i) is the number of individuals of one species in relation to the number of individuals in the population.

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.

$$D = 1 - \Sigma p_i^2$$

Where D is the diversity index,
P_i is the proportion of individuals in the ith Species, and $\sum$ is the 'sum of'.

Margalef Species Richness: The Margalef index is a species diversity index divided into two types of species richness (how many types are there) and assessment of species evenness or dominance (how individual species are distributed among the community.

$$D = (S - 1) / \ln N$$

Where S is the number of species,

N is the total number of individuals in the sample

Pielou's Eveness index: Species evenness refers to how close in numbers each species in an environment is. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically.

$$J' = \frac{H'}{H'max}$$

Where H' is the number derived from the shanon diversity index,

H' max is the maximum possible value of H'

$$H'_{max} = -\sum H'_{max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S.$$

J' is constrained between 0 and 1. The less evenness in communities between the species (and the presence of a dominant species), the lower J' is. And vice versa.

2.4.3 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.

2.4.4 AMBI index

The AZTI Marine Biotic Index (AMBI) is software developed by AZTI-Tecnalia for assessing the quality of benthic macro-invertebrate 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.

2.4.5 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).

2.4.6 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 invertebrate's 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).

2.4.7 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 was calculated by 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), 3.3–5.0 (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 2.2).

2.4.8 BENTIX Index

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.

Table 2.2: Threshold limits used for ecological status of AMBI and M-AMBI index

Status	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

2.5 Methodology for physical parameters measurement

This section comprises of the physical measurements carried out at Mandovi Estuary for the validation of numerical model. The deployment locations (Figure 2.1), duration and various instruments used for measuring different parameters, are given in Table 2.3. Current measurements (MC1 and MC2) and water level measurements (ML1) were done in the Mandovi Estuary. During pre and post-monsoon, current measurements were carried out at MC2 while during monsoon, current measurements were carried out at MC1. Current measurements at mid-depth were carried out using self-recording current meters (RCM). Watch-keeping boats were engaged for guarding the same. The current meter was hanged from the watch keeping boat. Water level measurement was carried out at ML1. CEESCOPE portable echosounder was used to measure the water depths along the cross sections of Mandovi estuary during January, 2021. The water depth measurement track is shown below (Figure 2.2).

Table 2.3: Table showing instruments used and deployed locations

Location ID	INSTRUMENT	POSITION (Latitude and longitude)	Measurement Period	Water depth at measuring point (m)
MC1	RCM9	15°29'50.10"N 74° 1'5.43"E	Aug-Sep, 2020	8

MC2	RCM9	15°30’08.7” N 73°50’24.6’’E	Nov-Dec, 2020	6
		15°30'9.00"N 73°50'24.40"E	March-April, 2021	5.8
ML1	SeaGuard	15°30'1.54"N 73°50'15.77"E	Jan-Feb, 2021	3.2



Figure 2.1: Locations of current and water level measurements in the Mandovi Estuary

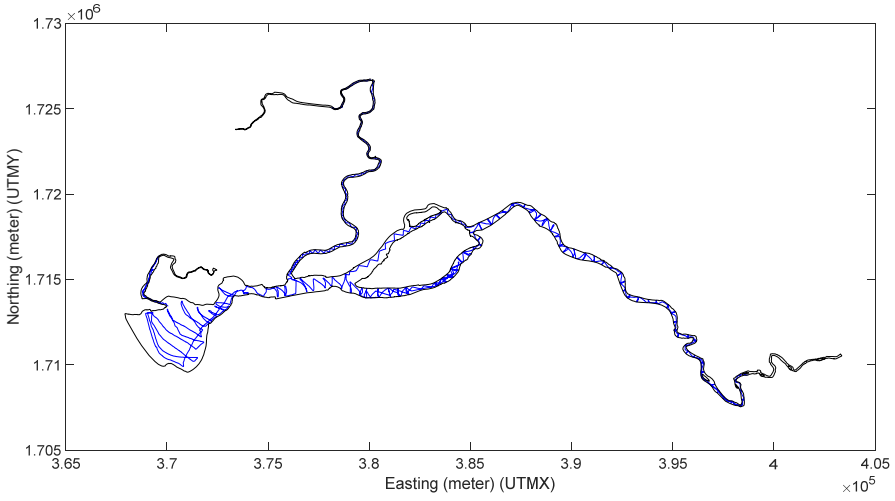


Figure 2.2: Water depth measurement track

2.6. Methodology for Numerical Modelling Studies

The main inputs considered to the numerical model are river topography and water level. The water depth information of Mandovi Estuary was collected during January-February, 2021 using an echosounder. Then the collected water depth information is processed and used for numerical modelling. The base case scenario (Case-1) is with measured water depth information. The second scenario (Case-2) is the modified bathymetry by deepening 3m uniformly at 9 locations (A-I), as in Figure 2.3, of Mandovi Estuary.

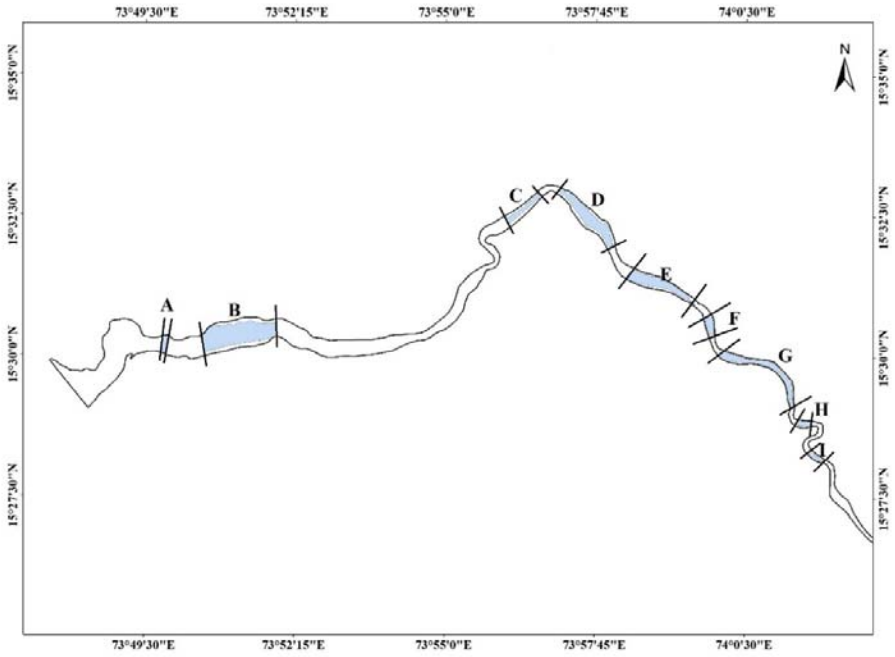


Figure 2.3: Figure showing nine different sections (A-I).

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 Mandovi estuary, is given to the model and the hydrodynamic results are compared.

In this study, the effects of the deepening of the river at A-I 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 both monsoon and non-monsoon period to understand the dynamics of the sediment transport. In this study, after testing the validity of the model, the numerical model is simulated for August-November, 2020 (during monsoon period) and November, 20 - May, 21 (during non-monsoon period) of Mandovi estuary.

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-I, 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.

CHAPTER 3- PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS

3.1 Introduction

Estuaries are specialized ecosystems with contrasting biogeochemical regimes linking two ecosystems, riverine and marine, with distinct biological communities and the structuring processes. It is well known that estuaries receive a substantial contribution of carbon and nitrogen, more so from the terrestrial region that can at times lead to the uncontrolled growth of some organisms, such as harmful algal blooms.

The Mandovi –Zuari, the two primary rivers in the state of Goa described as the lifeline of Goa, are no exception to this. These tropical monsoonal estuaries of India undergo an extreme change in salinity regime seasonally. Owing to its geographical set up the estuarine systems receive enormous precipitation during the wet season and run-off from a large catchment area. In contrast, negligible riverine discharge leads to seawater domination and a prominent salinity gradient formation during the dry season. Thus, the estuarine sediments have a vital role to play in ecosystem functioning/health, such as preventing an estuarine system from being nutrient-limited by giving out nutrients and, on the other side, can avoid being eutrophic by acting act as a nutrient trap. Thus, any disturbance to the benthic ecosystem, including sand mining, is likely to disturb the benthic life and its effect expect to percolate into the food chain bringing imbalance in the whole ecosystem, which is addressed through this project to facilitate appropriate ecosystem management.

3.2 Physico-chemical parameters

3.2.1 Temperature and Salinity

During the sampling period, the Mandovi station depths varied between 1.5 and 10m (avg. 6m), with a deeper zone between station 7 and station 16 (Figure 3.1). As seen in the other estuaries of Goa, the Mandovi Estuary is also being influenced by the tidal currents. Hydrographic variations are thus known to vary accordingly, controlling the temperature and salinity variation.

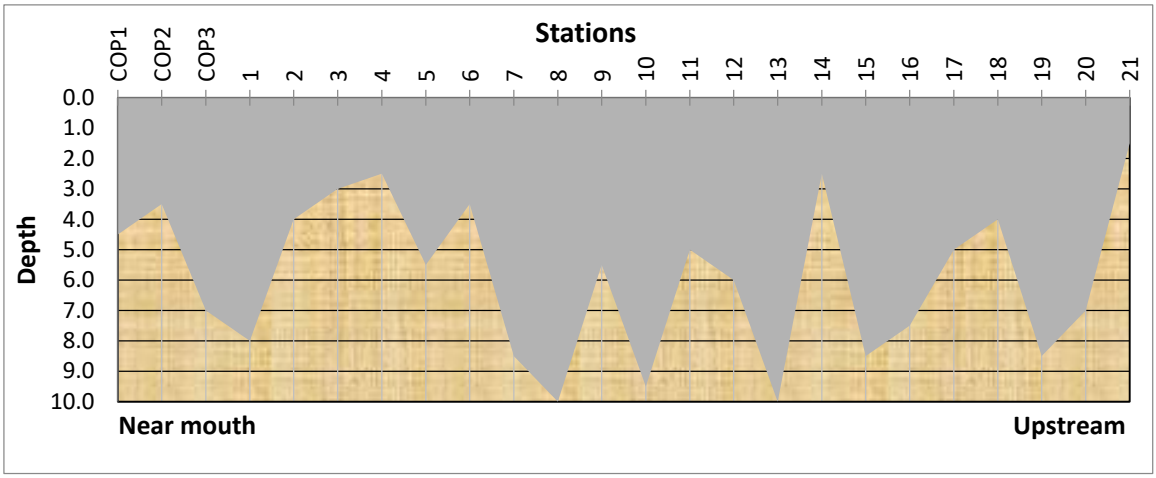
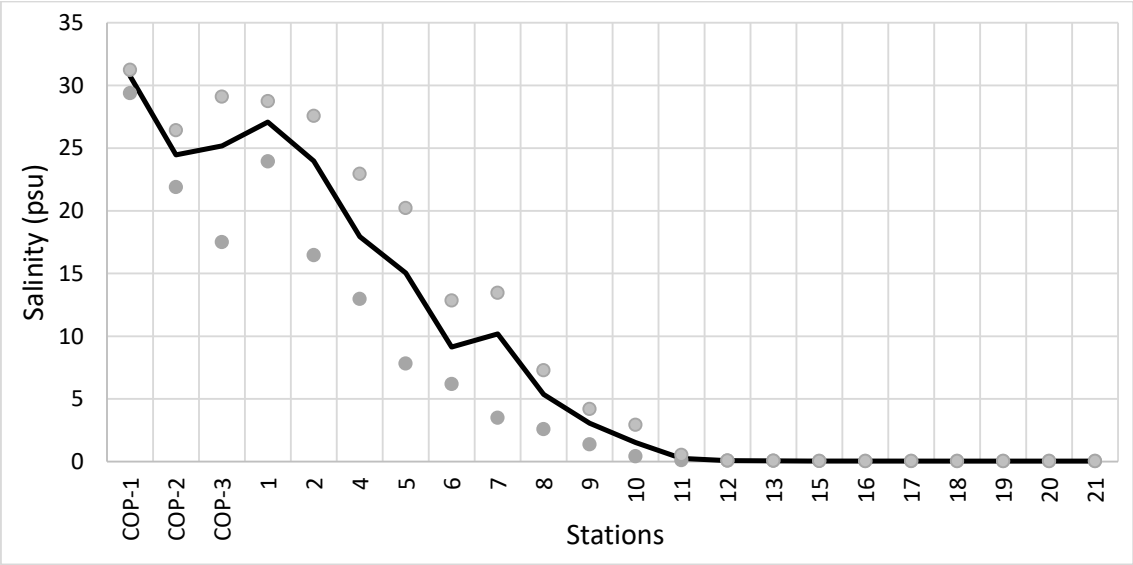


Figure 3.1: Depths of the stations in the Mandovi estuary.

In general, salinity profiles in the water column depicted significant variations (0.0-28.7 PSU) than that of temperature (see below) (27.0° C- 29.5°C) (Figure 3.2a). Freshwater dominated the estuary beyond station 11. Thus, hydrographic features characteristically divided the estuary into two zones; region under the influence of seawater (Zone 1; stn M1-M10) and region influenced by the freshwater (Zone 2; M11-M20) (Figure 3.2a).

On the other hand, the water temperature varied narrowly between 27.9 and 29.9°C (avg. 28.9°C). The relatively higher water temperature (>29°C) was restricted to the middle part of the estuary (Stn 4 and Stn 10) while lower temperature waters (<28.5°C) prevailed in the upstream region (beyond Stn 19; Figure 3.2b). The temperature fluctuation could be a function of time of day during the sampling period.



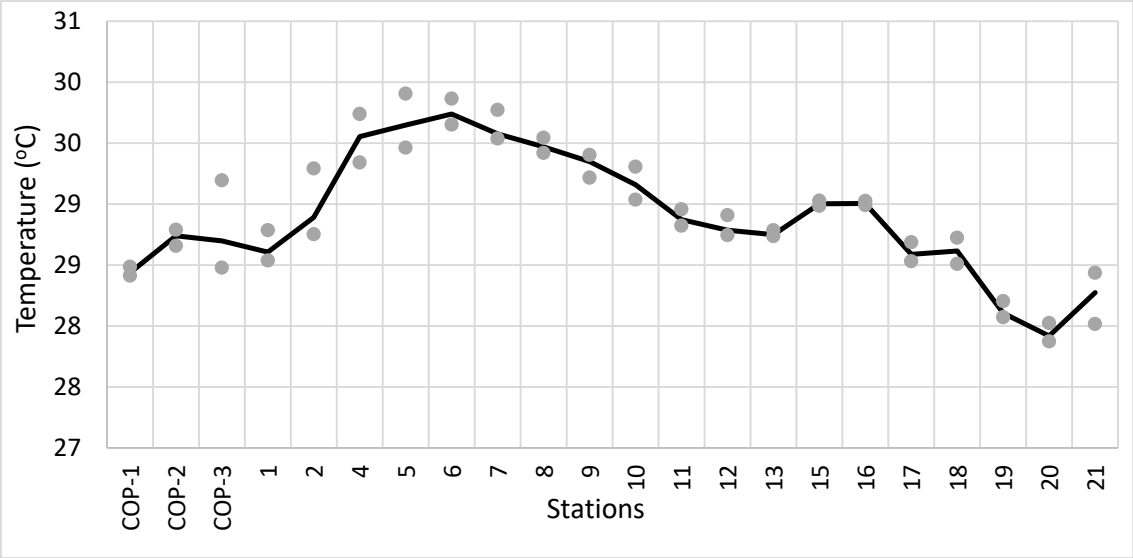


Figure 3.2: Spatial variations in (a) Salinity and Temperature (b) in the Mandovi Estuary. (1-estuary mouth station and 21-upstream station; solid line indicate average values and circles represents low & high values).

3.3.2 Dissolved oxygen and nutrients

Sampling carried out in the Mandovi Estuary starting from downstream region to upstream region found waters to be saturated with oxygen varying from 3.2 to 5.3 ml L^{-1} (avg. 4.2 ml L^{-1}) with an increasing trend from downstream to upstream. Mainly, the bottom water oxygen was found to be above the hypoxic threshold (O2 >1.4 ml L^{-1}), which indicated a healthy environment for aquatic organisms (Figure 3.3).

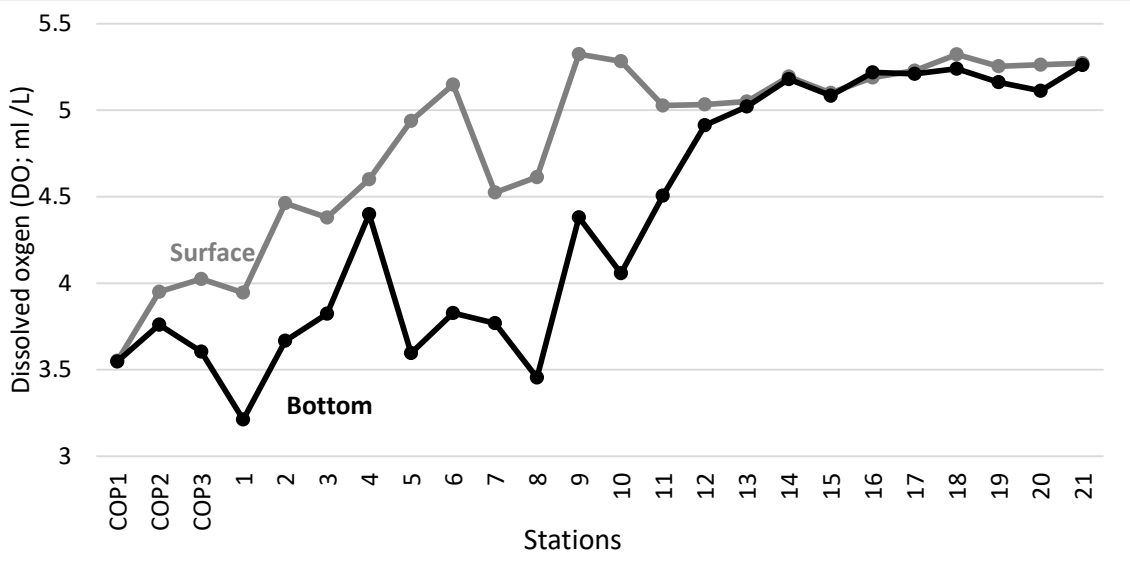
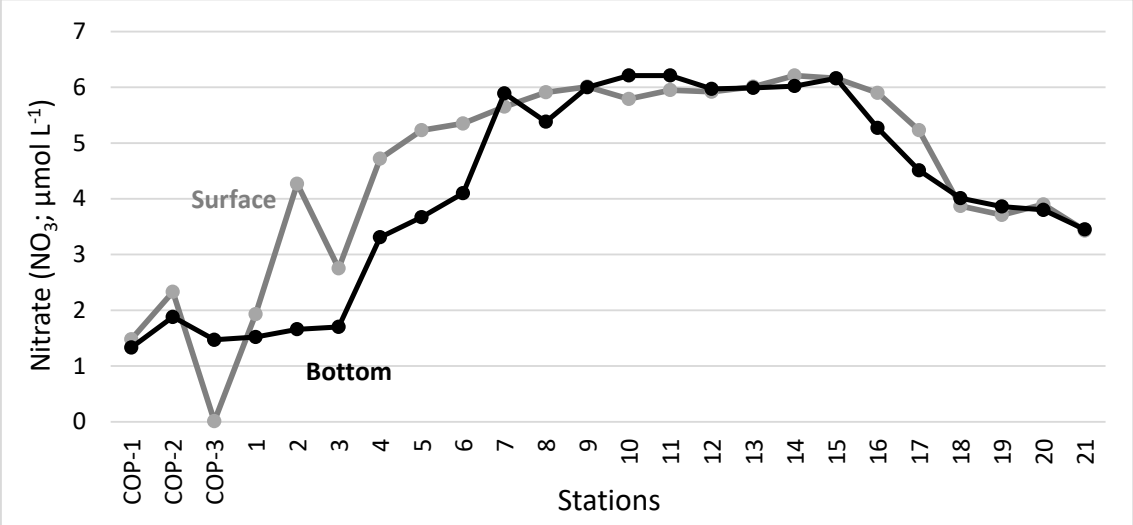
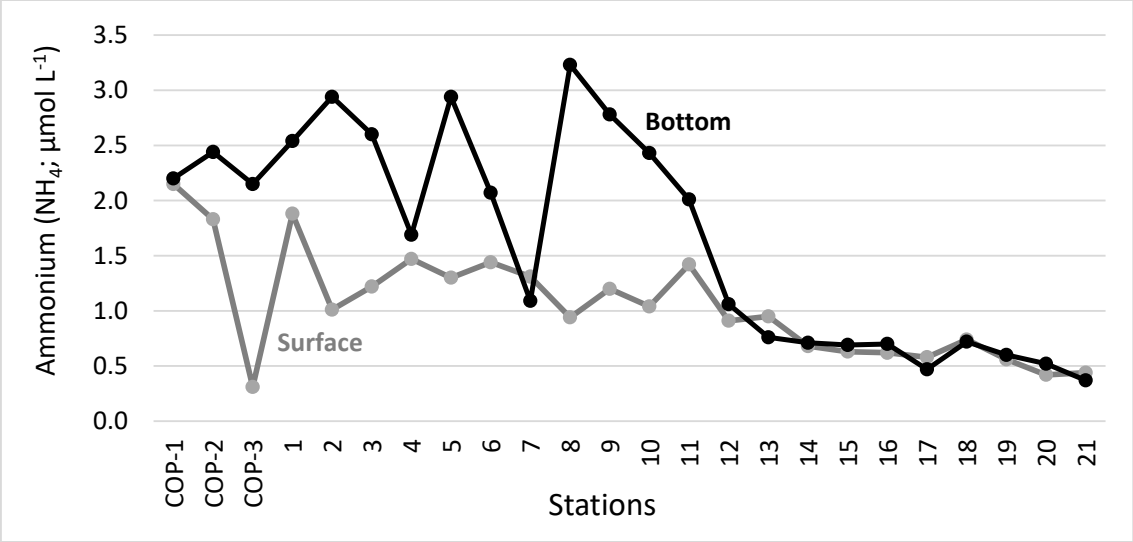


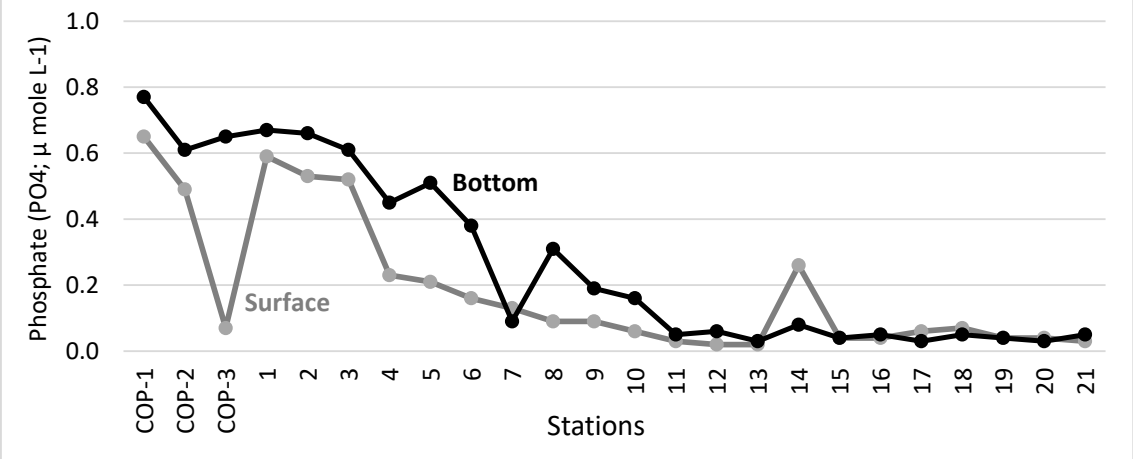
Figure 3.3: Spatial variations (surface and bottom) in dissolved oxygen in the Mandovi Estuary.

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.

The nitrate level varied from 1.5 to 6.2µM with an increasing trend from near mouth to the middle part of the estuary and decreased further upstream to 3.4 µM, showing a mid-estuary maximum (Figure 3.4a). Similar trend was also seen in Ammonium level that varied from 2.9µM (near mouth) to 0.3µM (upstream; Figure 3.4b) and in phosphate concentration; varied from 0.67µM (near mouth) to 0.03µM (upstream; Figure 3.c). On the contrary, silicate levels that varied from 32µM (near the mouth) to 193µM (upstream) showed a clear increasing trend from downstream to upstream (Figure 3.4d). It is remarkable to see the impact of seawater penetration in the bottom water up to Amona as observed from salinity data. This is well reflected in the difference in surface and bottom concentrations of oxygen and nutrients, which gradually decreases from Panjim to Amona and becomes insignificant further upstream. The concentrations of O_2 and nutrients (especially in bottom water) and their trends are typical of the Mandovi Estuary, as expected during the dry season.


Nitrate (NO_3; µmol L^{-1})
Surface
Bottom
Stations
COP-1
COP-2
COP-3


Ammonium (NH_4; µmol L^{-1})
Bottom
Surface
Stations
COP-1
COP-2
COP-3


Phosphate (PO4; µ mole L-1)
Bottom
Surface
Stations
COP-1
COP-2
COP-3

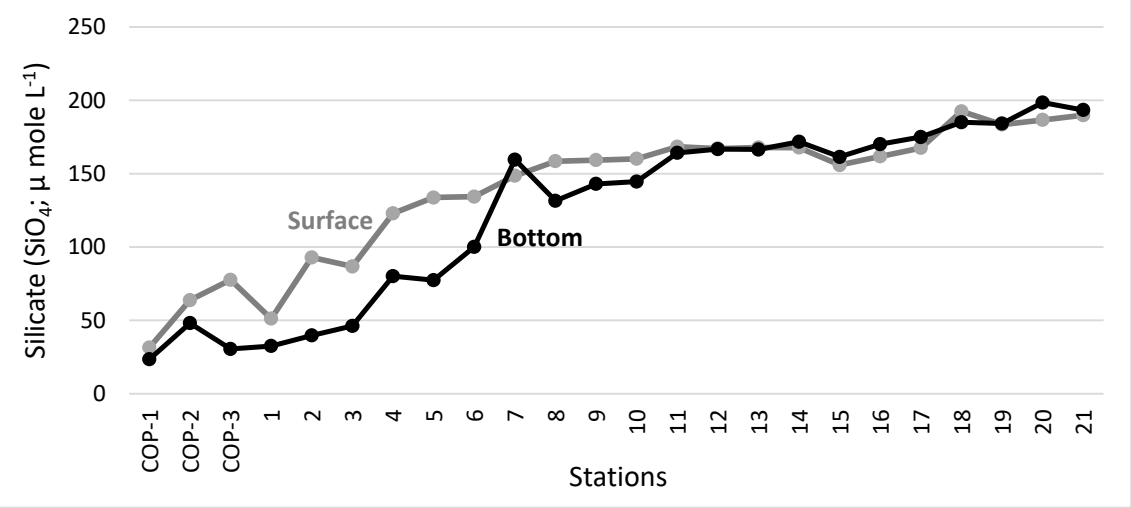


Figure 3.4: Spatial variations in (a) nitrate (NO_3); (b) Ammonium (NH_4,); (c) phosphate (PO_4) and (d) silicate (SiO_4) in the Mandovi Estuary.

3.3.3 pH

The increasing amount of carbon dioxide in the atmosphere alters the Earth's climate and shifts ocean chemistry as carbon dioxide gas can dissolve into the water bodies. This extra carbon dioxide imparts acidity to the liquid represented as pH. The lower the pH value, the higher the acidity, while solutions with high pH are basic (= alkaline). Before the industrial revolution, the average ocean pH was about 8.2.

In the Mandovi Estuary, pH was generally well below 8.0 (avg. 7.38; 6.82-8.39) except at central part estuarine stations (stn M11-M14). Vertically in the water column, higher values were recorded in the near-surface compared to the near-bottom measurements. Spatially, less alkaline condition (<7.5) prevailed in the freshwater-influenced region (Figure 3.5).

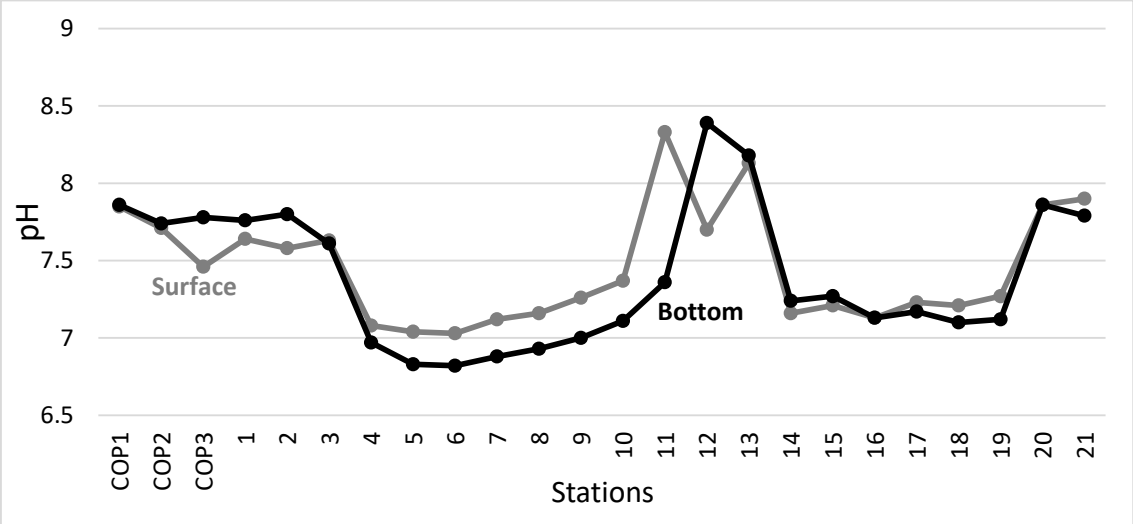


Figure 3.5: Spatial variations (surface and bottom) in pH in the Mandovi Estuary. (1-estuary mouth station and 21-upstream station)

3.3.4 Turbidity layer

This layer in the water column contains significant amounts of suspended sediment (called turbidity/napheloid layer), which generally forms due to resuspension of bottom sediments caused by tidal currents/ anthropogenic activities, including mining. The turbidity layer can scavenge organic particles from the water column, such as phytoplankton, which act as tracers of productivity.

In the Mandovi estuary, turbidity varied between 4.9 and 95.0 NTU, with higher values at the near bottom (>20NTU) (Figure 3.6). Noted peak values (>50 NTUs) at stations M5, M10, M11, M15, and M19 indicate sites of anthropogenic disturbance.

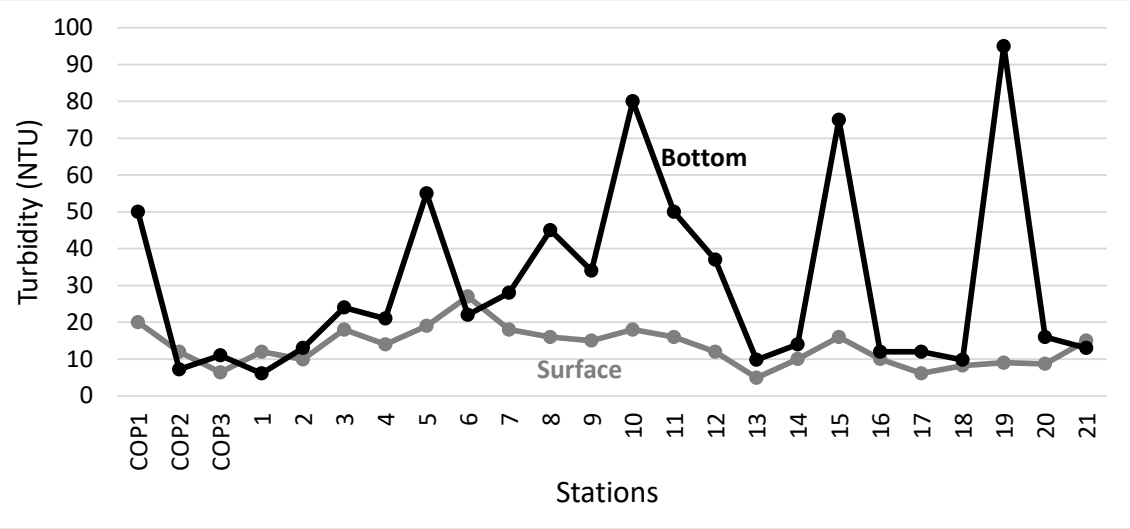


Figure 3.6: Spatial variations (surface and bottom) in turbidity (NTU) in the Mandovi Estuary.

3.3 Phytoplankton biomass

3.3.1 Chlorophyll a (Chl a)

One of the most widely used proxies of phytoplankton biomass is the total chlorophyll-a concentration measured fluorometrically. Chl *a* (µg/L) showed spatial variation generally decreasing trend towards the upstream region. Biomass that varied between 0.1 and 5.3 (avg. 0.87) with the highest concentration in the mid-stream region, particularly at stn M10, also showed variations in the water column vertically. The near-surface waters were found to be more productive, especially near the mouth region (stns: M1-M12), while the upstream (Stns: M13-M21) area remained well mixed (Figure 3.7).

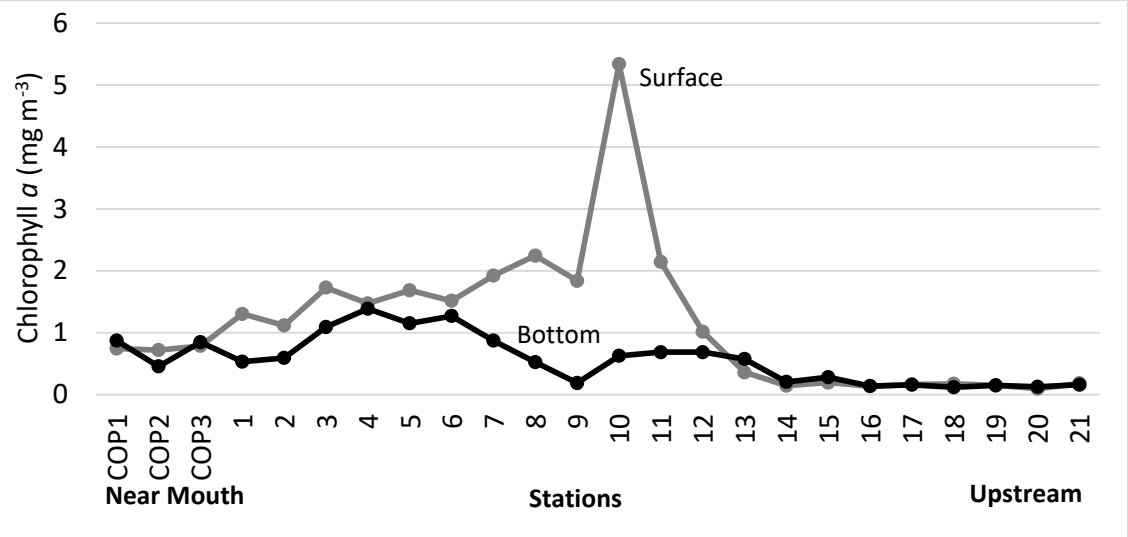


Figure 3.7: Spatial variations (surface and bottom) in Chlorophyll *a* (mg m^{-3}) in the Mandovi Estuary. (1-estuary mouth station and 21-upstream stations)

Likewise, sedimentary chlorophyll *a* biomass also showed a variability (0.01 and 0.6 mg Chl a g^{-1}; avg 0.14) with higher concentration, particularly in the midstream region consistently lower values ($\leq$ 0.06 mg g^{-1}) were recorded in the upstream region (beyond stn M10; Figure 3.8).

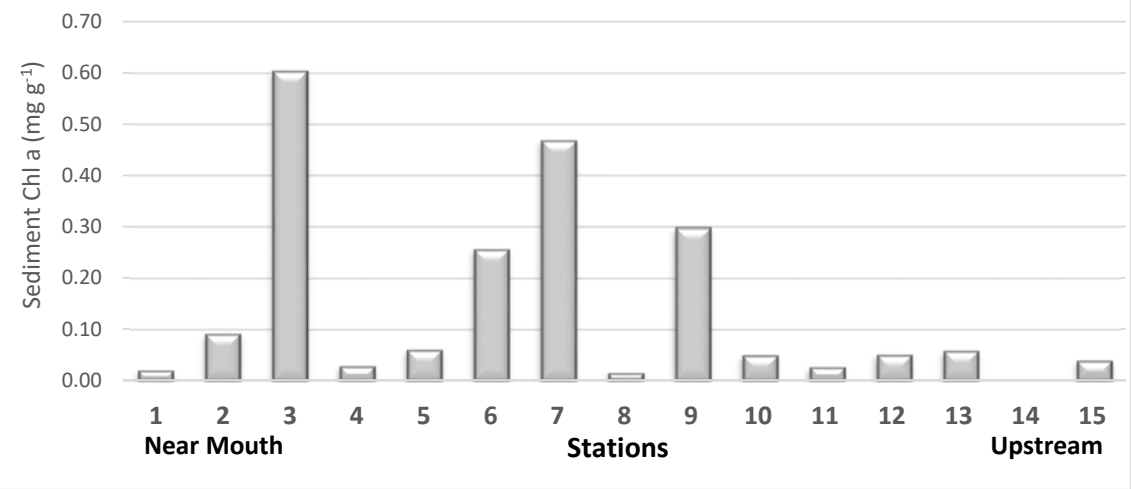


Figure 3.8: Spatial variations in sedimentary Chlorophyll *a* (mg g^{-1}) in the Mandovi Estuary.

3.4 Phytoplankton

3.4.1 Species composition and abundance of phytoplankton

Phytoplankton composition and its numerical abundance studied from the Mandovi estuary following microscopic technique (>10µm in size) showed diverse forms (Genera: 104; Table 3.1). These forms representing the phytoplankton community are grouped broadly into five Phyllum: (i) Bacillariophyta (ii) Dinoflagellata (iii) Cyanobacteria (iv) Charophyta, and (v) Chlorophyta. The Bacillariophyta comprising diatoms were predominantly pennate forms (centric: 20 genera and pennate: 30 genera). While Dinoflagellata, the second-most diverse form, was comprised of 23 genera. The forms belonging to other phylum were less diverse: Charophyta represented by 17 Genera, Cyanobacteria (by 6 genera), and Chlorophyta (5 genera).

Amongst species belong to Genera *Surirella, Cyclotella, Dictyosphaerium, Stephanodiscus, Aulacoseira, Coscinodiscus, Melosera, Thalassiosira*, and *Chaetoceros* (of centric diatoms); *Navicula, Synedra, Nitzschia, Pinnularia, Pleurosigma, Gomphonema, Cymbella, Gyrosigma, Thalassionema, Amphora, Cocconeis, Diatoma, Diploneis, Pseudo-nitzschia* (of pennate diatoms); *Gymnodinium, Peredinium, Cryptomonas, Euglena, Gonyaulax, Oxytoxum, Chlamydomonas, Prorocentrum, Protoperidinium, Rhodomonas, Scrippsiella, Alexandrium* (of dinoflagellates); *Oscillatoria, Anabaena* (of cyanobacteria); *Staurastrum, Scenedesmus, Coelastrum, Micrasterias, Chlorella, Elakatothrix* (of Charophyta) and *Monoraphidium, Ankistrodesmus* (of Chlorophyta) dominated the community.

Table 3.1: Station wise and spatial variation of phytoplankton composition and abundance in the Mandovi estuary.

	Stations																			
	<-- Near mouth													--> Upstream						
Phytoplanton compostion & abundance(average abundances of surface and near bottom samples)	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**
Phyllum: Bacillariophyta																					
DIATOM (Centric)																					
Actinoptychus spp.					190																
Amphanizomenon spp.										553											
Aulacoseira spp.							640	373		211	195		300						273	68	
Aulacodiscus spp.						147		50													
Bacteriastrum spp.	28				71			25													
Chaetoceros spp.	254	1098	400	43																	
Coscinodiscus spp.	84			29				132	27	109			22		33						
Cosmerium spp.																					309
Cyclotella spp.	997	364		270	626	1101	318		82				97								
Dictyosphaerium spp.		207				132					142	75	99	624	214	51					
Guinardia spp.		414																			
Leptocylindrus spp.		10278	3400		3141																
Melosera spp.	38				728	1896	674	1159		448											
Rhizosolania spp.	113																				
Skeletonema spp.	1408			3354																	
Stephanodiscus spp.							900	1182	1708	4581	1161	132			164					102	
Surirella spp.	38						64	44	82	237	73	38	172		33	94	32		109	136	69
Telmemorus spp										316	2911								328		
Thalassiosira spp.	898	2352	2600	279	190																
DIATOM (Pennate)																					
Actinastrum spp.								2038	546				264								
Actinotaenium spp.										158											
Amphiprora spp.										1610	799										
Amphora spp.	336			93		196	96						375								
Asterionella spp.				93					164												
Asterionellapsess spp.	226			172																	
Bacillaria spp.													450								
Cocconeis spp.	42									79	73	36					139				
Cymatopleura spp.							90														
Cymbella spp.			200		95		372	131	94	346			357		436		291		82	204	
Cylindrotheca spp.			400																		
Diatoma spp.	28					98				53			19					64			
Diploneis spp.				179	190					158	142							166			
Fragillaria spp.	339		800															261			
Gloeotrichi spp.					252																
Gomphonema Spp.							96		176	1047	361	144	1848		2707	450	1851		8585	9273	17450
Gyrosigma spp.			200					66		277			38		164	45			123		51
Licmophora spp.	113																				
Meridion spp.																		249			
Navicula spp.	126	137		571	22		91	74	116	556	146	61	517	246	333	303	329	53	831	1225	205
Neidium sp.										158			75								204
Nitzschia spp.	327	600		1080	365	775	1074	151	321	927	146		173	134	87			84	115	664	411
Peronia spp.				93				1054													
pinnularia spp.				47			96	50	211	608	321	18	563	651	255	45	354		854	1061	1489
Pleurosigma spp.	38			29			96	186	348	1113	266	48	344		327	157	67		476	268	34
Pseudo-nitzschia spp.	197	1734	400		84																
Rhoicosphenia spp.						196															
Synedra spp.	75	108		153	95	33	534		86	184	242	60	1213	224	1544	67	561	343	2057	1234	1639
Tabellaria spp.														236				513			
Thalassionema spp.	3549	7674	4000	1523	3528	3893												87			
Ulothrix spp.																101					
Phyllum:Dinoflagellata																					
Alexandrium spp.	281		400	258	95																
Amphidinium spp.		138			190																
Carteria spp.				186				262	94			36									
Ceratium spp.	168																				
Chlamydomonas spp.				516					2632					288	109			261			
Chromulina spp.												156		96							
Cryptomonas spp.				233			672	131	22372	127270	12461							216		408	
Dinophysis spp.	113	108	400																		
Dissodinium spp.					285																
Euglena spp.							90	99	182					201			52		58	153	257
Gonyaulax spp.	57	3485		22	42	74	360	99											29		
Gymnodinium spp.	875	138	200	1032	1392	3967	750	297	2632	8455	1994	1188	225	192	1063	595	603		115	507	103
Heterocapsa spp.		414																			
Oxytoxum spp.	23	138		854	1430	1600	4862	4012	188												
Phacus spp.				358	285	490								192							
Prorocentrum spp.	141	35		22	24	49															
Protoperidinium spp.	478	1308	200		274								264								
Peredinium spp.	140			124	32	807	224	406	376	59	24	12				30	32				
Pyramimonas spp.											73										
Pyrophacus spp.				93																	
Rhodomonas spp.				558			288		1880			36	792								
Rhoicosphenia spp.							90	131						588							
Scrippsiella spp.	1056	2604		172	221															153	
Trachelomonas spp.				279			864											166		408	
Phylum- Cyanobacteria																					
Chroococcus spp.											730			96							
Anabaena spp.				93						356					327		388				
Arthrospira spp.							90		82												
Gloeocapsa spp											142										
Homoeothrix spp.																		83			
Oscillatoria spp.	126		1400		258	49		197	205	79	110					101	208			99	257
Rivularia spp.																	388				
Phylum: Charophyta																					
Arthrodesmus spp.								198						384							
Closterium spp								131												300	103
Chlorella spp.				387	238		192											208			
Coelastrum spp.							2115	2228	705	1516	36						65		633		
Cosmarium spp.							180													297	719
Crucigonia spp.							630		376											495	
Closterium spp.																90					
Elakatothrix spp.						1078	810	393		79											
Euastrum spp.													66				97				
Micrasterias spp.												4938	2115	3276	4470	909	873				
Oedogonium spp.						98						72									
Spondylosium spp.																		688			
Staurastrum spp.								156	323	33	80	38	17	26	258	121	54	96	49	87	38
Scenedesmus spp.				22	155			322	352	287		36	33		55	101	119		115		
Xanthidium spp.																270					
Spirogyra spp.																			312		
Sphaerozosma spp										267											
Desmidium spp.											284										
Phylum: Chlorophyta																					
Chladophora spp.																				396	
Ankistrodesmus spp.							6792	3560			1798	624			1100		971				
Monoraphidium spp.				527	1099	2310	480		3722	2072	218	102	47		133	30	340	29	191	170	274
Mougeotia Sp.																			574		
Tribonema spp.												1404			327						
Total phytoplankton Abundance (Cells/L)	**12711**	**33333**	**15000**	**13739**	**15596**	**18988**	**24630**	**19332**	**40082**	**154199**	**24925**	**9254**	**10483**	**7454**	**14138**	**3560**	**7813**	**3566**	**15907**	**17707**	**23613**

Numerically, phytoplankton abundance (x 10^3/L) that varied within the water column (3.56-154.19; avg. 23.14+ 31.37) showed spatial variation along the estuary length (Figure 3.9). The higher population, chiefly at the near mouth region (station M1-M6 and at stations. M9 & M10), was primarily due to the contribution of diatoms and dinoflagellates (Figure 3.10a). A sudden spike in the abudance was noted at M11 which also coincided with high chl-a conc. probably due to high nutrients. While a few upstream locations (stns: M19-M21) showed an increasing trend of numerical abundance due to the presence of freshwater species of phytoplankton belonging to Phylum Cyanobacteria and Charophyta (Figure 3.10b). Interestingly, Chlorophyta was found to proliferating in the middle part of the estuary (Stns M5- M12; Figure 3.10b).

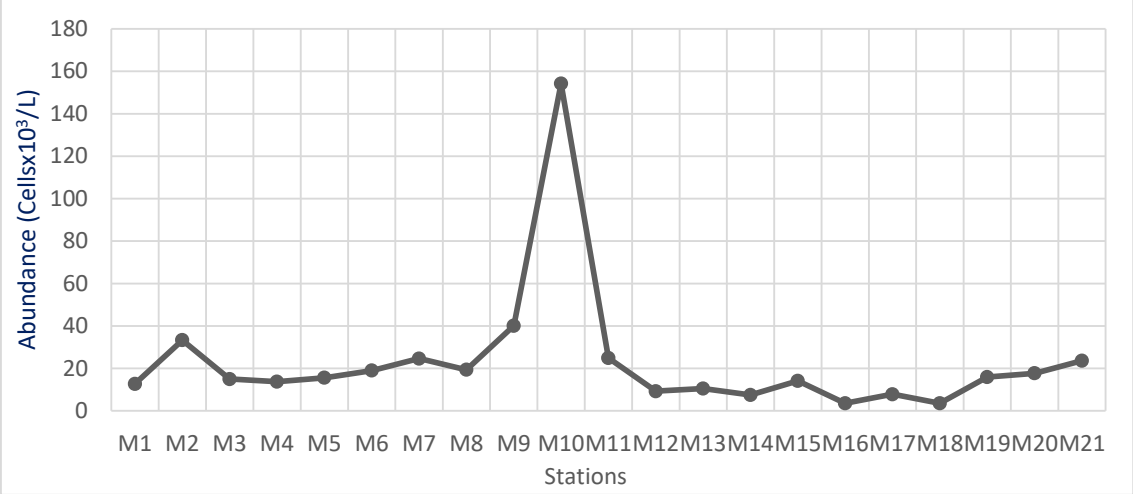
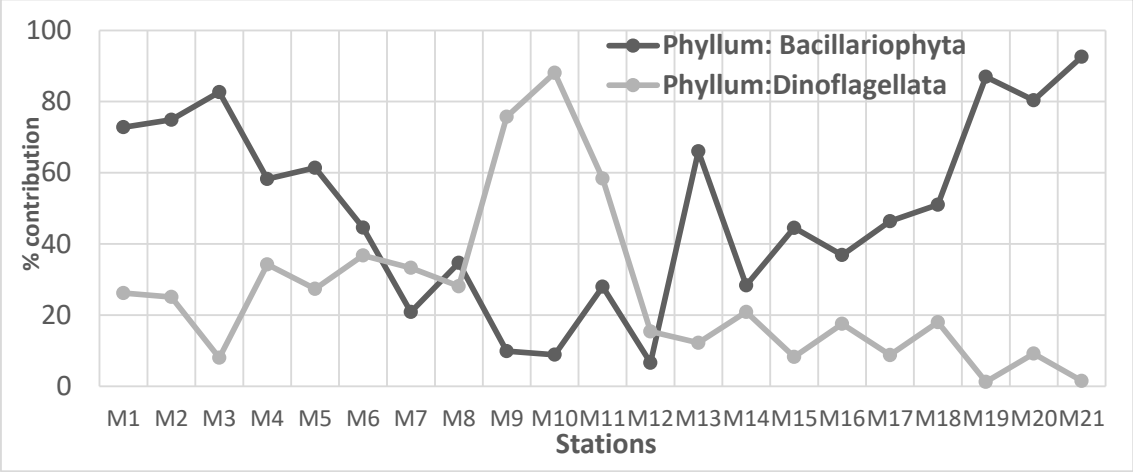


Figure 3.9: Spatial variations in phytoplankton abundance (average) in the Mandovi Estuary.



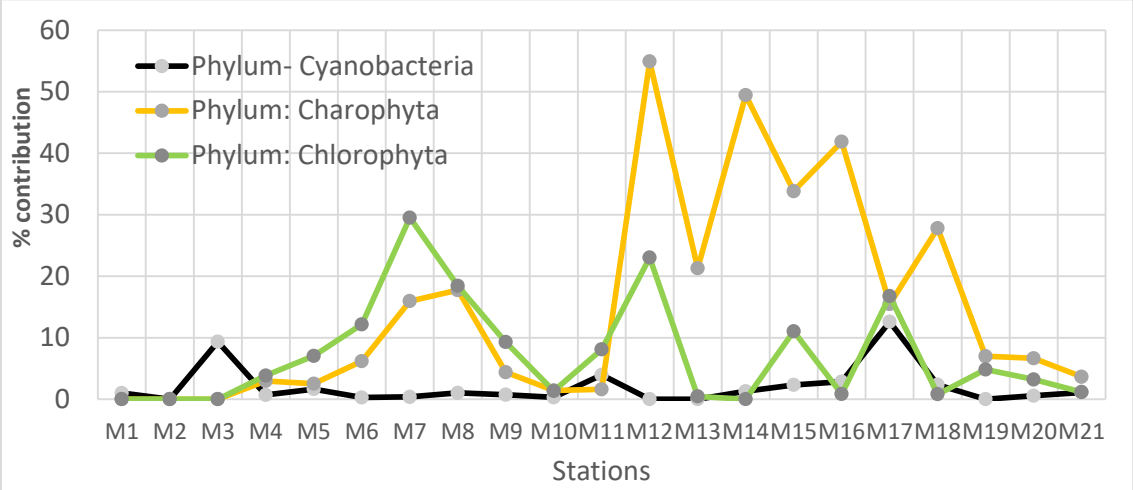


Figure 3.10: Percent contribution of (a) Bacillariophyta & Dinoflagellata and (b) Cyanophyta, Charophyta and Chlorophyta to the phytoplankton abundance (average) in the Mandovi Estuary.

3.4.2 Phytoplankton Diversity

Statistical analysis of phytoplankton diversity in the Mandovi Estuary is shown in Table 3.2. Overall, the total number of species (s) decreased towards the upstream region and vertically in the water column; they were higher at the near bottom (data not shown here). Analyses depicted species richness (d) to vary from 1.11-2.53 (avg:1.72 +0.36). Similarly, evenness (J) ranged from 0.48-0.94 (avg. 0.77+0.10), and Diversity index (H) from 1.62-2.63 (avg. 2.21+0.27). The low value of 'd' and J' at stn.M10 was due to the dominance of dinoflagellate Cryptomonas spp. that accounted ca. 82% numerical abundance of phytoplankton.

Table 3.2: Distribution of number of species (S), total abundance (N), species richness (d), evenness (J') and diversity (H') of phytoplankton in Mandovi Estuary.

Stations	S	N	*d*	*J'*	*H'(loge)*
M1	27	24504	2.53	0.80	2.63
M2	19	61062	1.60	0.74	2.12
M3	22	18800	2.13	0.82	2.53
M4	25	30679	2.34	0.80	2.57
M5	23	33558	2.11	0.73	2.27
M6	16	45568	1.35	0.84	2.19
M7	21	67008	1.78	0.71	2.12
M8	23	53125	2.05	0.73	2.28
M9	21	81784	1.83	0.67	2.01
M10	25	306266	2.01	0.48	1.62
M11	19	45223	1.71	0.65	1.91
M12	15	11460	1.53	0.72	1.92
M13	19	20415	1.83	0.82	2.41
M14	12	12288	1.11	0.87	2.04
M15	17	24822	1.58	0.85	2.40
M16	13	8099	1.34	0.87	2.24
M17	17	13835	1.63	0.90	2.51
M18	15	7417	1.52	0.94	2.52
M19	15	30837	1.36	0.78	2.10
M20	17	35271	1.48	0.80	2.22
M21	15	33048	1.35	0.64	1.73

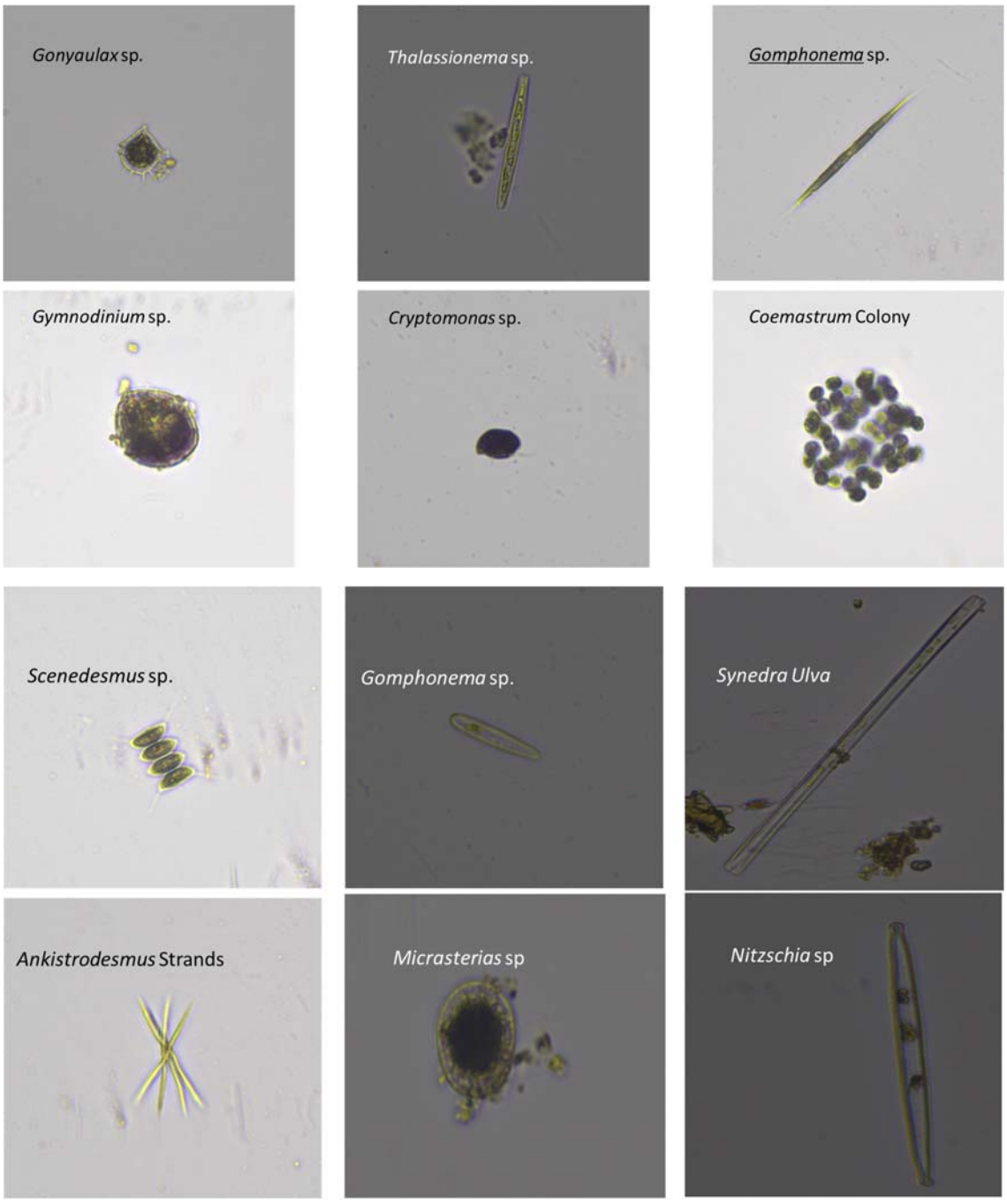


Plate 3.1: Represantative species of Phytoplankton

3.5 Zooplankton

Mesozooplankton are the key link between phytoplankton (primary producers) and fishes (secondary or tertiary consumers) in marine, estuarine and freshwater systems. These organisms play a significant role in regulating algal and microbial productivity through grazing. Hence, they are critical intermediaries in the flow of both energy and matter in the aquatic food web. Also, they are essential contributors and modifiers of the biogeochemical cycles.

Prominent zooplankton includes radiolarians, foraminiferans, cnidarians, crustaceans, mollusks, and chordates. The conspicuous members of the tropical plankton are the crustaceans, dominated by copepods. Others ecologically important zooplankton include crustaceans (such as ostracods, cladocerans, isopods, amphipods, mysids, and krill); chaetognaths, mollusks (bivalves, gastropods, pteropods), and chordates (salps and fish larvae, fish egg).

Different species have different tolerance/adaptive levels to environmental variables, hydrographical conditions (pollutants), and responses to changes in their diversity and abundance. Hence, they act as indicators to monitor aquatic ecosystems. Hence for understanding the ecology of any water body, study on zooplankton communities is essential.

3.5.1 Samples analysed

A total of 24 stations were selected from estuary mouth to upstream region. The zooplankton samples were collected using Heron Trancter net (200um mesh size; horizontal tow). Samples from stations COP1, COP3, M2, M4, M6, M8, M10, M11, M12, M13, M14, M15, M16, M18, and M20 (from estuary mouth to upstream) are processed for biomass estimation, taxonomic identification, and enumeration of mesozooplankton. Stations labeled as 'COP' are additional sampling sites at the near mouth region of the estuary close to station 1.

3.5.2 Biomass of Mesozooplankton

The current study results reveal the spatial variation of mesozooplankton along the Mandovi Estuary. Measured biomass was highest at the mouth region (COP1 with 70.65ml/100m^3) and observed a decreasing trend towards midstream, further decreasing towards the upstream regions to an undetectable level (UDL) (Table 3.3).

Table 3.3: The spatial variation of mesozooplankton biomass in the Mandovi estuary. For the stations M8-20, the displacement volume-based biomass is negligible; hence their biomass is marked as UDL; COP –near mouth and M20 - upstream).

Station	Lat N	Long E	Biomass (ml/100m³)
COP1	15° 29.339'	73° 48.388'	70.65
COP3	15° 30.219'	73° 49.792'	14.75
M2	15° 30.361'	73° 51.360'	10.57
M4	15° 30.180'	73° 53.505'	14.88
M6	15° 31.093'	73° 55.251'	4.27
M7	15° 31.965'	73° 55.762'	0.36
M8	15° 32.653'	73° 56.436'	0
M10	15° 31.918'	73° 58.076'	0
M12	15° 30.607'	73° 59.844'	0
M14	15° 29.299'	74° 1.332'	0
M16	15° 27.855'	74° 2.092'	0
M18	15° 45.0550'	74° 05.2959'	0
M20	15° 28.255'	74° 4.012'	0

3.5.3 Total abundance of Mesozooplankton

The abundance of mesozooplankton showed a downtrend from the estuary mouth to upstream. However, this trend was not uniform in the upstream region. This may be due to community shift and dominance of any particular group of organisms (like a higher abundance of decapod larva and mosquito larva in certain upstream regions). Near mouth station COP1 observed the highest (1875159 ind./100m³) abundance, while the lowest was at M13 (108.49 ind./100m³) (Figure 3.11).

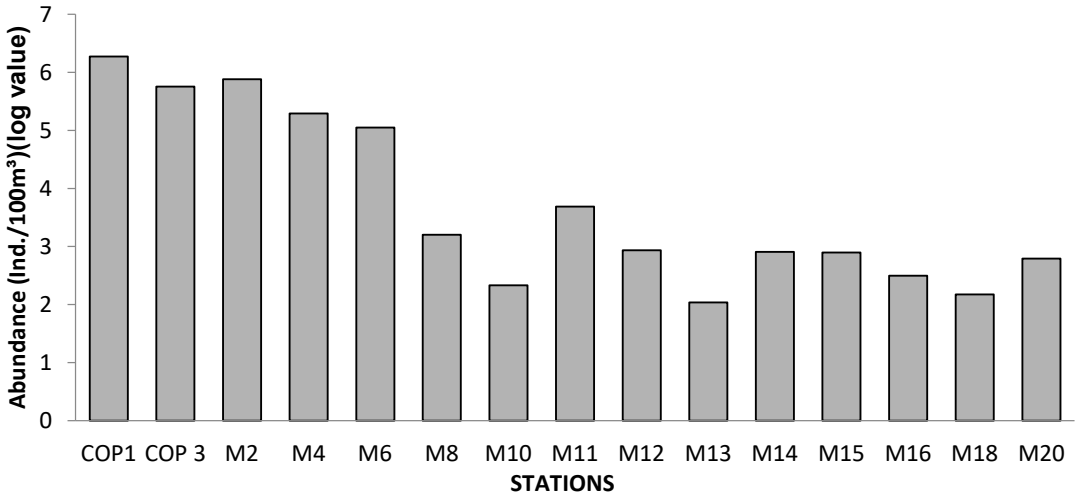


Figure 3.11: Spatial variations in mesozooplankton abundance (Ind./100m3, log values) in the Mandovi Estuary.

3.5.4 Distribution of taxonomic groups of Mesozooplankton

Mesozooplankton community composition was grouped into two major categories such as copepods and non-copepods. The percentage composition of copepod varied from 3.76% (M14) to 92.27% (COP1). In estuary mouth (COP1–COP3), copepod dominated over non-copepod groups. In contrast, non-copepod groups were major contributors (96.27-65%) in midstream and upstream (except stns M8, M10, and M11) (Figure 3.12).

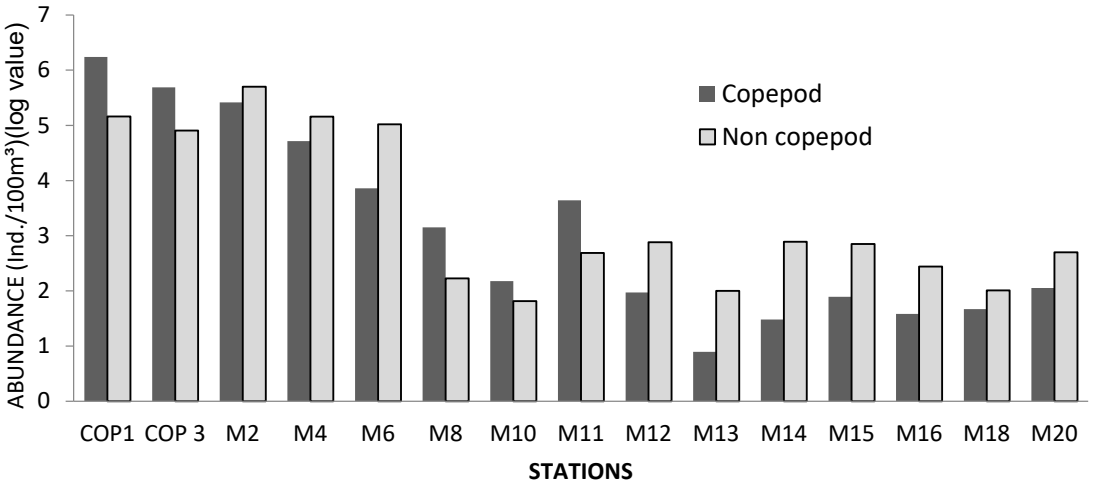


Figure 3.12: Distribution of copepods and non-copepods along the Mandovi estuary.

Among non-copepod groups, cladoceran, decapod larva, fish larva, and gastropods have more or less even distribution throughout the estuary. However, certain groups such as Siphonophora, hydrozoa, polychaete, and bryozoans larva were observed only in the estuary mouth region. Also, barnacle nauplius, bivalve, lucifer, and isopod juvenile were absent in the upstream areas. Whereas, Ostracoda, a sizable number of mosquito larva and other insect larvae were found only in upstream waters.

3.5.5 Distribution of copepods

The taxonomic composition and abundance of copepods varied from the estuary mouth to upstream regions. The copepod in the estuary comprised form belong to orders calanoida, cyclopoida, harpacticoida, poicelostomatoida. However, order calanoid was found to have a more consistent distribution throughout the estuary. Again, calanoids dominated copepods along the estuary, with a few exception upstream stations (stns: M12, M14, M16, M20). The presence of cyclopoid and poecilostomatoid copepods were noted in the estuary mouth, midstream, and upstream regions. In comparison, harpacticoid copepods were rarely present in the upstream areas. Even though copepods were present all along the estuary, species composition was different upstream than midstream and mouth regions (Figure 3.13).

The species such as *centropages furcatus, Temora discaudata, Tortanus* sp., **Subeucalanus** sp., *Nanocalanus minor, Labidocera kroyeri, Labidocera detruncate, Centropages orsinii, Acartia bispinosa,* and *Acartia ambionensis* are mostly confined to estuary mouth region. *Acrocalanus gibber*, *Acrocalanus gracilis*, *Paracalanus* sp., *Acartia* sp., *Oithona* spp, and *Euterpina acutifrons* were present both in the mouth region and midstream. But species like *Oithona plumifera* and *Tortanus* sp. are observed only in midstream stations. Nevertheless, *Sinodiaptomus indicus* and a parasitic copepod, *Ergasilus* sp. were observed in midstream and upstream areas. Also, species belong to *Diacyclops bicuspidatus*, *Megacyclops* and *Acanthocyclops* were confined to upstream regions. Moreover, specific genus like *Pseudodiaptomus*, *Oncea*, and *Corycaeus* were distributed all along the estuary.

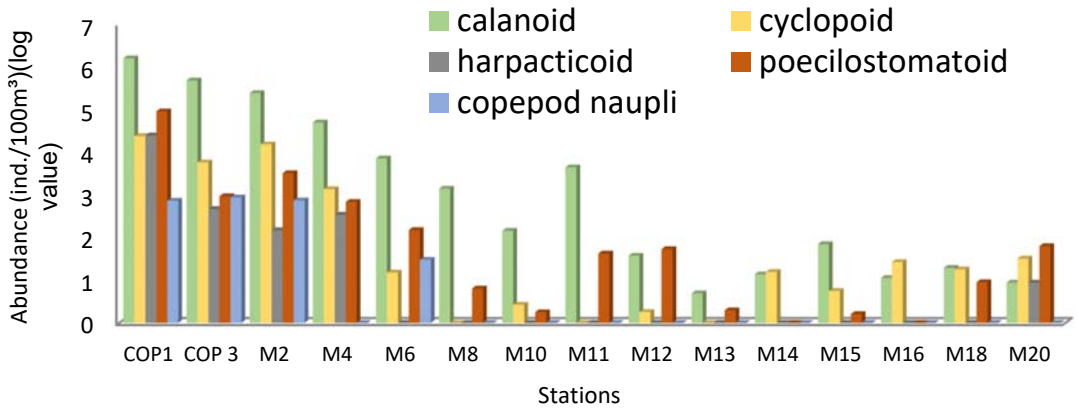


Figure 3.13: The abundance and spatial distribution of copepod orders in the Mandovi Estuary.

3.5.6 Species Diversity

Diversity indices are significant aids to characterize the diversity, richness, and evenness of the species in the community. Shannon diversity indices are commonly used to describe a community. The number of species (S) and the range of diversity indices (based on Shannon index) in the Mandovi estuary is given in Table 3.4 showing the number of species is highest at the estuary mouth, followed by midstream. In comparison, a comparatively a smaller number of species inhabits upstream regions. Diversity index (H') also shows a similar pattern with the highest diversity at the near mouth (stn: COP1; 4.054) and lowest at upstream (stn: M11; 1.98).

Table 3.4: Number of species (S), species richness (d), evenness (J') and species diversity(H') in the Mandovi estuary. COP1 (near mouth) and M14 (Upstream).

STATION	S	*d*	*J'*	*H'*
COP1	26	2.963	0.8625	4.054
COP 3	24	3.049	0.7164	3.285
M2	25	3.093	0.7665	3.56
M4	21	2.833	0.7983	3.506
M6	14	2.028	0.6464	2.461
M8	8	1.626	0.7373	2.212
M10	12	3.035	0.8531	3.058
M11	12	2.333	0.5532	1.983
M12	13	2.846	0.7941	2.938

M13	9	2.661	0.7963	2.524
M14	9	2.075	0.6763	2.144
M15	11	2.564	0.6789	2.349
M16	6	1.44	0.8194	2.118
M18	9	2.368	0.8875	2.813
M20	11	2.516	0.8036	2.78

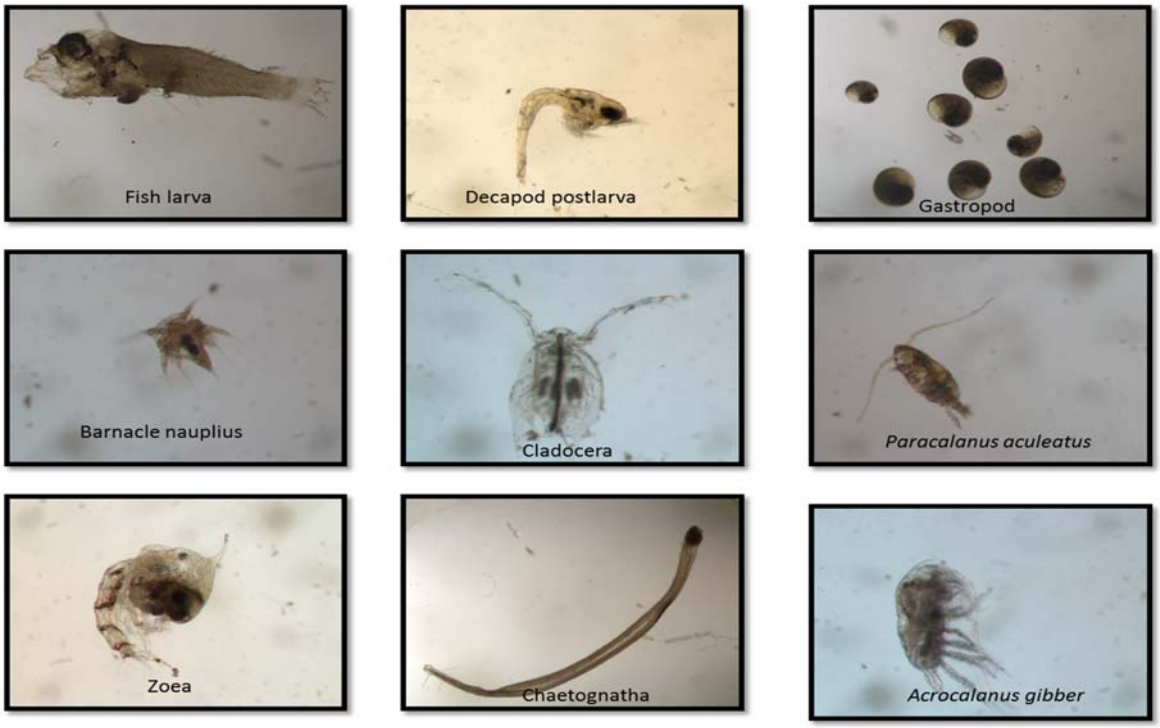




Plate 3.2: Representative species of Zooplankton

3.6 Sediment Characteristics:

The sand fraction increases towards the mouth of Mondovi. Also, at a majority of the stations, the central part of the Mandovi (channel) has a higher percentage of sand compared to either estuary margins (Figure 3.14). The organic carbon was less near the mouth of Mandovi and increased away from the mouth (Figure 3.15). The stations with higher sand fraction had corresponding lesser organic carbon. As the margins has relatively finer sediments, the organic carbon was also higher for the either side of the estuary and comparatively lesser in the central part. The calcium carbonate ($CaCO_3$) was estimated from the inorganic carbon. The stations towards the mouth had higher $CaCO_3$ and it was insignificant (<2%) at a majority of the inner estuarine stations (Figure 3.15). Since it is estuary sample the Nitrogen values were coming in negligible level. C/N ratios didn't show any significant trend.

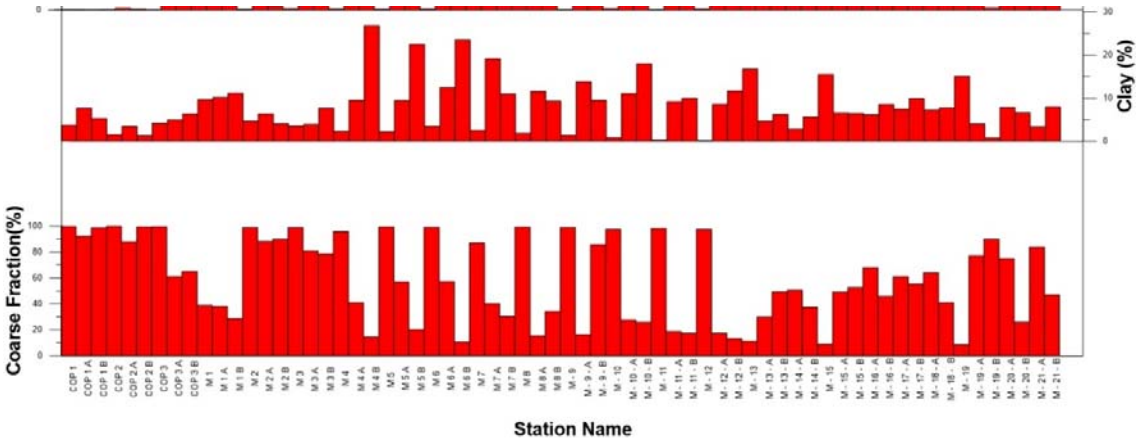


Figure 3.14: The relative abundance of coarse fraction and clay in the surface sediments of the Mandovi.

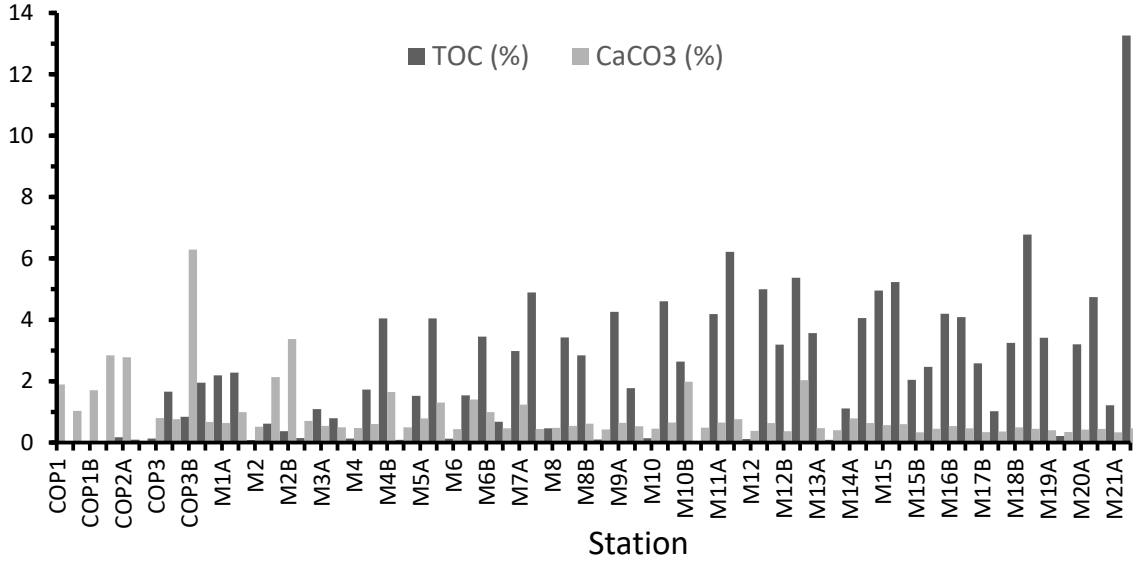


Figure 3.15: The organic carbon and $CaCO_3$ at different stations in the Mandovi.

3.6.1 Total suspended matter (TSM)

The total suspended matter (TSM) is much higher at the estuary mouth, and decreases in the inner estuary (Figure 3.16). TSM varies from as high as 11 mg/l to as low as 1 mg/l. The higher TSM at the mouth is attributed to strong tidal influence leading to re-suspension of the material.

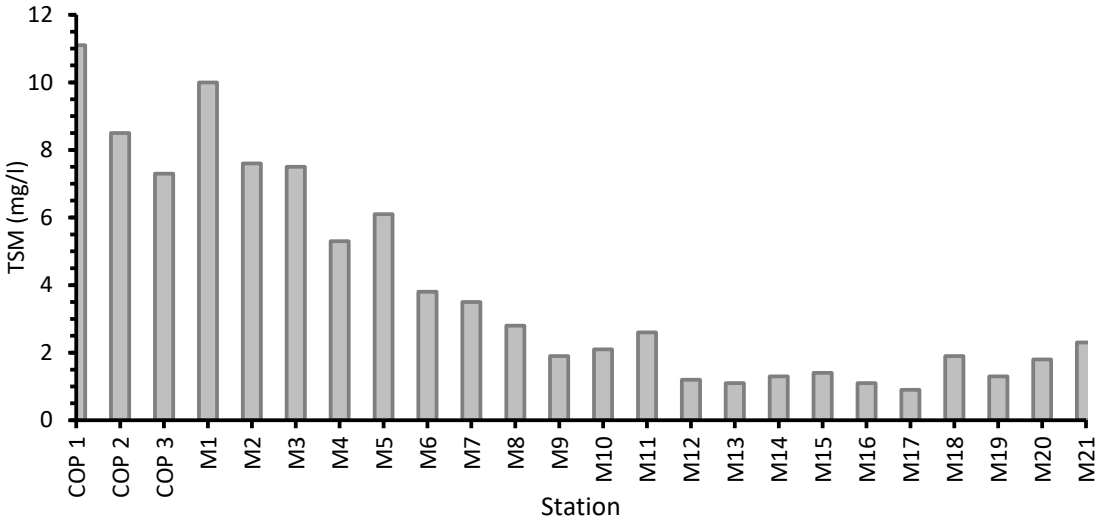


Figure 3.16: Total suspended matter at different stations of the Mandovi.

3.7 Meio-benthos:

Central transect:

The meiofaunal abundance was recorded from 24 stations (Table 3.5). Total 14 meiofaunal taxa were identified in the central region of the estuary (Figure 3.17). Among them, Nematoda was the most abundant group followed by Harpacticoida, Turbellaria, Polychaeta, Naupli larva, Isopoda, Gastropoda larva, Oligochaeta, Nemertea, Bivalvia and Kinorhyncha. (Figure 3.19; Table 3.5). The highest meiofaunal abundance (696 ind/10 cm^2) was recorded at station COP1 and lowest (5 ind/10 cm2) at station M 19 (Table 3.5). The percent composition of meiofaunal community showed that Nematoda (73.1 %) was the most dominant meiofaunal groups followed by Harpacticoida (15.1%), Turbellaria (5.4%), Polychaeta (2.2%), Naupli larva (1.4%), Isopoda (0.5%), Gastropoda larva (0.5%), Oligochaeta (0.5%), Nemertea (0.2%), Bivalvia (0.2%) and Kinorhyncha (0.1%) (Table 3.5, Figure 3.19).

Peripheral transects

In the peripheral region of Mandovi estuary 13 meiofaunal taxa were identified from the 24 sampled stations. The highest meiofaunal abundance (3070 ind/10 cm2) was recorded at station M1A and lowest (0 ind/10 cm2) at station M14A, M14B and M19A (Table 3.6, Figure 3.18). Nematoda was found to be the most abundant group followed by Harpacticoida, Turbellaria, Polychaeta, Naupli larva, Oligochaeta, Gastropoda larva, Isopoda, Nemertea,

Bivalvia and Kinoryncha. The percent composition of meiofaunal community showed that Nematoda (73.1%), Harpacticoida (15.9%), Turbellaria (5.4%), Polychaeta (2.2%), Naupli larva (1.4%), Oligochaeta (0.5%), Gastropoda larva (0.5%), Isopoda (0.5%), Nemertea (0.2%), Bivalvia (0.2%) and Kinoryncha (0.1%) (Figure 3.20)

Nematoda: Copepoda ratio

A ratio of Nematoda: Copepoda <100 indicates degrading quality of water (Raffaelli and Mason, 1981). In the central transect the nematode copepod ratio showed an increasing trend towards the lower part of the Mandovi Estuary with the Nematoda: Copepoda ratio being 96 at station M4 and 175 at station COP1(Table 3.7; Figure 3.21). This indicates polluted water at these stations. In the peripheral transect the Nematoda Copepoda ratio shows a similar increasing trend towards the lower estuary (Table 3.8; Figure 3.22). The Nematoda Copepoda ratio is 137 at station COP1B indicating polluted water quality at this station. The next highest ratio of 52 was observed at station M1B.

Conclusion

The distribution and abundance of meiobenthic community was analysed and revealed variations in the distribution of meiofaunal community. Our observations showed that meiofaunal abundance was found to be increasing towards the periphery in the lower estuary i.e., COP1- M6, increasing towards the centre between M7-M15 with the exception of M12 and again increasing towards periphery in the upper estuary. The Nematoda: Copepoda ratio suggested by Raffaelli and Mason (1981) used to assess water quality where values greater than 100 is used to indicate polluted water quality indicated polluted water at stations COP1 (175), COP1B (137). The value for station M4 was also close to the threshold value at 96.

Table 3.5: Total meiofaunal abundance (ind/10 cm^2) of Mandovi Estuary (Central transect).													
Taxa	**COP1**	**COP2**	**COP3**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**
Nematoda	661	183	128	14	42	59	362	56	7	49	111	145	47
Polychaeta	3	1	5	3	0	5	1	11	0	13	1	1	3
Harpacticoida	4	3	29	6	14	5	4	31	0	3	20	227	67
Naupli Larva	1	0	9	1	5	9	0	3	0	0	0	0	6
Isopoda	0	0	0	0	4	0	0	1	0	1	0	3	0
Kinoryncha	0	0	1	1	0	0	0	0	0	0	0	0	0
Bivalvia	0	0	0	0	0	0	0	1	0	3	0	0	1
Gastropoda Larva	0	0	1	1	0	0	0	0	0	5	5	0	0
Oligochaeta	9	1	0	0	0	1	0	1	0	1	0	1	1
Nemertea	5	1	0	0	1	0	0	0	0	0	0	0	0
Turbellaria	14	1	14	0	28	5	24	13	1	18	4	1	6
Total	**696**	**189**	**188**	**26**	**93**	**84**	**391**	**117**	**8**	**92**	**141**	**378**	**130**

Table 3.5: Total meiofaunal abundance (ind/10 cm^2) of Mandovi Estuary (Central transect). Cont..													
Taxa	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**	**Total**	**%**
Nematoda	35	78	49	0	15	0	0	0	4	0	0	**2045**	73.1
Polychaeta	11	3	0	0	1	0	0	0	0	0	0	**60**	2.2
Harpacticoida	15	8	1	0	9	0	0	0	0	0	0	**444**	15.9
Naupli Larva	1	1	1	0	0	0	0	0	0	0	0	**38**	1.4
Isopoda	0	1	0	0	3	0	0	0	0	0	0	**13**	0.5
Kinoryncha	0	0	0	0	0	0	0	0	0	0	0	**3**	0.1
Bivalvia	1	1	0	0	0	0	0	0	0	0	0	**7**	0.2
Gastropoda Larva	0	1	0	0	0	0	0	0	0	0	0	**14**	0.5
Oligochaeta	0	0	0	0	0	0	0	0	0	0	0	**15**	0.5
Nemertea	0	0	0	0	0	0	0	0	0	0	0	**7**	0.2
Turbellaria	11	0	0	0	11	0	0	0	1	0	0	**152**	5.4
Total	**76**	**93**	**52**	**0**	**39**	**0**	**0**	**0**	**5**	**0**	**0**	**2797**	100.0

Table 3.6: Total meiofaunal abundance (Ind/10 cm^2) of Mandovi Estuary (Peripheral transect).

Taxa	COP1A	COP1B	COP2A	COP2B	COP3A	COP3B	M1A	M1B	M2A	M2B	M3A	M3B	M4A
Nematoda	63	863	1007	15	30	25	2593	131	249	98	99	55	60
Polychaeta	1	47	3	64	1	1	42	4	0	0	1	5	1
Harpacticoida	8	6	25	10	0	52	258	3	20	3	11	166	10
Naupli larvae	18	0	26	1	0	16	65	0	18	0	0	3	1
Amphipoda	0	0	4	0	0	0	0	0	0	0	0	0	0
Isopoda	34	0	0	0	0	0	0	0	0	0	0	0	0
Kinoryncha	0	0	4	0	0	0	23	0	9	0	1	0	0
Bivalvia	0	0	3	0	0	0	0	0	0	0	0	0	0
Gastropoda Larva	0	1	0	0	0	0	0	1	4	0	0	0	0
Oligochaeta	13	0	3	0	6	0	59	1	4	0	5	1	1
Nemertea	0	1	5	0	1	0	20	0	0	0	3	0	0
Turbellaria	15	26	47	8	1	3	10	0	55	0	20	4	1
Total	**151**	**945**	**1125**	**98**	**40**	**97**	**3070**	**140**	**359**	**101**	**141**	**234**	**76**

Table 3.6: Total meiofaunal abundance (ind/10 cm^2) of Mandovi Estuary (Peripheral transect).Cont.

Taxa	M4B	M5A	M5B	M6A	M6B	M7A	M7B	M8A	M8B	M9A	M9B	M10A	M10B
Nematoda	67	50	122	18	5	26	0	3	47	8	15	68	10
Polychaeta	0	1	1	1	0	0	0	1	0	1	0	0	0
Harpacticoida	6	4	19	16	0	0	0	0	4	0	1	82	0
Naupli larvae	0	0	0	0	1	0	0	0	0	0	0	4	0
Amphipoda	0	0	0	0	0	0	0	0	0	0	0	4	0
Isopoda	0	0	0	0	0	0	0	0	0	0	0	1	0
Kinoryncha	0	0	0	0	0	0	0	0	0	0	0	0	0
Bivalvia	0	0	0	1	0	0	0	0	0	0	0	0	0
Gastropoda Larva	0	0	0	23	0	0	0	0	0	0	0	0	0
Oligochaeta	3	19	8	1	5	0	0	0	4	0	0	5	8
Nemertea	0	3	5	1	0	0	0	0	0	0	0	0	4
Turbellaria	1	1	1	9	1	0	0	0	0	0	0	1	0
Total	**77**	**78**	**156**	**70**	**13**	**26**	**0**	**4**	**54**	**9**	**16**	**165**	**21**

Table 3.6: Total meiofaunal abundance (ind/10 cm^2) of Mandovi Estuary (Peripheral transect).Contd..												
Taxa	**M11A**	**M11B**	**M12A**	**M12B**	**M13A**	**M13B**	**M14A**	**M14B**	**M15A**	**M15B**	**M16A**	**M16B**
Nematoda	3	35	10	517	16	4	0	0	1	18	0	24
Polychaeta	0	0	5	1	0	0	0	0	0	0	0	0
Harpacticoida	0	1	10	164	0	4	0	0	0	1	0	0
Naupli larvae	0	0	1	45	0	0	0	0	0	0	0	0
Amphipoda	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	0	0	0	0	0	0	0	0	0	0	0	0
Kinoryncha	0	0	0	1	0	0	0	0	0	0	0	0
Bivalvia	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda Larva	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta	0	0	3	30	5	1	0	0	0	4	1	8
Nemertea	0	0	3	0	0	0	0	0	0	0	0	0
Turbellaria	1	0	1	0	1	0	0	0	0	0	0	0
Total	**4**	**37**	**32**	**759**	**23**	**9**	**0**	**0**	**1**	**23**	**1**	**31**

Table 3.6: Total meiofaunal abundance (ind/10 cm^2) of Mandovi Estuary (Peripheral transect). Contd..												
Taxa	**M17A**	**M17B**	**M18A**	**M18B**	**M19A**	**M19B**	**M20A**	**M20B**	**M21A**	**M21B**	**Total**	**%**
Nematoda	0	9	9	15	0	4	13	28	0	1	6435	77.2
Polychaeta	0	0	1	0	0	0	1	0	0	0	184	2.2
Harpacticoida	0	0	0	0	0	0	0	0	1	0	885	10.6
Naupli larvae	0	0	0	0	0	0	0	0	0	0	200	2.4
Amphipoda	0	0	0	0	0	0	0	0	0	0	8	0.1
Isopoda	0	0	0	0	0	0	0	0	0	0	35	0.4
Kinoryncha	0	0	0	0	0	0	0	0	0	0	38	0.5
Bivalvia	0	0	0	0	0	0	0	0	0	0	4	0.0
Gastropoda Larva	0	0	0	0	0	0	0	0	0	0	29	0.3
Oligochaeta	5	5	0	16	0	23	0	8	0	0	253	3.0
Nemertea	0	0	0	0	0	0	0	4	0	0	48	0.6
Turbellaria	0	0	1	1	0	5	0	0	0	0	216	2.6
Total	**5**	**14**	**11**	**33**	**0**	**31**	**13**	**39**	**1**	**1**	**8334**	**100.0**

Table 3.7: Nematoda:Copepoda ratio of Mandovi Estuary (Central transect)													
Station	**COP1**	**COP2**	**COP3**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M 10**
Nematoda	1050	290	204	22	66	94	576	89	11	78	176	231	74
Harpacticoida	6	4	46	10	22	8	6	50	0	4	32	360	106
Nematoda: Copepoda Ratio	**175**	**73**	**4**	**2**	**3**	**12**	**96**	**2**	**0**	**20**	**6**	**1**	**1**

Table 3.7: Nematoda:Copepoda ratio of Mandovi Estuary (Central transect) Cont											
Station	**M11**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**M21**
Nematoda	56	124	78	0	24	0	0	0	6	0	0
Harpacticoida	24	12	2	0	14	0	0	0	0	0	0
Nematoda: Copepoda Ratio	**2**	**10**	**39**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**

Table 3.8: Nematoda:Copepoda ratio of Mandovi Estuary (Peripheral transect)												
Taxa	**COP1A**	**COP1B**	**COP2A**	**COP2B**	**COP3A**	**COP3B**	**M1A**	**M1B**	**M2A**	**M2B**	**M3A**	**M3B**
Nematoda	100	1372	1600	24	48	40	4121	208	396	156	158	88
Harpacticoida	12	10	40	16	0	82	410	4	32	4	18	264
Nematoda: Copepoda Ratio	**8**	**137**	**40**	**2**	**0**	**0**	**10**	**52**	**12**	**39**	**9**	**0**

Table 3.8: Nematoda:Copepoda ratio of Mandovi Estuary (Peripheral transect) Cont												
Taxa	**M4A**	**M4B**	**M5A**	**M5B**	**M6A**	**M6B**	**M7A**	**M7B**	**M8A**	**M8B**	**M9A**	**M9B**

Nematoda	96	106	80	194	28	8	42	0	4	74	12	24
Harpacticoida	16	10	6	30	26	0	0	0	0	6	0	2
Nematoda: Copepoda Ratio	**6**	**11**	**13**	**6**	**1**	**0**	**0**	**0**	**0**	**12**	**0**	**12**

Table 3.8: Nematoda:Copepoda ratio of Mandovi Estuary (Peripheral transect) Contd..

Taxa	**M10A**	**M10B**	**M11A**	**M11B**	**M12A**	**M12B**	**M13A**	**M13B**	**M14A**	**M14B**	**M15A**	**M15B**
Nematoda	108	16	4	56	16	822	26	6	0	0	2	28
Harpacticoida	130	0	0	2	16	260	0	6	0	0	0	2
Nematoda: Copepoda Ratio	**1**	**0**	**0**	**28**	**1**	**3**	**0**	**1**	**0**	**0**	**0**	**14**

Table 3.8: Nematoda:Copepoda ratio of Mandovi Estuary (Peripheral transect) Contd..

Taxa	**M16A**	**M16B**	**M17A**	**M17B**	**M18A**	**M18B**	**M19A**	**M19B**	**M20A**	**M20b**	**M21A**	**M21B**
Nematoda	0	38	0	14	14	24	0	6	20	44	0	2
Harpacticoida	0	0	0	0	0	0	0	0	0	0	2	0
Nematoda: Copepoda Ratio	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

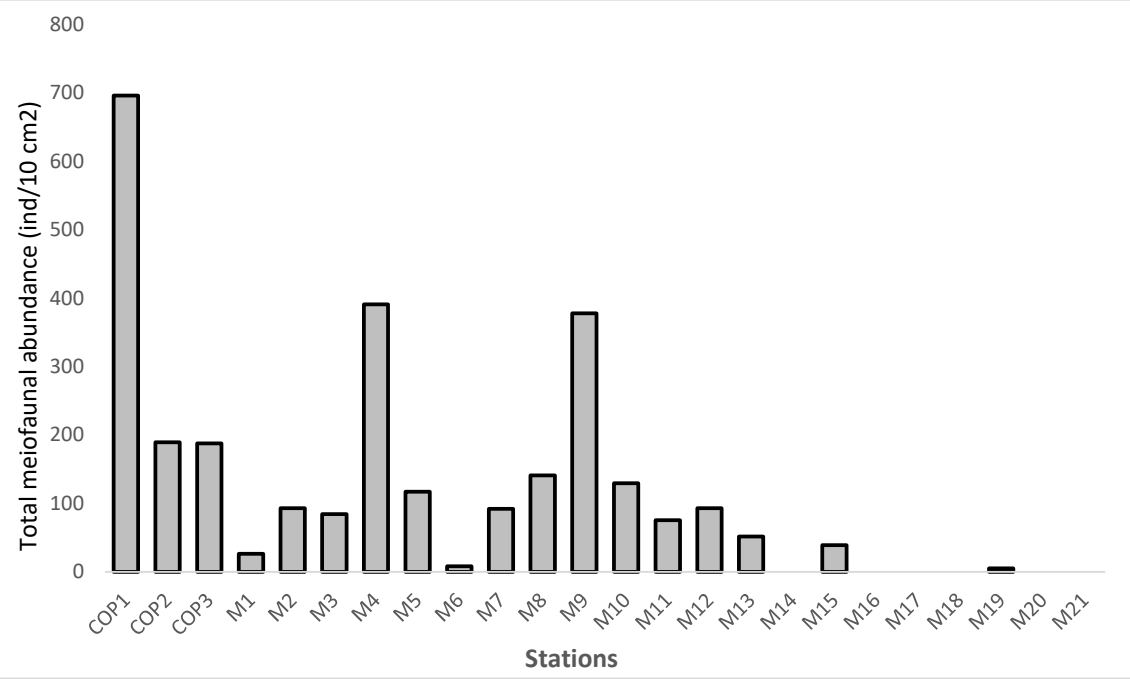


Figure 3.17: Station-wise meiofaunal abundance (ind/10 cm^2) from Mandovi Estuary (Central transect).

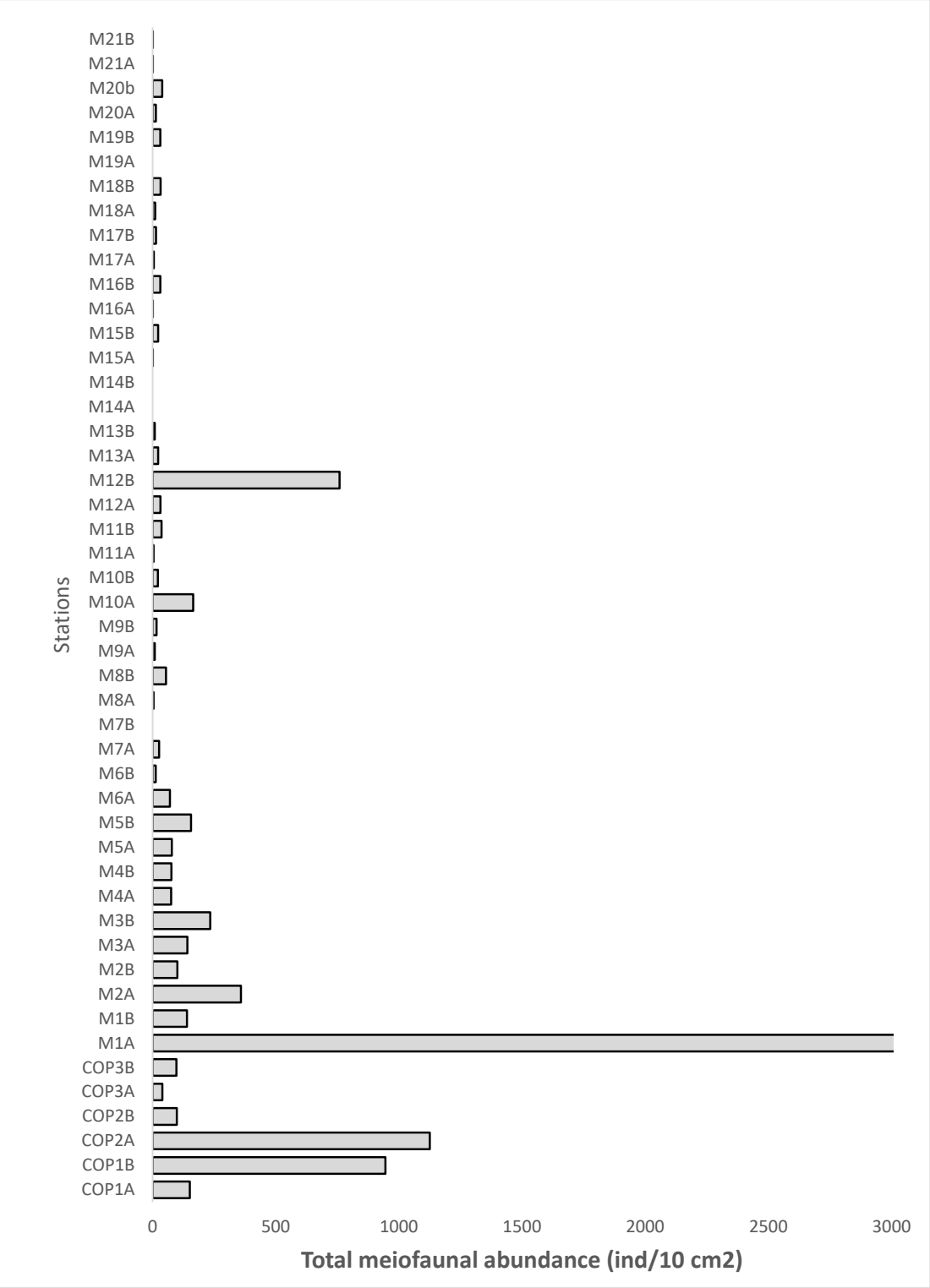


Figure 3.18: Station-wise meiofaunal abundance (ind/10 cm^2) from Mandovi Estuary (Peripheral transect).

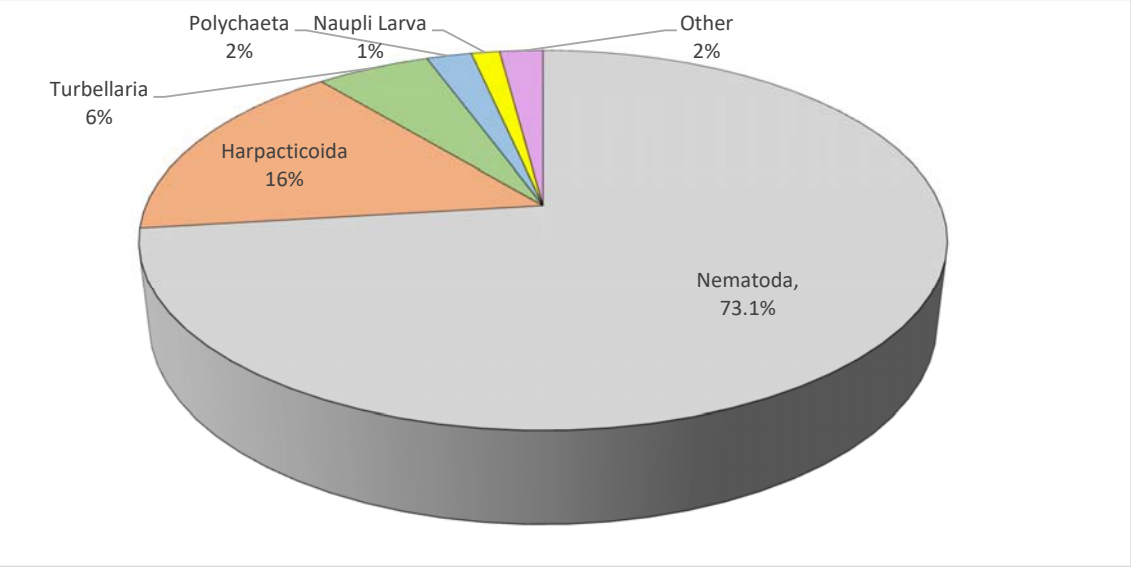


Figure 3.19: Percent composition of meiofaunal taxa from the Mandovi Estuary (Central transect).

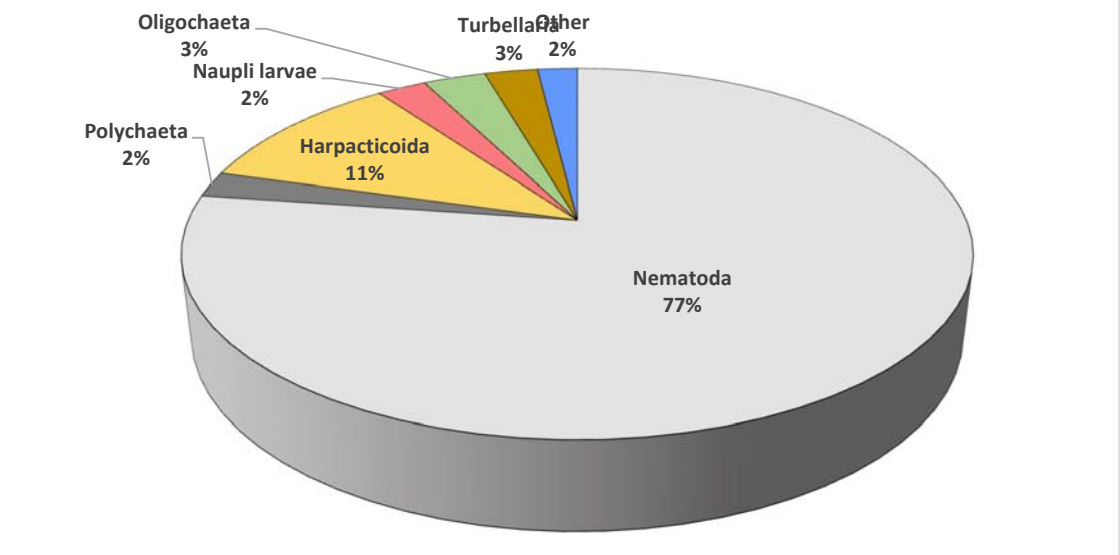


Figure 3.20: Percent composition of meiofaunal taxa from the Mandovi estuary (Peripheral transect).

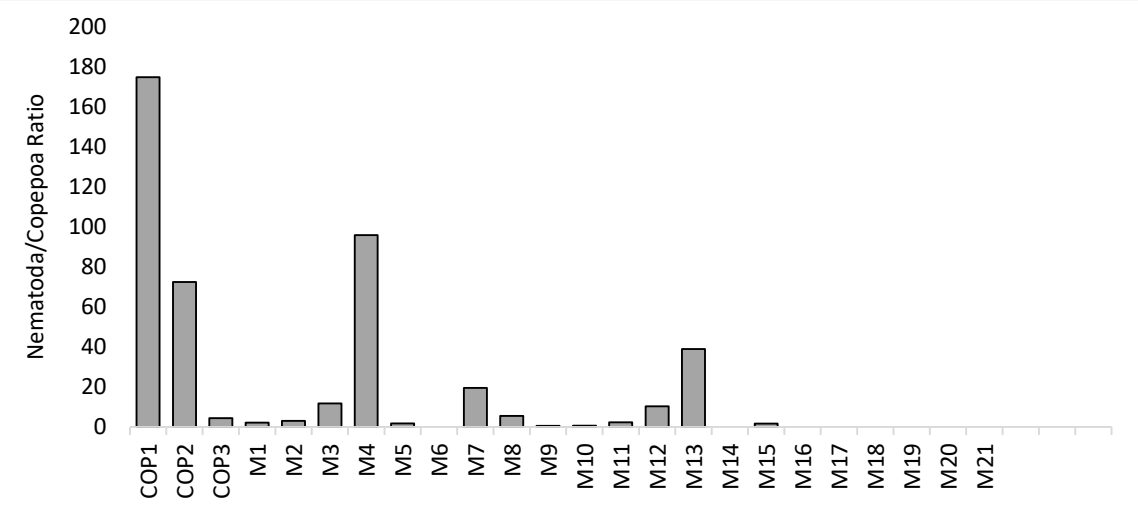


Figure 3.21: Station-wise Nematoda:Copepoda ratio from the Mandovi estuary (Central transect).

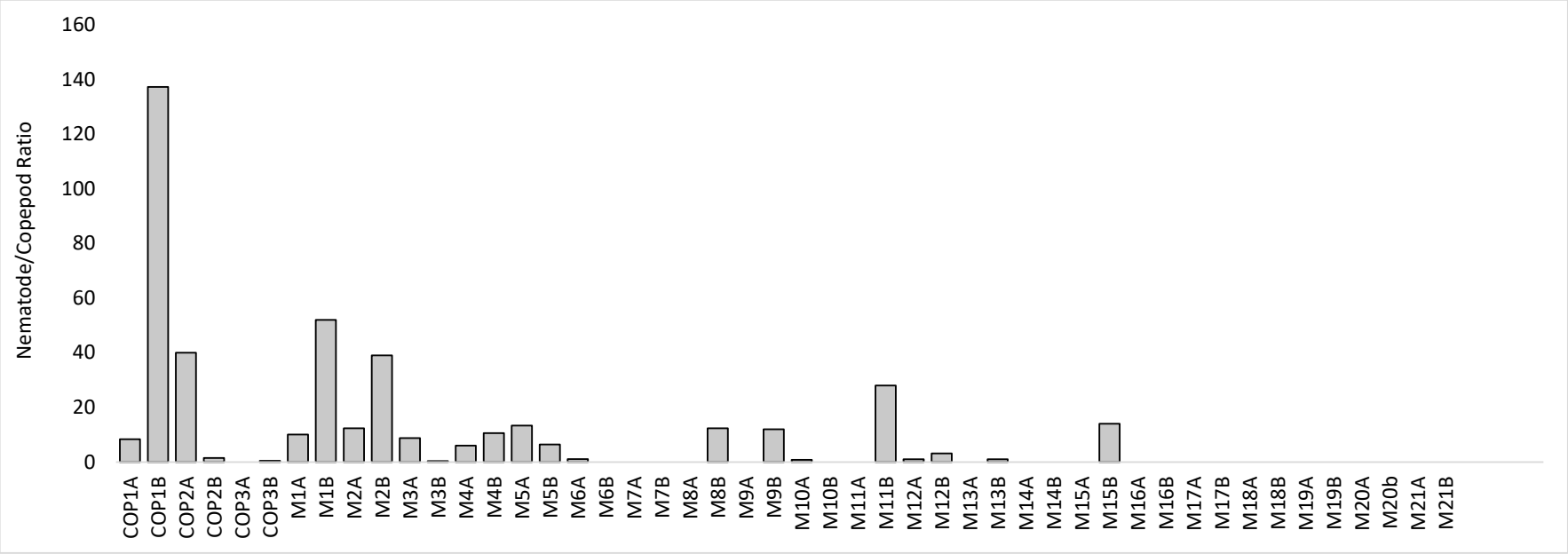


Figure 3.22: Station-wise Nematoda:Copepoda ratio from the Mandovi estuary (Peripheral transect).

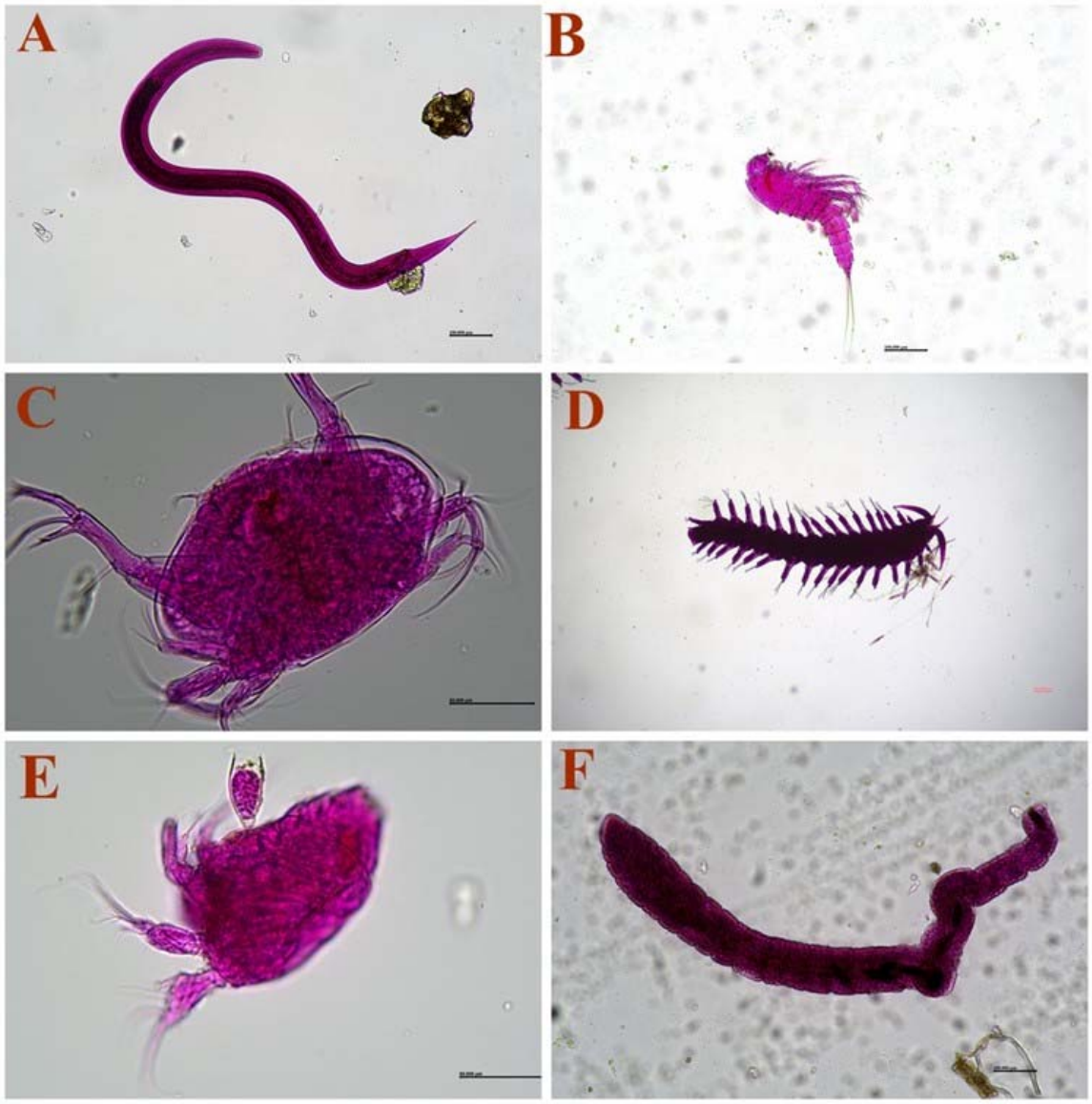


Plate 3.3: A. Nematoda; B. Harpacticoida; C. Ostracoda; D. Polycheta; E. Naupli Larva; F. Oligocheta.

3.8 Foraminifera

The foraminifera abundance increased towards the mouth of the Mandovi. The foraminifera were rare in the inner part of the Mandovi. The trochospiral and rounded forms were dominant in the foraminiferal assemblage (Plate 3.4). A large number of relict and reworked tests were also observed. The foraminiferal abundance was comparatively high in fine grained organic matter rich sediments, falling within the large tidal influence region.

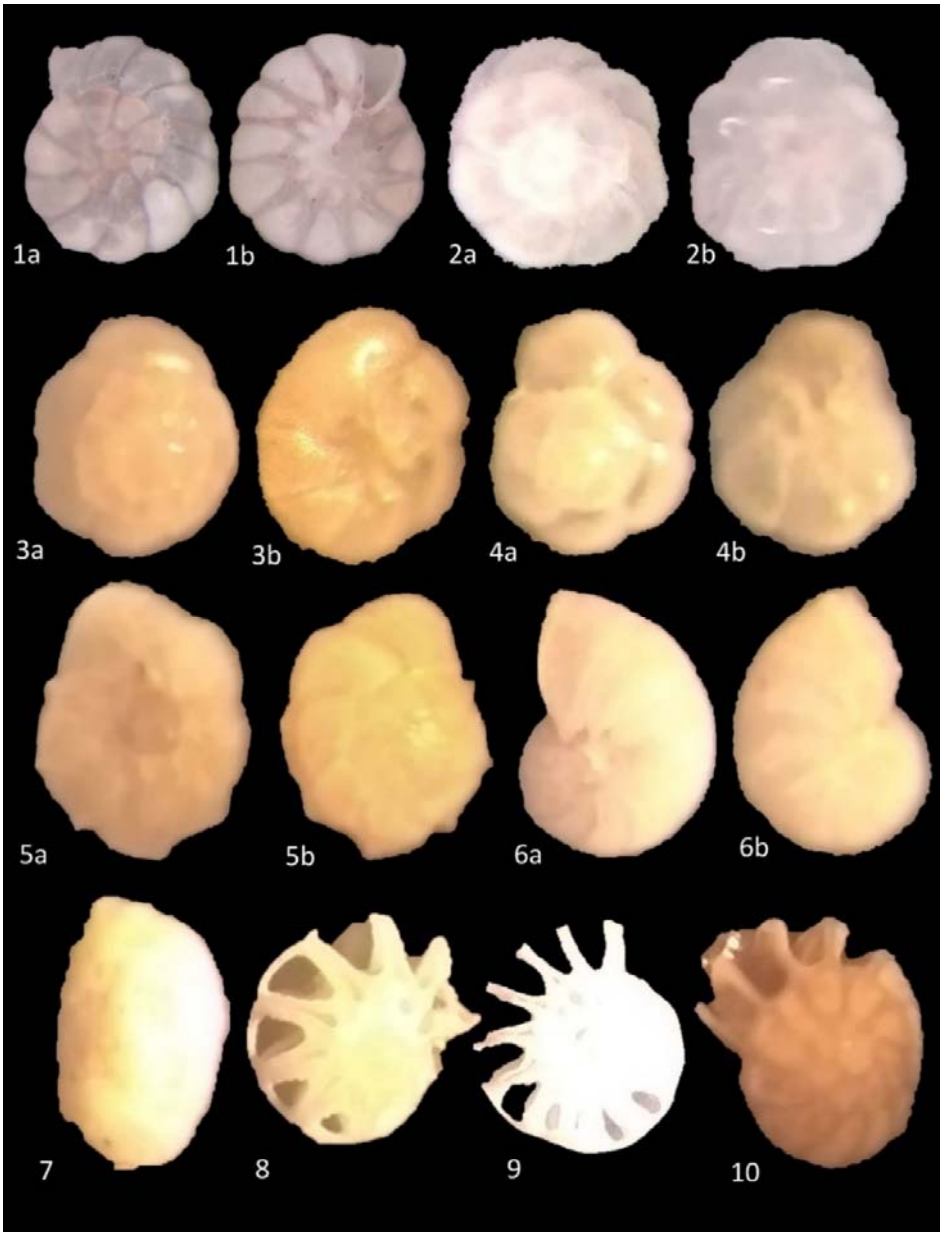


Plate 3.4: Dominant benthic foraminifera in the Mandovi. 1. *Rotalidium*, 2-4. *Ammonia*, 5. *Asterorotalia*, 6. *Nonion*, 7. Miliolid, 8-10 reworked tests.

3.9 Macro benthos

Central transect

Total 37 invertebrate taxa belonging to 10 phyla were identified from the Centre stations of Mandovi Estuary. Highest abundance of macrofauna was recorded at station M11 (12998 no/m^2) followed by station M10 (2994no/m^2) and M9 (2969 no/m^2) whereas, lowest abundance was recorded at station M4 (24no/m^2) (Table 3.9, Figure 3.23). Among all the macrofauna, polychaetes were the most abundant taxa (Figure 3.24). High abundance of polychaetes was found at station M11 (5501 no/m^2) followed by station M10 (2604 no/m^2), however lowest abundance was found at station M3 (24 no/m^2). In Polychaeta, *Mediomastus capensis* was highly abundant species at station M11 (4089 no/m^2) and showed less in abundance in all the stations. *Prionospio cirrifera* was the second dominant species at station M10 (2410 no/m^2) followed by station M9 (2166 no/m^2) and *Pisione* sp. was also found only at COP 1 (949 no/m^2) and COP2 (1144 no/m^2) station. Crustacea was the second dominant taxa which showed high abundance of Amphipoda (5623 no/m^2) and Cumacea (633 no/m^2) from all the stations. Other taxa like Oligochaeta, Nematoda, Chyronomous larvae, Nemertea, Platyhelminthes, and Bryozoan were found less in abundance among all the stations (Table 3.9). Macrofauna was absent at Stations M14, M16, M18A, M18B, M19A, M20A, M20B, M21A and M21B.

The macrofaunal composition (%) showed polychaetes was highly abundant (60%) followed by Crustacea (20%), Chyronomidae larvae (7%), Nematoda (5%) and the remaining 8% of the fauna was comprised by Bryozoan, Nemertea, Platyhelminthes, Bivalvia and Oligocheata (Figure 3.24). Among polychaeta, *Prionospio cirrifera* (44%) showed highest composition followed by *Mediomastus capensis* (23%), *Pisione* sp. (11%) and remaining (22%) polychaete species include *Glycera alba, Nepthys inermis, Sigambra* sp. etc. were found less in abundance at the central station of the estuary (Figure 3.25)

Peripheral transects

Total 34 invertebrate belonging to 10 phyla were recorded from peripheral stations of Mandovi Estuary. Highest abundance of macrofauna was recorded at station M11B (14969 no/m^2) followed by station M5A (13728 no/m^2) and M6A (8495 no/m^2) whereas the lowest abundance was recorded at M14B (32 no/m^2) (Table 3.10; Figure 3.26). Among all these

macrofauna, polychaeta was the most dominant group in all the stations. High abundance of *Mediomastus capensis* was recorded at station M11B (10637no/m^2) and M5A (10637no/m^2) followed by station M1B (7862 no/m^2) and the lowest abundance was recorded from 3 different stations (M 15A, M 16A, M16B (16no/m^2) respectively. *Prionospio cirrifera* was the second dominant species with (7010 no/m^2) at station 1B followed by station 5B (4844 no/m^2), station 4B (4625 no/m^2) and station 6A (4381 no/m^2) and the remaining stations showed less in abundance. *Dendronereis* sp. (5225 no/m^2) was also found in some stations. Other taxa include Nematoda, Nemertea, Oligochaeta, Chyronomous larvae, Gastropod larvae, Platyhelminthes etc were also found in less abundance (Table 3.10).

The macrofaunal composition showed polychaeta (82%), Crustacea (9%), Chyronomous larvae (4%), Oligochaeta (3%) and others (2%) from all the stations. The remaining fauna includes Nemertea, Bryozoan, Nematoda etc (Figure 3.27) Among polychaeta, *Prionospio cirrifera* showed high composition (47%) followed by *Mediomastis capensis* as the second dominant composition (36%) followed by *Dendroneries* sp (5%), *Orbinia* sp (5%) and others (7%). The remaining polychaete species include *Cossura* sp., *Lumbrineries* sp.etc (Figure 3.28).

Biomass

Macrofaunal biomass (wet weight) from central station of Mandovi Estuary varies from 0.02 to 5.35g/m^2. Highest diversity of macrofauna was recorded at station COP3 (5.35g/m^2) which was contributed by polychaetes and oligochaetes and lowest diversity was recorded at station M 4 and M 19 (0.02g/m^2) respectively due to low abundance (Figure 3.29). Peripheral stations of macrofaunal biomass of Mandovi Estuary vary from 0.03 to 33.69g/m^2. Highest diversity in the peripheral region was recorded at station M10A (33.69g/m^2) due to high abundance of polychaetes and the lowest diversity was recorded at station M 17B and M 19B (0.03g/m^2) due to low abundance of polychaetes (Figure. 3.30).

Conclusion

Based on the present data set, macrofaunal abundance was found to be higher at mid region of the Mandovi Estuary as compared to upper stream area. The present analysis also found that the peripheral region of upstream was rich in macrofaunal diversity, while the abundance found decreased gradually towards the up-stream area. The centre stations of the estuary found less diversity may be because of the continuous dredging in the estuary.

Table 3.9: Abundance (no/m^2) of macrofauna from Mandovi Estuary (Centre transect)																				
Taxa	COP 1	COP 2	COP 3	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 10	M 11	M 12	M 13	M 15	M 19	Total	%
Bryozoan	0	24	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0.14
Nematoda	0	1631	97	0	0	0	0	24	0	0	0	24	0	0	0	0	0	0	1777	5.04
Mediomastus capensis	0	0	268	0	0	0	0	0	0	97	49	195	122	4089	0	24	0	0	4844	13.73
Heteromastus sp.	0	0	706	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	730	2.07
Capitella capitata	0	0	0	49	0	0	0	0	0	146	0	0	0	0	0	0	0	0	195	0.55
Prionospio pinnata	0	0	0	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	97	0.28
Prionospio cirrifera	0	0	0	49	146	24	0	560	24	1533	1217	2166	2410	755	219	122	97	0	9322	26.43
Scolelepis sp.	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	24	0.07
Glycera alba	49	0	243	73	24	0	0	24	24	73	0	0	0	0	0	0	0	0	511	1.45
Diopatra sp.	0	0	243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	243	0.69
Onuphis sp.	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0.14
Pisione sp.	949	1144	0	0	0	0	0	97	24	0	0	49	0	0	24	0	0	0	2288	6.49
Nephtys inermis	0	0	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0.21
Orbinia sp.	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0.14
Saccocirrus sp.	0	122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	122	0.35
Sigambra sp.	0	0	438	195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	633	1.79
Namalycastis sp.	0	0	195	0	0	0	0	0	0	73	0	0	24	535	0	0	0	0	828	2.35
Dendroneries sp.	0	0	0	462	0	0	0	0	0	73	24	97	49	122	24	73	24	97	1047	2.97
Phyllodocea sp.	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0.07
Amphipoda	0	97	49	24	24	0	0	0	24	24	268	0	268	4746	0	97	0	0	5623	15.94
Isopoda	0	0	0	0	0	0	0	0	0	0	49	0	0	0	0	0	0	0	49	0.14
Harpacticoida	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0.07
Mysis	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	24	0.07
Cumacea	0	0	0	0	0	0	0	268	170	24	24	97	49	0	0	0	0	0	633	1.79
Tanaidacea	0	0	0	0	0	0	0	0	0	122	0	0	0	0	0	0	0	0	122	0.35

Decapoda	0	0	0	24	0	0	24	0	0	0	0	0	0	0	0	0	0	0	49	0.14
Shrimp	0	0	24	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	49	0.14
Zoae larvae	0	0	0	0	0	0	0	24	341	0	0	0	0	0	0	0	0	0	365	1.04
Bivalvia	0	0	0	0	24	0	0	122	0	0	49	0	73	0	0	0	0	0	268	0.76
Gastropod larvae	0	0	0	0	0	0	0	535	170	0	0	0	0	0	0	0	0	0	706	2.00
Cirrithidia	0	0	0	0	0	73	0	0	0	0	0	0	0	0	0	0	0	0	73	0.21
Platyheminthes	0	0	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0.21
NeMrtea	0	49	0	0	0	0	0	487	146	0	0	341	0	0	0	0	24	0	1047	2.97
Chironomidae larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	2702	0	0	0	0	2702	7.66
Oligochaeta	0	49	462	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	535	1.52
Total abundance(no/m^2)	**1047**	**3116**	**2921**	**1047**	**243**	**97**	**24**	**2166**	**974**	**2166**	**1679**	**2969**	**2994**	**12998**	**268**	**316**	**146**	**97**	**35269**	**100.00**

Table 3.10: Abundance (no/m^2) of macrofauna from Mandovi Estuary (Peripheral transect)

Taxa	COP 1 A	COP 1B	COP 2A	COP 2 B	COP 3 A	COP 3 B	M 1 A	M 1 B	M 2 A	M 2 B	M 3 A	M 3 B	M 4 A	M 4 B	M 5 A	M 5B	M 6A	M 6 B	M 7A	M 7B
Bryozoan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0
Nematoda	0	0	1047	24	0	0	0	0	0	0	24	195	24	0	0	0	0	0	0	0
Mediomastus capensis	0	0	0	122	24	146	1801	122	24	0	487	462	24	316	1436	316	779	268	609	122
Prionospio cirrifera	243	49	0	24	2385	146	2069	7010	0	195	341	1728	268	4625	10637	4844	4381	1947	24	24
Scolelepis sp.	0	0	0	682	49	49	24	0	438	0	0	0	122	0	0	0	0	0	24	0
Glycera alba	73	49	0	73	49	0	0	122	24	24	49	170	0	24	146	0	0	122	0	0
Lumbrineris sp.	0	0	0	0	0	0	146	73	0	0	0	0	0	0	0	0	0	0	0	0
Pisione sp.	0	0	1193	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cossura sp.	0	0	0	0	0	24	0	146	0	0	0	0	0	0	0	0	0	0	0	0
Capitella capitata	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0
Levinsenia oculata	0	0	0	0	0	24	0	0	0	24	0	0	0	0	0	0	0	0	0	0

Nephtys inermis	24	0	0	24	535	97	0	24	0	0	0	0	0	24	0	0	0	0	0	0
Onuphis sp.	0	0	0	0	0	0	0	0	0	0	0	73	0	0	0	0	0	0	0	0
Sigambra sp.	0	0	0	170	97	49	0	219	0	49	0	0	0	0	0	0	0	0	0	0
Namalycastis sp.	0	0	0	0	0	170	414	49	0	0	0	0	0	170	122	0	535	122	0	0
Dendroneries sp.	0	0	0	73	292	24	195	97	24	24	122	341	0	0	195	219	0	122	122	0
Orbinia sp.	146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saccocirrus sp.	0	0	146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maldinella sp.	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	24	73	24	341	0	0	0	73	0	49	73	97	49	0	0	146	2653	195	0	195
Isopoda	0	24	0	0	0	0	0	73	0	0	49	97	0	73	24	122	0	316	0	0
Harpacticoida	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0
Mysis	0	0	0	24	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0
Lucifera	0	24	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cumacea	0	0	0	0	0	0	0	0	0	0	0	73	122	0	0	24	0	0	0	0
Tanaidacea	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	268	0	0
Shrimp	0	0	0	0	0	0	0	0	0	0	24	24	49	0	49	49	24	0	0	0
Bivalvia	49	24	0	24	0	0	0	49	195	0	170	73	414	24	0	24	73	0	0	0
Gastropoda (Juvenile)	0	0	0	0	0	24	0	0	0	0	0	0	24	0	0	0	0	0	0	0
Platyheminthes	0	0	0	0	0	0	0	24	0	0	0	0	0	0	73	0	0	0	0	0
Nemrtea	0	49	535	24	49	24	0	0	0	0	0	0	0	0	97	0	0	0	0	0
Chironomidae larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	24
Oligochaeta	0	24	0	0	438	0	49	462	24	24	24	49	0	73	949	0	0	560	0	0
Total abundance (No/m^2)	559	365	2969	1655	3919	779	4698	8543	730	389	1387	3408	1120	5330	13728	5744	8495	3919	828	365

Taxa	M 8 A	M 8 B	M 9A	M 9 B	M10 A	M 10 B	M 11 A	M 11 B	M 12 A	M 12 B	M 13 A	M 13B	M 14 A	M14 B	M15A	M 15 B	M16 A	M16 B	M17A	M17B	M19B	Total	%
Bryozoan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0
Nematoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	1346	1
Mediomastus capensis	609	1606	5257	195	122	1558	4040	10637	2832	288	0	272	1776	32	0	0	0	0	0	0	0	36282	30
Prionospio cirrifera	0	1606	316	657	2020	97	146	389	0	0	0	0	128	0	0	0	0	0	0	0	0	46301	38
Scolelepis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1388	1
Glycera alba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	925	1
Lumbrineris sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	219	0
Pisione sp.	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1217	1
Cossura sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	0
Capitella capitata	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	56	0
Levinsenia oculata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0
Nephtys inermis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	729	1
Onuphis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73	0
Sigambra sp.	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	609	0
Namalycastis sp.	0	24	828	0	0	0	0	1290	352	0	0	0	480	0	0	0	0	0	0	0	0	4556	4
Dendroneries sp.	414	195	243	97	49	170	0	1071	0	608	48	128	96	0	16	208	16	16	0	0	0	5225	4
Orbinia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	194	0
Saccocirrus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	146	0
Maldinella sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0
Amphipoda	0	73	219	828	341	1850	0	1022	0	0	0	0	80	0	0	0	0	0	16	0	0	8420	7
Isopoda	0	0	0	560	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	1355	1
Harpacticoida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0
Mysis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0
Cumacea	0	0	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	243	0
Tanaidacea	0	0	0	0	0	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	341	0
Shrimp	0	0	24	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	268	0
Bivalvia	0	0	0	49	73	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	1266	1
Gastropoda (Juvenile)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	0
Platyhelminthes	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	113	0
Nemertea	0	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0	0	0	0	48	0	876	1

Chironomidae larvae	122	122	633	0	0	0	243	487	768	1456	272	432	512	0	0	0	0	0	0	0	0	5119	4
Oligochaeta	0	24	0	0	0	24	0	49	0	0	32	0	16	0	112	80	288	96	16	256	272	3943	3
Total abundance (No/m2)	**1144**	**3700**	**7521**	**2410**	**2653**	**3797**	4454	14969	3968	2352	368	864	3088	32	128	288	304	112	80	304	304	121770	100

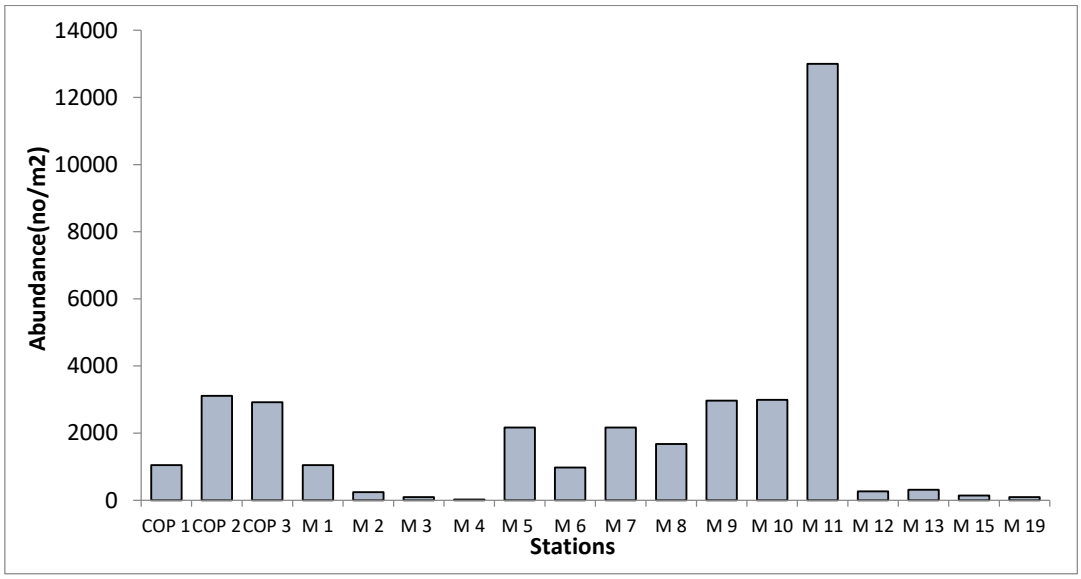


Figure 3.23: Station- wise macrofaunal abundance (no/m^2) of the Mandovi Estuary (Central transect).

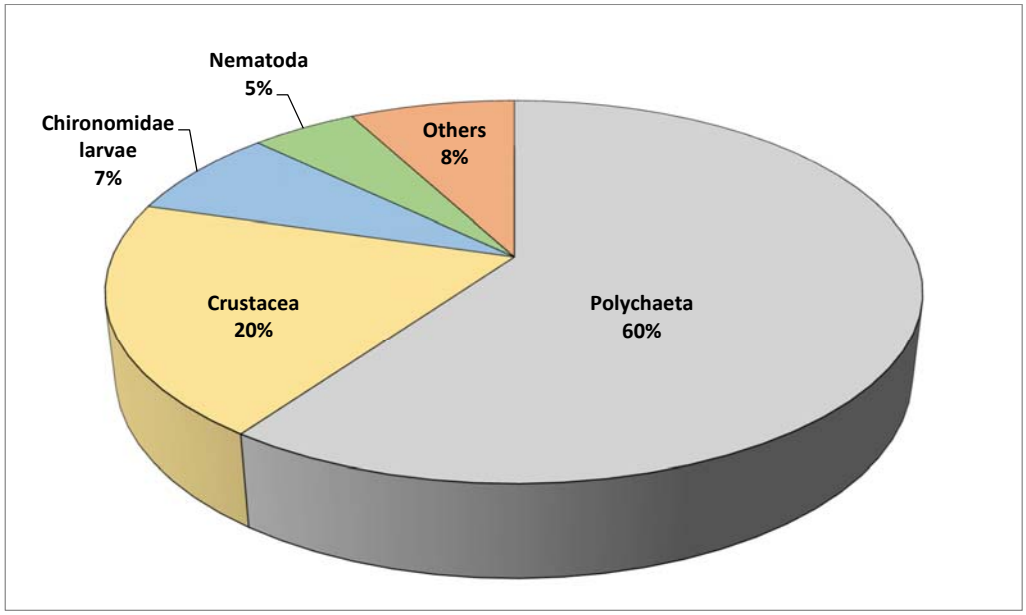


Figure 3.24.: Percent (%) composition of macrofaunal abandance of the Mandovi Estuary (Central transect)

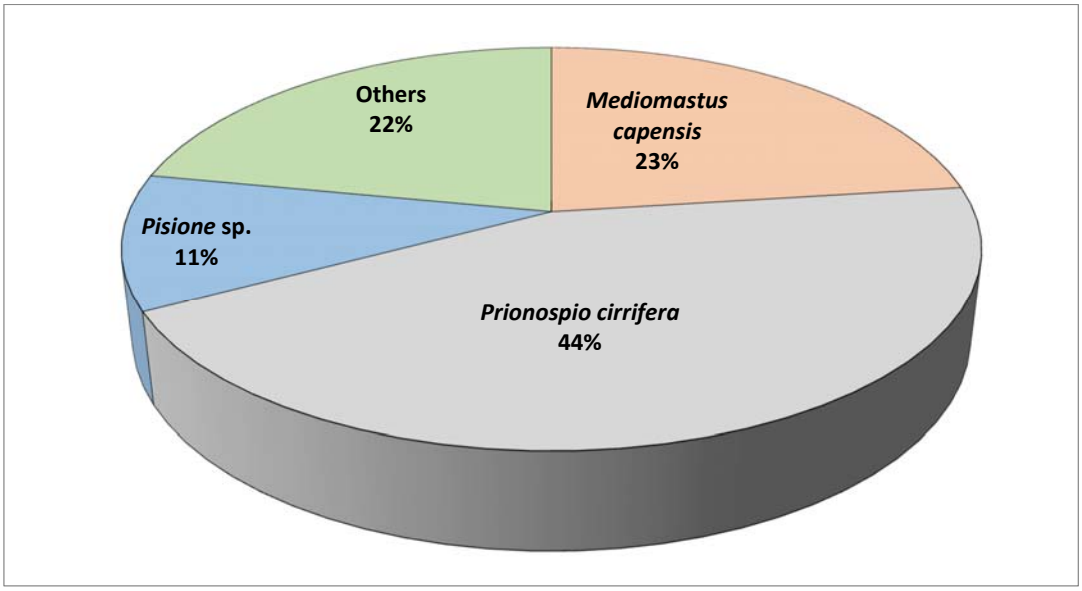


Figure 3.25: Percent (%) composition of polychaetes of the Mandovi Estuary (Central transect)

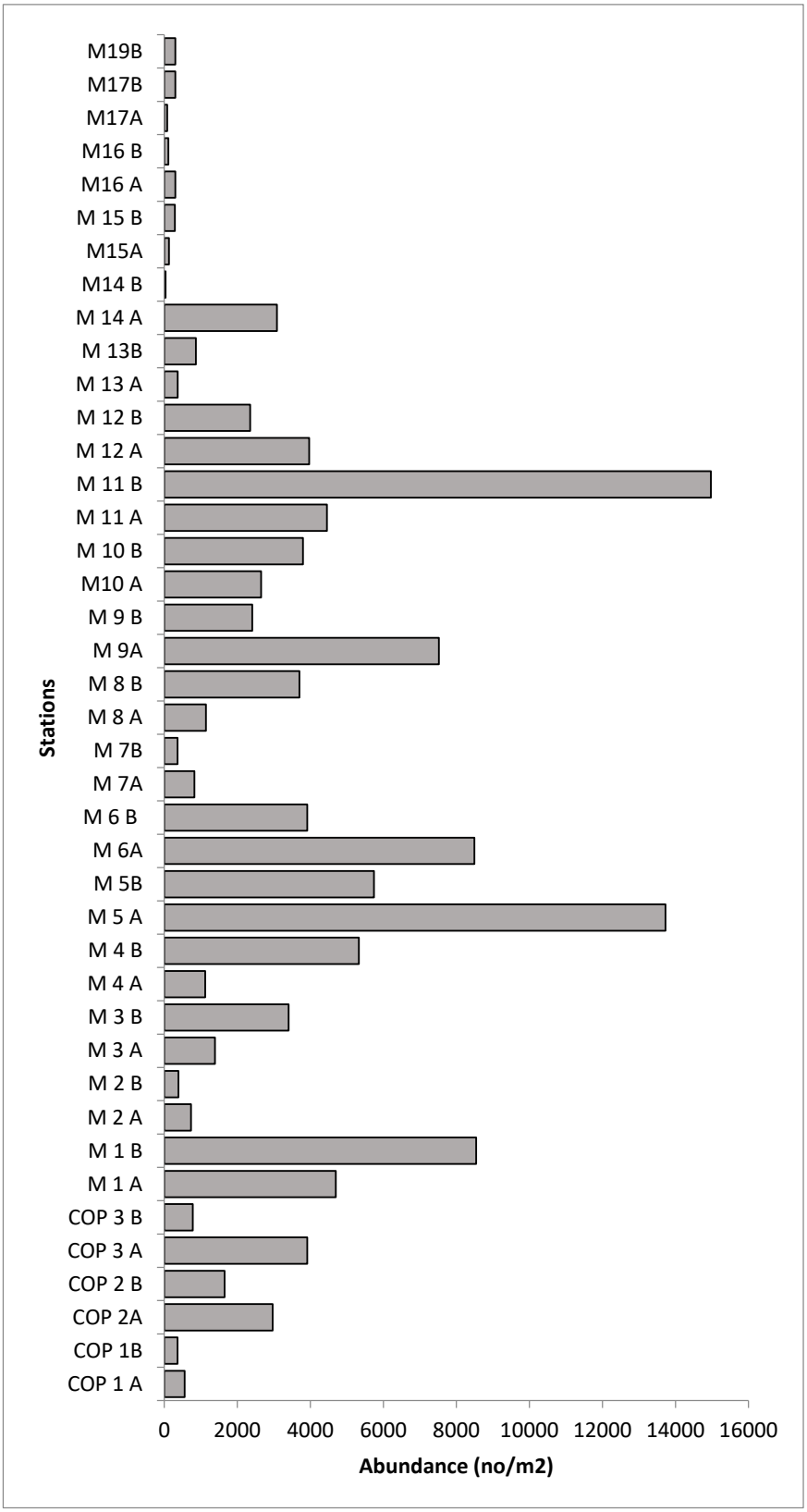


Figure 3.26: Station-wise macrofaunal abundance (no/m^2) of the Mandovi Estuary (Peripheral transect)

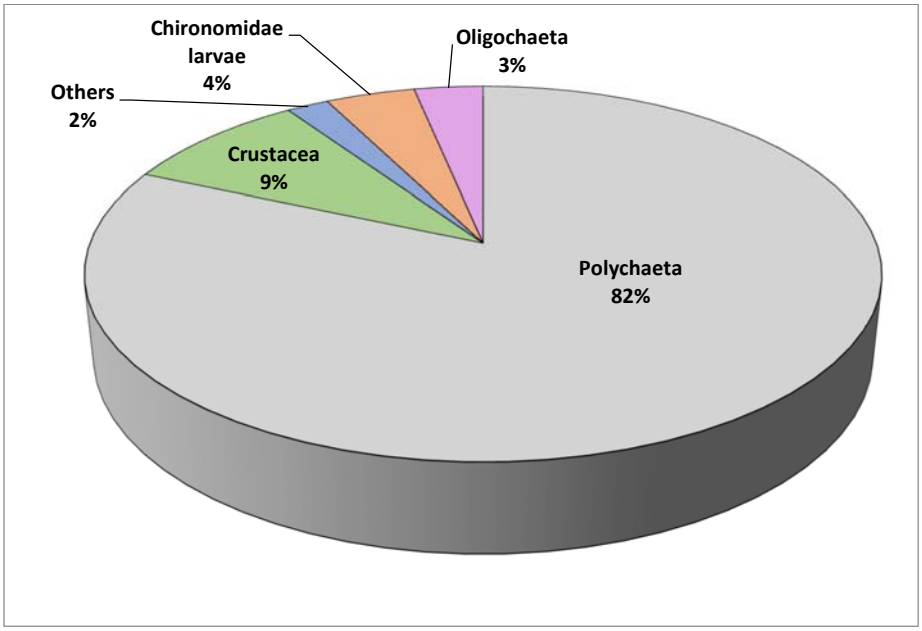


Figure 3.27: Percent (%) composition of macrofaunal abandance of the Mandovi Estuary (Peripheral transect)

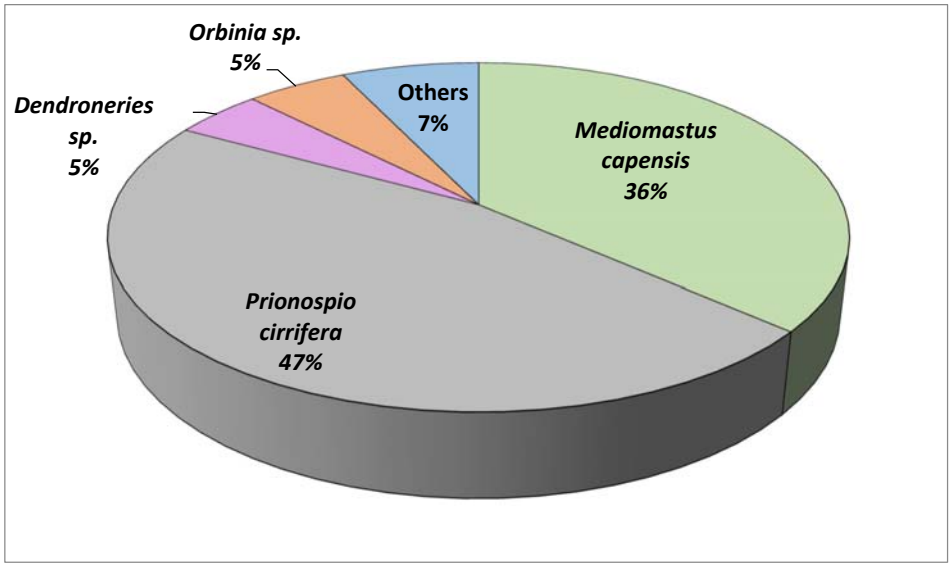


Figure 3.28: Percent (%) composition of polychaetes of the Mandovi Estuary (Peripheral transect)

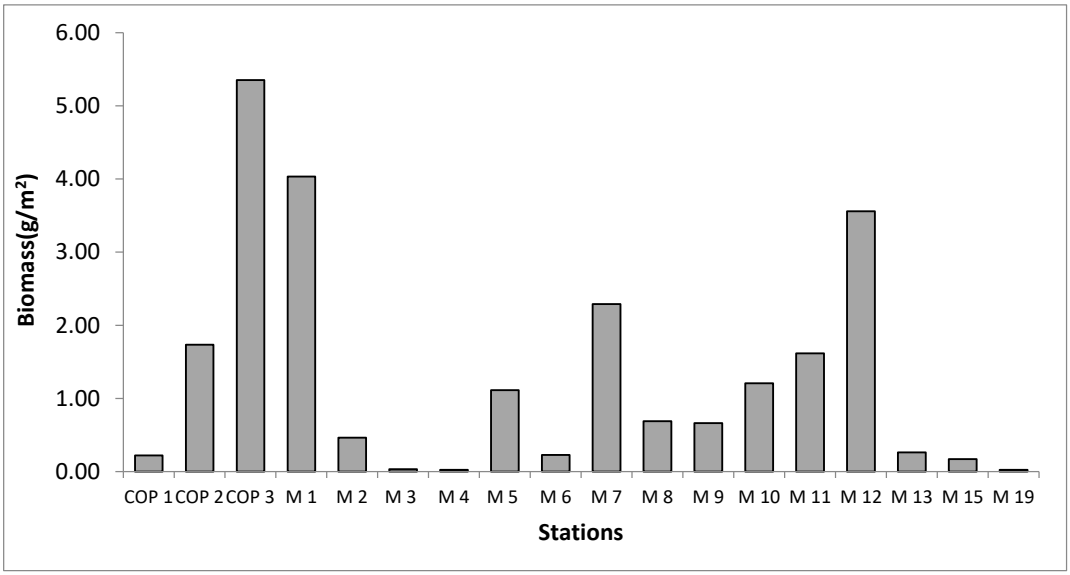


Figure 3.29: Station-wise Biomass (g/m^2) of macrofauna in the Mandovi Estuary (Central transect)

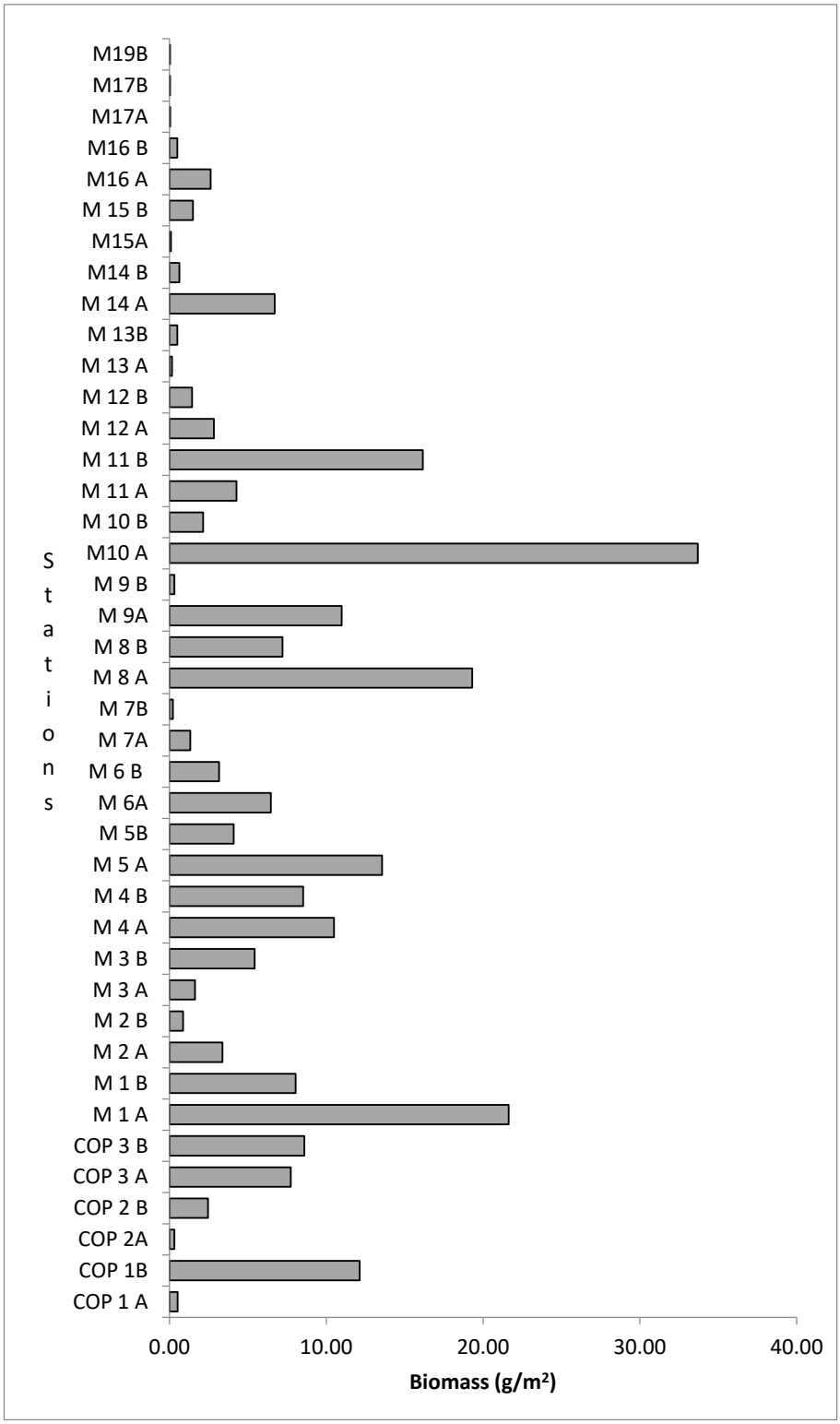


Figure 3.30: Station-wise Biomass (g/m^2) of macrofauna in the Mandovi Estuary (Peripheral transect)

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 carried out. This index is mainly 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 the second abundant fauna of the estuarine area 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:

$$BPA = \log10 [fp/(fa+ 1)+ 1]$$

Where *f*p was the polychaete frequency and *f*a 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 (annelida) 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 valves 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 Mandovi Estuary, the BPA ratio ranged from 0.040 to 0.301 (Table 3.11). At station M3, M5, M6, and M11, the BPA ratio showed good status and in stations COP3 and M13, the BPA ratio showed moderate status whereas the remaining stations (COP1, COP3, M1, M2, M8, M9, M10, M12, M15 and M19, the BPA ratio showed poor status (Table 3.11) where there was absence or low abundance of amphipods and high abundance of polychaetes. At the periphery region, the BPA ratio ranged from 0.05 to 0.30 at Station M13A and M1A (Table 3.12). *Mediomastus capensis* of the family Capitellidae and *Prionospio cirrifera* of family Spionidae dominated in the Mandovi estuary, which are the opportunistic polychaete species.

Table 3.11: Benthic Polychaete Amphipode (BPA) ratio of Mandovi Estuary (Central transect)	
Stations	Benthic Polychaete Amphipod ratio (BPA)
COP 1	0.301
COP 2	0.144
COP 3	0.240
M 1	0.281
M 2	0.214
M 3	0.097
M 5	0.122
M 6	0.040
M 7	0.281
M 8	0.221
M 9	0.266
M 10	0.255
M 11	0.117
M 12	0.301
M 13	0.185
M 15	0.263
M 19	0.301

Table 3.12: Benthic Polychaete Amphipode (BPA) ratio of Mandovi Estuary (Peripheral transect)	
Stations	Benthic Polychaete Amphipod ratio (BPA)
COP 1 A	0.26
COP 1B	0.09
COP 2A	0.16
COP 2 B	0.20
COP 3 A	0.27
COP 3 B	0.29
M 1 A	0.30
M 1 B	0.28
M 2 A	0.23
M 2 B	0.24
M 3 A	0.23
M 3 B	0.25
M 4 A	0.13
M 4 B	0.29
M 5 A	0.28
M 5B	0.28
M 6A	0.18
M 6 B	0.21
M 7A	0.29

M 7B	0.10
M 8 A	0.28
M 8 B	0.28
M 9A	0.27
M 9 B	0.11
M10 A	0.24
M 10 B	0.12
M 11 A	0.29
M 11 B	0.26
M 12 A	0.26
M 12 B	0.14
M 13 A	0.05
M 13B	0.18
M 14 A	0.25
M14 B	0.30
M15A	0.05
M 15 B	0.24
M16 A	0.02
M16 B	0.06
M17A	0.18
M17B	0.00
M19B	0.00

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), Margalef's species richness (d), Pielou's evenness (J') and Shannon index (H') and Simpson index (1-lambda') using square root scale at each station (Clarke & Gorley, 2001). In central region of Mandovi estuary, the number of species was maximum at station COP3 (14) and minimum at station M3 (2) (Figure 3.31). The species richness (d) was highest at COP3 (d= 1.62) and lowest at M3 & COP2 (d= 0.2) (Figure 3.31). Evenness was recorded highest at M13 (J'=0.9) and lowest at COP1 (J'=0.3) (Figure 3.31). The Shannon index was highest at COP3 (H'=2.2) and lowest at M3 (H'=0.5) (Figure 3.31). Simpson index was high at COP3(Figure 3.31). COP stations were located at the estuary mouth and the M stations

were located where sand mining is carried out which might be the main reason in low macrofaunal diversity. In peripheral region, the number of species was maximum at station COP2B (14) and M1B (14) and minimum at station M3 (2) (Figure 3.32). The species richness (d) was highest at COP2B (d= 1.75) and lowest at M17 and M19 (d= 0.17) (Figure 3.32). Evenness was recorded highest at COP1B (J'=0.96) and lowest at M4B (J'=0.2) (Figure 3.32). The Shannon index was highest at COP1B & COP3B (H'=2.1) and lowest at M16A (H'=0.) (Figure 3.32). Because of mangroves adjacent to the estuary, the diversity was high in the peripheral area. Simpson index was high at COP1B (Figure 3.32)

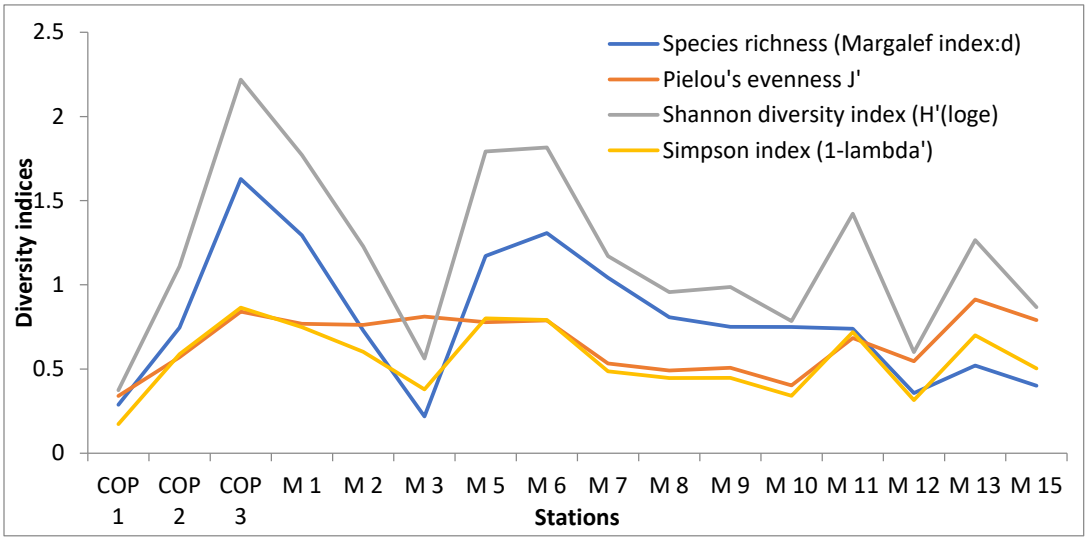


Figure 3.31: Station-wise diversity indices of the Mandovi Estuary (Central transect).

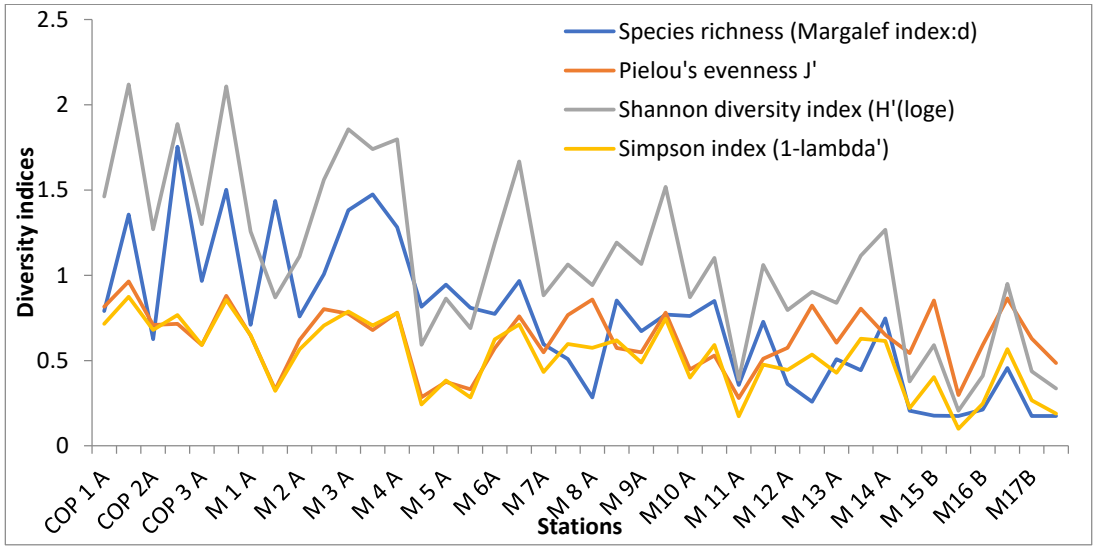


Figure 3.32: Station-wise diversity indices of the Mandovi Estuary (Peripheral transect).

Biotic indices

Ecological quality status assessment carried out by AMBI analysis based on the benthic polychaete diversity and abundance. This index assigned most of the sampling sites as moderately disturbed to slightly disturbed. Upper stream stations (M16, M18, M19, M20) of Mandovi estuary were extremely disturbed. Only sites COP1, COP2, COP3 and M17 were found to be undisturbed based on the AMBI results (Figure 3.33). According to M-AMBI, most of the sampled sites were assigned to poor ecological quality status. Stations COP3 and M1 were in good status, COP1, COP2, M2A, M3A, M6 and M8 showed moderate status. Station M11, M11A, M14B showed bad status. Stations towards the mouth of the estuary showed good to moderate status whereas the stations towards the upper stream areas, it showed poor status (Figure 3.34).

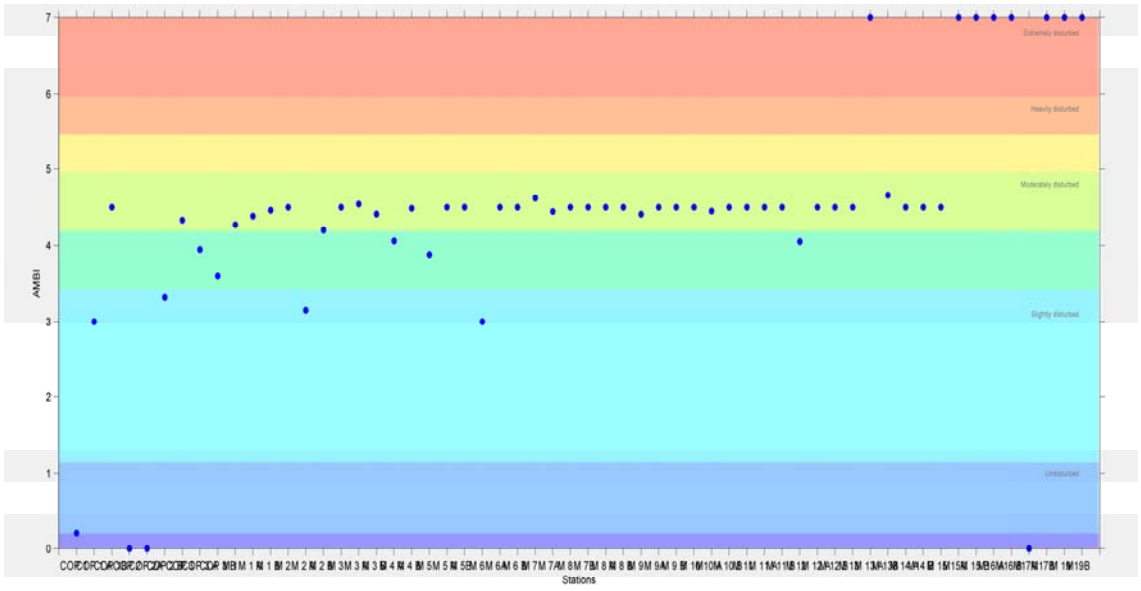


Figure 3.33: Ecological quality status assessment through AMBI index from the Mandovi Estuary

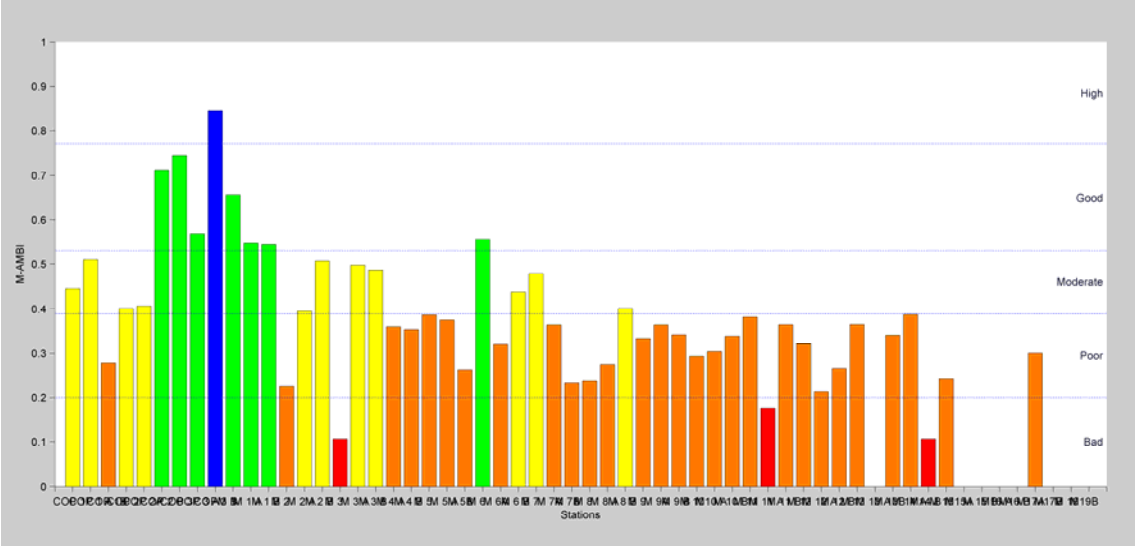


Figure 3.34: Ecological quality status assessment through M-AMBI index from the Mandovi Estuary

BENTIX produced a poor status in most of the stations mainly in the upper stream of the Mandovi Estuary, except the station COP1A, COP3, COP3A and COP3B, which displayed moderate ecological quality status (Figure 3.35). Stations of upper stream areas showed poor ecological quality status due to the diversity and abundance in benthic fauna present in all the stations. Tolerant species were more dominant in all the sampling stations (Figure 3.36).

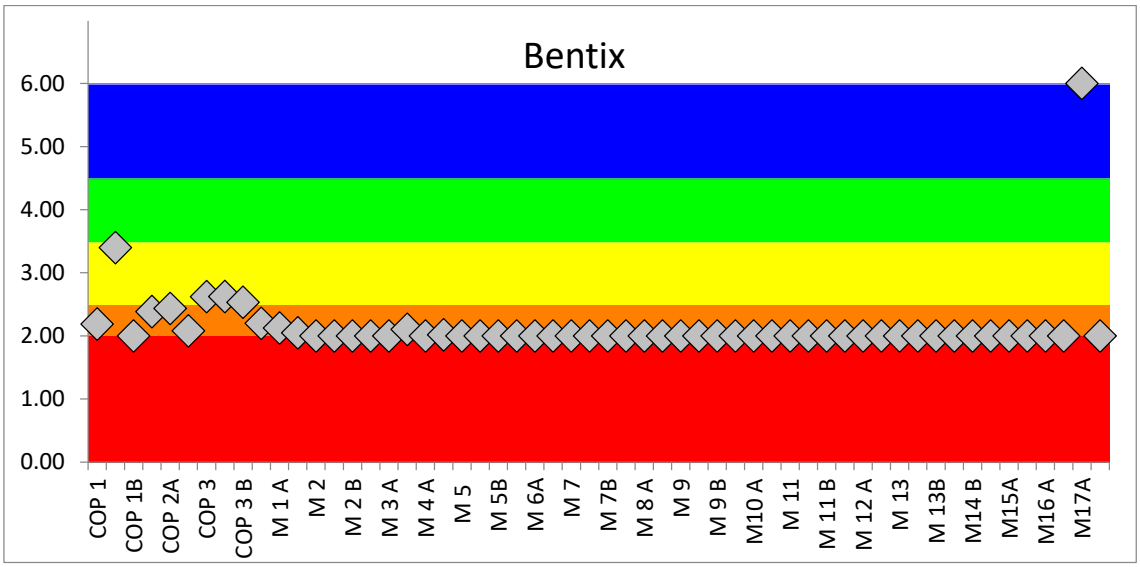


Figure 3.35: Ecological quality status assessment through BENTIX index from the Mandovi Estuary

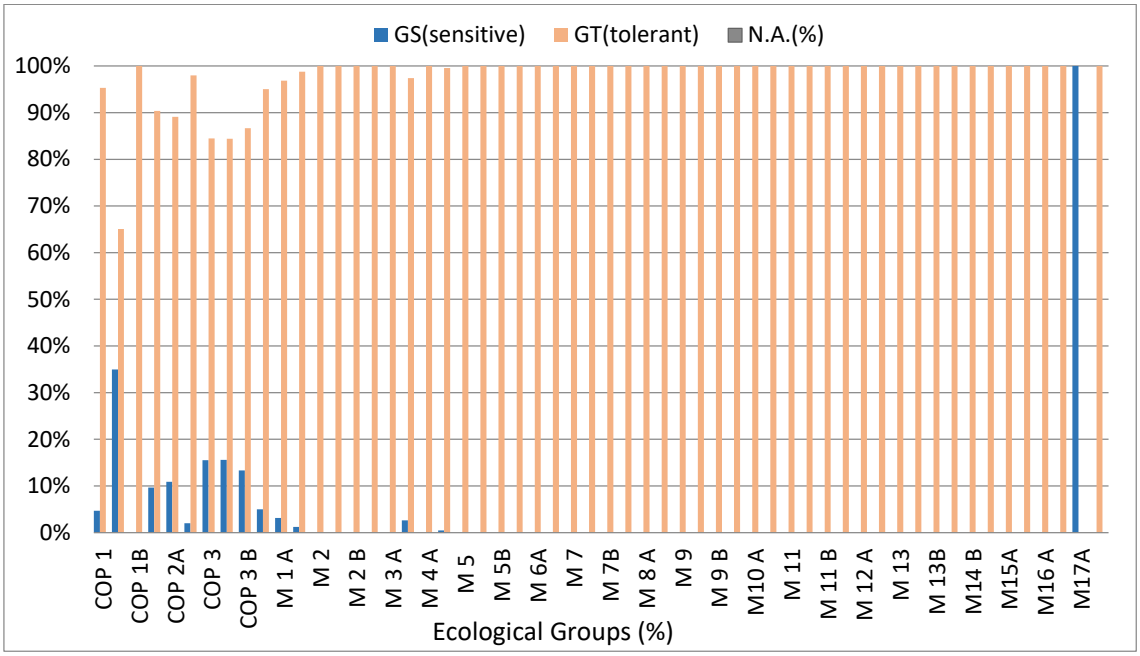


Figure 3.36: Distribution of macrobenthic- Polychaeta based on the ecological sensitivity group assessed through BENTIX index from the Mandovi Estuary.

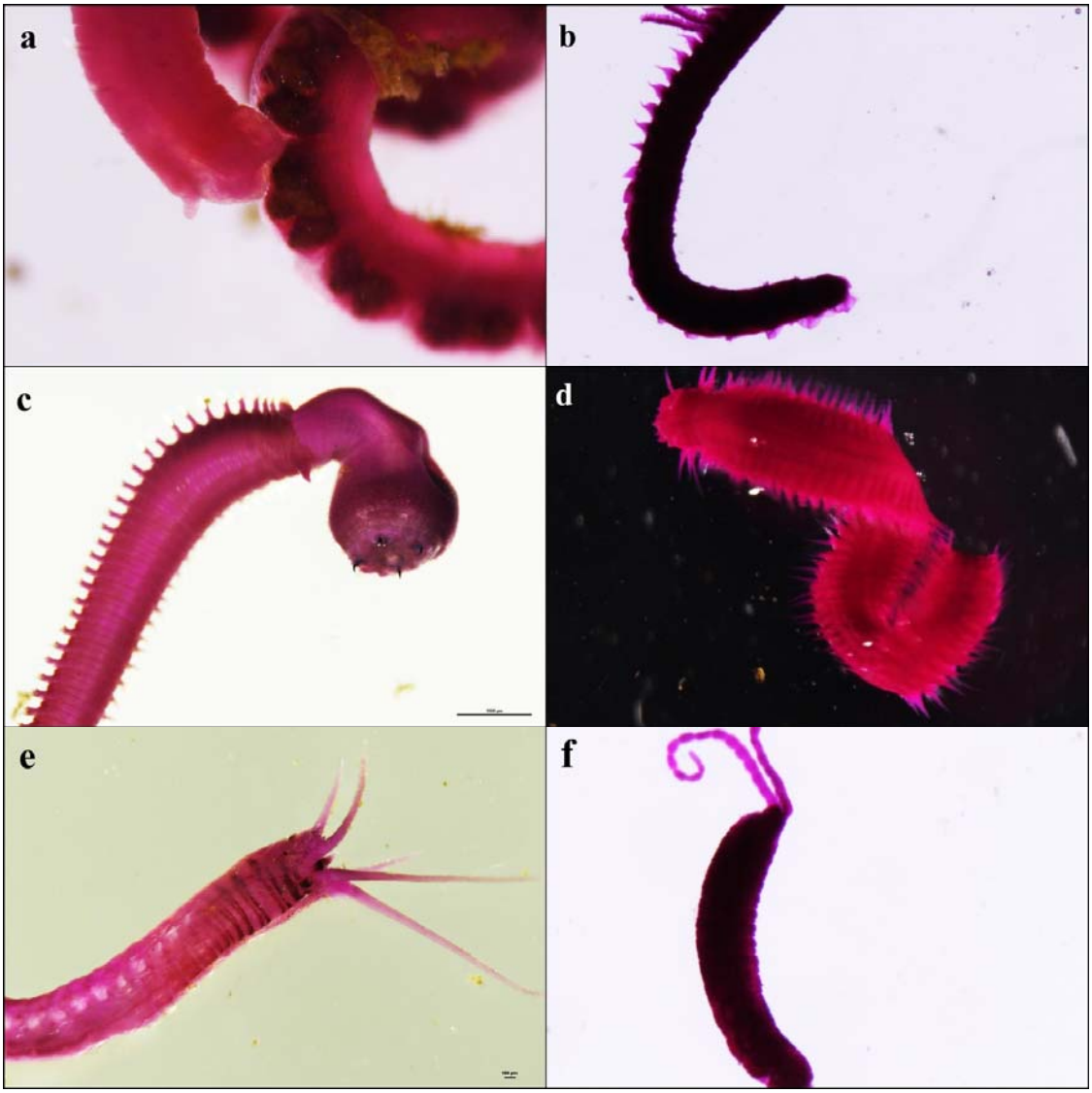


Plate 3.5: a. *Mediomastu scapensis*; b. *Prionospo pinnata*; c. *Glycera alba*; d. *Sigambra* sp.; e. *Onuphis* sp.; f. *Saccocirrus* sp.



Plate 3.6: a. Amphopida; b. Isopoda; c. Bivalvia; d. Shrimp

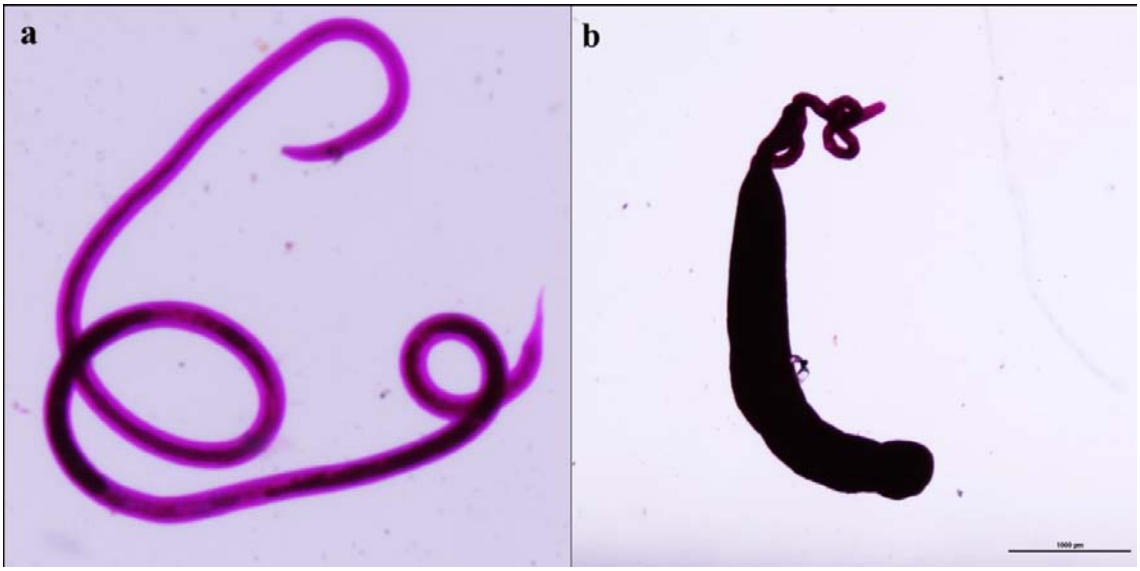


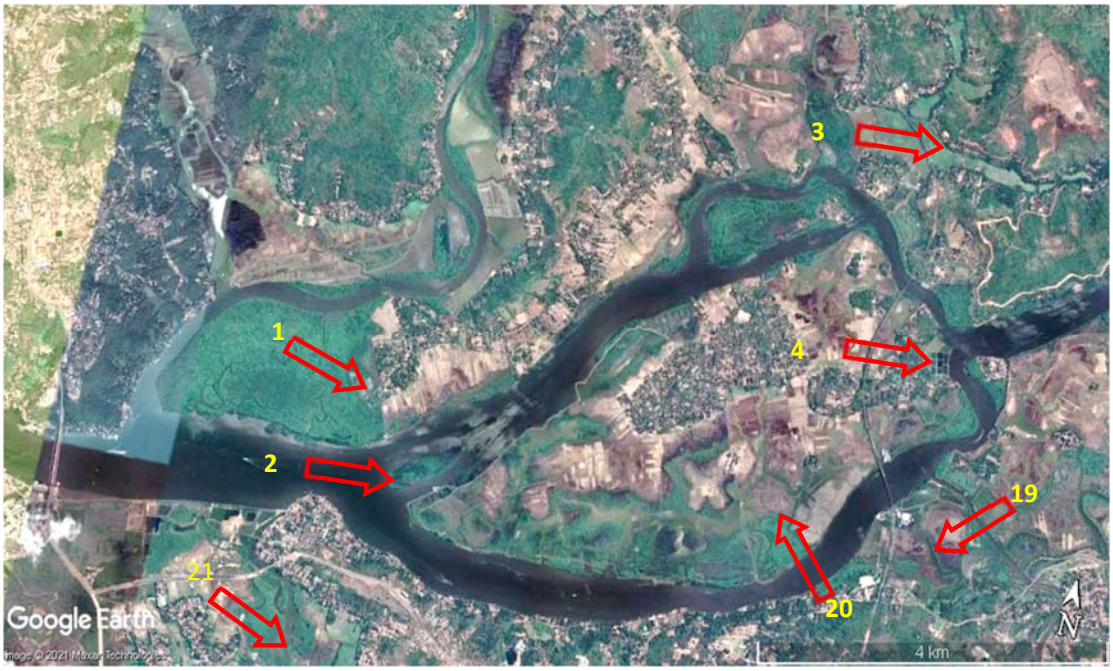
Plate 3.7: a.- Nematode and b.- Nemertea.

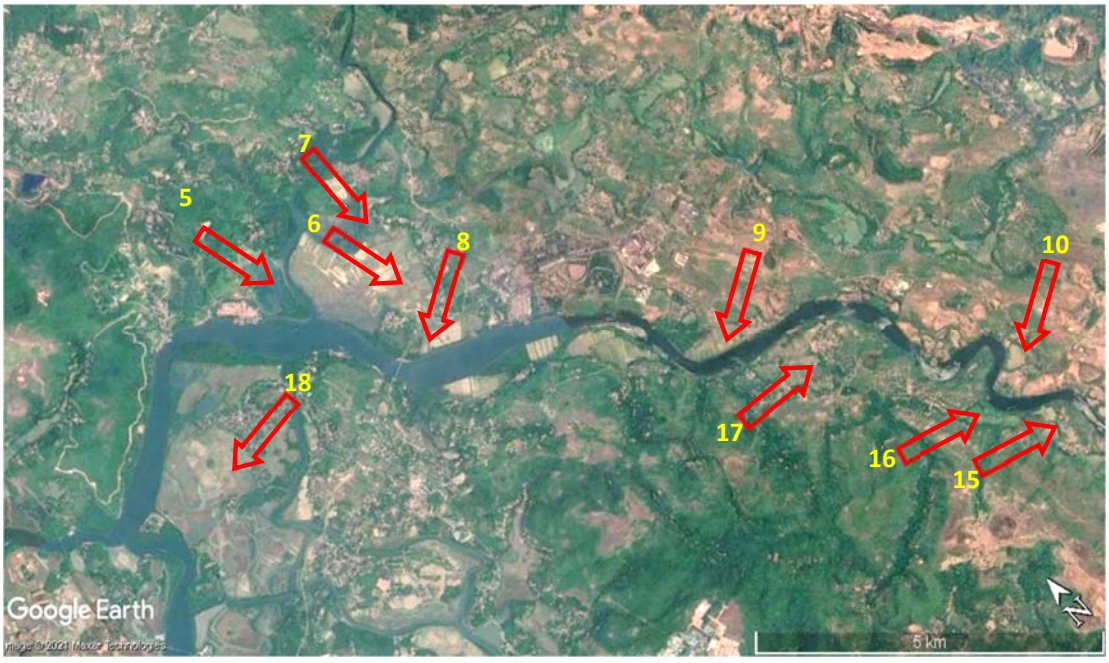
3.10 Land Use Land Cover (LULC)

LISS 4 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 4 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 Mandovi 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 Mandovi river were prepared by using Google earth.


1
2
3
4
19
20
21
Google Earth
4 km
N


5
6
7
8
9
10
15
16
17
18
Google Earth
5 km
N

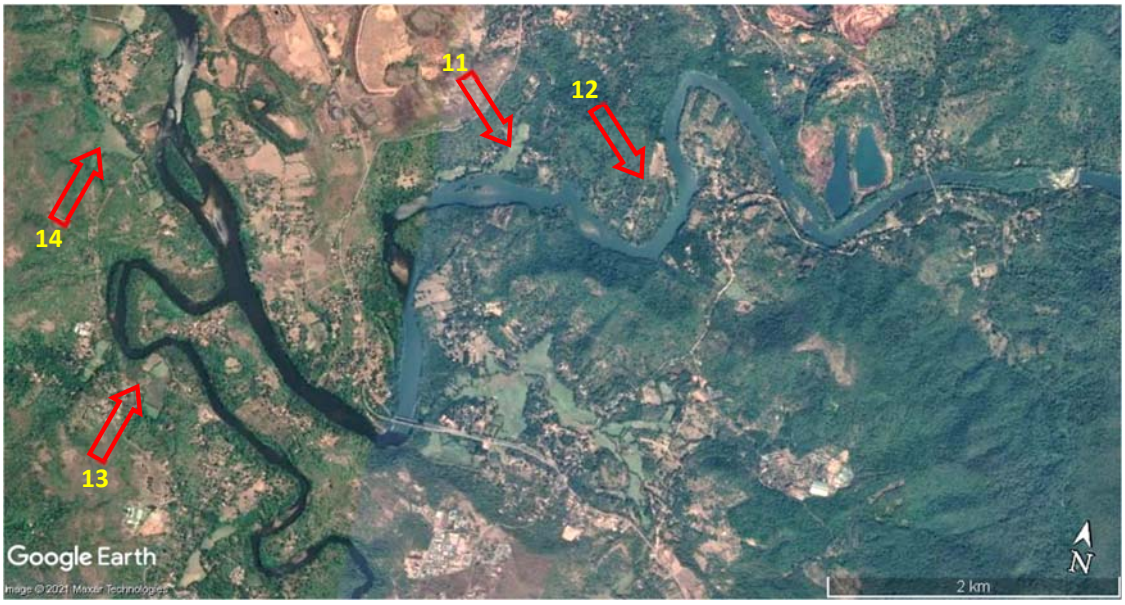
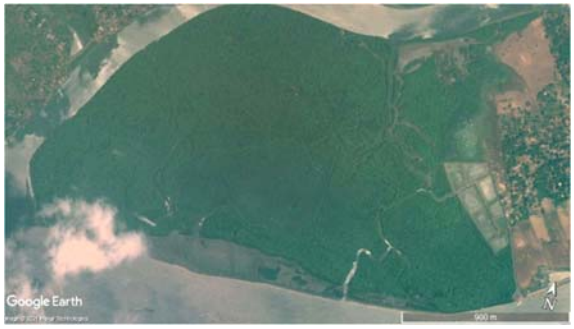


Figure 3.37: Sections of the rivers depicting areas highlighted in the subsequent Figure 3.38 for land use changes.

2010	2021
	
1a	1b
	
2a	2b
	
3a	3b
	
4a	4b



5a



5b



6a



6b



7a



7b



8a



8b





9a	9b
	
10a	10b
	
11a	11b
	
12a	12b
	
13a	13b



14a



14b



15a



15b



16a



16b



17a



17b



Figure 3.38: Areas depicting Land Use Land Cover along the Mandovi Estuary in 2010 and 2021.

In the present study of Land Use Land Change (LULC) cover was observed and obtained by mapping the project area by comparing present scenario with year 2010. Several areas were noted and maps were prepared accordingly along the entire stretch of Mandovi Estuary. A

total of 21 regions were identified and depicted based on land use change. For all the regions two maps were created, representing current scenario and the other depicting 2010 scenario. These maps have been numbered 1-21.

First region lies near the mouth area of the estuary, from the year 2010 to present time it's shown very minimal change, present mangrove cover seems almost similar compared to the images from the year 2010 although the aquaculture ponds seem to abandoned which were observed functional during 2010. Similarly, in the next region there is an increase in mangroves on the island and also on the banks, signs of siltation can also be seen. Image 3 depicts loss of agriculture land which could be due to salt water intrusion. Image 4 denotes use of land for saltpans or aquaculture purpose. Images from (6,7,8,9,10,11,13,14,15,16,17,18 and 19) show that the land used for agriculture earlier is now not in use. This could be the result of salt intrusion and simultaneous increase in the mangrove cover which has grown into a thicket. The areas once utilised for paddy field cultivation, has now turned barren/ fallow probably 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 bunds/embankments, breach in embankments, eroding mudflats or shift in mangrove area to landward side as well as excavation of sand. While images from (5, 12, 20 and 21) denotes the land is used for agricultural purpose, which also indicates the reduction in mangrove cover in these areas and are replaced by paddy fields. This change of land use is noted mostly in the mid-region of the estuary. Furthermore, most of the regions clearly depicts that there is an increase habitation in and around the mangrove region, the structures can be houses, buildings or any sort of manmade structure.

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 3.38). Apart from the major areas depicted in the Figure 3.38 1A-B to 21A-B there are several small land parcels that have been either intruded by saline water or are eroded due to strong monsoon currents.

3.11 Fishery

Fisheries is one of the important economic activities in Goa. Goa has continental shelf of about ten million ha and an actively fished area of 20,000 sq. km. EEZ of Goa has estimated annual potential pelagic yield of 77,660 ton and demersal yield of 1,12,600 tons. A lot of communities in Goa are dependent upon fishing as a source of livelihood in the coastal as well as inland areas. The fish caught is used for both domestic consumption as well as export. Coastal marine waters off Mandovi and Mandovi 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. Fishery data was collected from observations during sampling as well as secondary data was collected from the locals and fishermen community living around Mandovi estuary. Malim jetty is a major fish landing centre on the banks of Mandovi estuary. Commercially important fish varieties such as mackerels, sardines, mullet, catfish, sharks, seerfish, pomfrets, cuttlefish as well as various prawns, crabs and shellfishes are also found in Mandovi estuary and surrounding coastal waters (Table 3.13). The fishery data represents marine, estuarine and freshwater species. The methods of fishing in Mandovi estuary are cast-nets, gill nets, stake nets, hook and line, shore seine (Rapon), purse seine, trawling and free diving for the collection of clams oysters and green mussels. The shell fishery is common fishing practice used by the local people. Bivalve clams, *Meritrix casta* and *Paphia malbarica* were commonly found in the estuary. These bivalves support the livelihood of locals' dependent on them. They are 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.



Plate 3.8 Fish species observed at the mouth of Mandovi estuary [A. *Penaeus monodaon*; B. *Stolephorus indicus*; C. *Sphyraena jello* D. *Portunus pelagicus*]

Table 3.13: Fish diversity from Mandovi Estuary

Families	Species	Common name	Vernacular name	Habitat class
Upper Estuary				
Cyprinidae	*Dawkinsia filamentosa*	Blackspot barb		Demersal
Cyprinidae	*Devario malabaricus*	Malabar danio		Demersal
Cyprinidae	*Pethia setnai*	Pethia		Demersal
Cyprinidae	*Rasbora daniconius*	Slender rasbora		Demersal
Cyprinidae	*Garra mullya*	Sucker fish		Demersal
Cyprinidae	*Systomus sarana*	Olive barb		Demersal
Cyprinidae	*Puntius mahecola*	Mahecola barb		Demersal
Cyprinidae	*Cabdio morar*	Morari		Demersal
Tetraodontidae	*Chelonodonpatoca*	milkspotted puffer	Bebo	Pelagic

Cobitidae	*Lepidocephalichthys thermalis*	Common spiny loach		Demersal
Middle Estuary				
Gobiidae	*Glossogobius giuris*	Tank goby	Khorsani	Demersal
Aplocheilidae	*Aplocheilus lineatus*	Striped panchax		Demersal
Mugilidae	*Mugil cephalus*	Flathead grey mullet	Shevtto	Demersal
Tetraodontidae	*Dichotomyctere nigroviridis*	Spotted green pufferfish	Bebo	Demersal
Lower Estuary				
Oxudercidae	*Boleophthalmus sp.*	Mudskipper	Kheldho	Demersal
Mugilidae	*Mugil cephalus*	Flathead grey mullet	Shevtto	Demersal
Gobiidae	*Glossogobius giuris*	Tank goby	Khorsani	Demersal
Gobiidae	*Acentrogobius nebulosus*	Shadow goby		Demersal
Sciaenidae	*Johnieops belangerii*	Croaker	Dhodiyare	Demersal
Sciaenidae	*Johnius borneensis*	Croaker	Dhodiyare	Demersal
Sciaenidae	*Johnius carouna*	Caroun croaker	Dhodiyare	Demersal
Sciaenidae	*Johnius dussumieri*	Croaker	Dhodiyare	Demersal
Sciaenidae	*Johnius macrorhynus*	Croaker	Dhodiyare	Demersal
Sciaenidae	*Otolithes ruber*	Tiger toothed croaker	Dhodiyare	Demersal
Sciaenidae	*Otolithes argenteus*	Croaker	Dhodiyare	Demersal
Lactariidae	*Lactarius lactarius*	False trevally	Saundallo	Pelagic
Clupeidae	*Sardinella longiceps*	Indian oil sardine	Tarle	Pelagic
Clupeidae	*Sardinella fimbriata*	Fringscale sardine	Pedi	Pelagic
Leiognathidae	*Secutor insidiator*	Pugnose pony fish	Kapi	Demersal
Leiognathidae	*Secutor ruconius*	Deep pugnose pony fish	Kapi	Demersal
Leiognathidae	*Leiognathus brevirostris*	Silver bellies	Kapi	Demersal
Leiognathidae	*Leiognathus blochii*	Silver bellies	Kapi	Demersal
Leiognathidae	*Leiognathus bindus*	Silver bellies	Kapi	Demersal
Leiognathidae	*Leiognathus splendens*	Silver bellies	Kapi	Demersal

Leiognathidae	*Leiognathus daura*	Silver bellies	Kapi	Demersal
Carangidae	*Alepes kleinii*	Razorbellyscad	-	Pelagic
Carangidae	*Parastromateus niger*	Black pomfret	Paplet	Pelagic
Carangidae	*Carangoides ferdau*	Blue trevally	Konkor	Pelagic
Chanidae	*Chanos chanos*	Milkfish	Gholsi	Pelagic
Carcharhinidae	*Carchachrinus sp.*		Vattu	Pelagic
Stromatidae	*Pampus chinensis*	Chinese pomfret	Paplet	Pelagic
Stromatidae	*Pampus argenteus*	Silver pomfret	Paplet	Pelagic
Stromatidae	*Rastrelliger karagurata*	Indian mackerel	Bangdo	Pelagic
Polynemidae	*Leptomelanosoma indicum*	Indian threadfin	Rawas	Demersal
Engraulidae	*Stolophorus indicus*	Indian anchovy	Dindvus	Pelagic
Engraulidae	*Thryssa malabarica*	Malabar thryssa	Khavali	Pelagic
Congridae	*Bathy congrusnasicus*	Eel	Vam	Demersal
Chirocentridae	*Chirocentrus dorab*	Wolf herring	Karli	Pelagic
Pristigasteridae	*Opisthopterus tardoore*	Tardoore	Kateri	Pelagic
Platycephalidae	*Eurycephalus carbunculus*	Papilose flathead	-	Demersal
Ambassidae	*Ambassis gymnocephalus*	Bald glassy	Burantte	Pelagic
Ambassidae	*Ambassis urotaenia*	Banded-tail glassy perchlet	Burantte	Pelagic
Nemipteridae	*Nemipterus japonicas*	Japanese threadfin bream	Rano	Demersal
Lutjanidae	*Lutjanus campechanus*	Red snapper	Tamoshi	Pelagic
Serranidae		Grouper	Palu	Pelagic
Cichlidae	*Etroplus suratensis*	Pearl spot	Kalunder	Benthopelagic
Terapontidae	*Terapon jarbua*	Crescent grunter	Korkoro	Pelagic
Terapontidae	*Terapon puta*	spiny-checked grunter	Korkoro	Pelagic
Gerridae	*Gerres filamentosus*	Silver biddy	Shetuk	Demersal

Gerridae	*Gerres limbatus*	Silver biddy	Shetuk	Demersal
Gerridae	*Gerres oyena*	Silver biddy	Shetuk	Demersal
Latidae	*Lates calcarifer*	Giant sea perch	Chonak	Demersal
Megalopidae	*Megalops cyprinoides*	Indo-Pacific tarpon	Ker	Pelagic
Muraenesocidae	*Muraenesox bagio*	Common pike conger	Toem-Baiem	Demersal
Muraenesocidae	*Congresox talabonoides*	Indian pike conger	Divodd Baiem	Demersal
Sillaginidae	*Sillago sihama*	Silver whiting	Mudoshi	Demersal
Polynemidae	*Polydactylusplebeius*	Stripped threadfin	Ravas	Pelagic
Scombridae	*Scomberomorus commerson*	seerfish	Visvonn	Pelagic
Scombridae	*Scomberomorus guttatus*	seerfish	Visvonn	Pelagic
Sparidae	*Chyrsophrys datnia*		Palu	
Sphyraenidae	*Sphyraena jello*	Pickhandle barracuda	Tonki	Pelagic
Triacanthidae	*Tricanthus biaculeatus*	Short-nosed tripodfish	Chamat	Demersal
Scatophagidae	*Scatophagus argus*	Spotted scat	Bannsire	Pelagic
Ariidae	*Arius jella*	Blackfin sea catfish	Sangot	Demersal
Ariidae	*Arius arius*	threadfin sea catfish	Sangot	Demersal
Ariidae	*Arius caelatus*	Spotted catfish	Sangot	Demersal
Ariidae	*Arius platystomus*	Flatmouth sea catfish	Sangot	Demersal
Ariidae	*Arius tenuispinis*	Thinspine sea catfish	Sangot	Demersal
Ariidae	*Arius thalassinus*	Giant catfish	Sangot	Demersal
Ariidae	*Arius venosus*	Veined catfish	Sangot	Demersal
Dasyatidae	*Himantura uarnak*	Reticulate whipray	Vagollim	Demersal
Dasyatidae	*Himantura imbricata*	Scaly whipray	Xevnne Vagollim	Demersal
Trichiuridae	*Lepturacanthus savala*	Ribbon fish	Baye	Pelagic
Trichiuridae	*Trichiurus lepturus*	Ribbon fish	Baye	Pelagic
Solidae	*Synapturaalbo maculata*	Kaup's sole fish	Lepo	Demersal
Pleuronectidae		Flounder	Lepo	Demersal
Cynoglossidae	*Cynoglossus arel*	Sole fish	Lepo	Demersal

Cynoglossidae	*C. macrostomus*	Malabar tongue sole	Lepo	Demersal
Penaeidae	*Penaeus monodon*	Tiger shrimp	Vaghi	Demersal
Penaeidae	*Fenneropenaeus merguensis*	Banana prawn	Safed sungata	Demersal
Penaeidae	*Metapenaeus affinis*	Jinga shrimp	Sungat	Demersal
Penaeidae	*Metapenaeus dobsonii*	Kadal shrimp	Sungat	Demersal
Penaeidae	*Meapeaneus monoceros*	Speckled shrimp	Sungat	Demersal
Penaeidae	*Parapenaeopsis hardwickii*	Spear shrimp	Kandianim	Demersal
Palaemonidae	*Palaemon stylifera*		Poting	Demersal
Sergestidae	*Acetes spp*		Galmo	Demersal
Portunidae	*Scylla serrata*	Mud crab	Kulli	Demersal
Portunidae	*Scylla olivacea*	Mud crab	Kulli	Demersal
Portunidae	*Charybdis lucifera*		Kulli	Demersal
Portunidae	*Charybdis (Charybdis) natator*		Kulli	Demersal
Portunidae	*Portunuss anguinolentus*	Three spot swimming crab	Tin doyanchi kurli	Demersal
Portunidae	*Portunus pelagicus*	Blue swimming crab	Padyachi kurli	Demersal
Portunidae	*Charybdis feriatus*	Crucifix crab	Khrusachi kurli	Demersal
Calappidae	*Matuta lunaris*	Moon crab	Bhamburte	Demersal
Dotillidae	*Dotilla myctiroides*	Sand bubbler crab		Demersal
Ocypodidae	*Uca sp.*	Fiddler crab		Demersal
Ocypodidae	*Gelasimus vocans*	Fiddler crab		Demersal
Oziidae	*Epixanthus frontalis*			Demersal
Pilumnidae	*Heteropanope glabra*			Demersal
Grapsidae	*Sesarma sp.*	Marsh crab		Demersal
Grapsidae	*Metopograpsus frontalis*			Demersal
Lithodidae	*Calappalophos*	Box crab	-	Demersal

Squillidae	*Oratosquilla aquinquedentata*	Mantis shrimp	Luchi	Demersal
Diogenidae	*Pagurus sp*	Hermit crab	-	Demersal
Xanthidae	*Leptodius exaratus*		-	Demersal
Loliginidae	*Uroteuthis duvauceli*	Indian squid	Manki	Demersal
Sepiidae	*Sepia* sp.	Cuttle fish	Bebo	Demersal
Cyrenidae	*Villoritacyprinoides*	Black clams	Khube	Benthic
Cyrenidae	*Polymesoda erosa*	Mud clam	Khube	Benthic
Mactridae	*Mactra sp.*			Benthic
Veneridae	*Meretrix meretrix*	Asiatic hard clam	Tissryo	Benthic
Veneridae	*Meretrix casta*	Backwater hard clam	Tissryo	Benthic
Veneridae	*Timoclea scabra*			Benthic
Veneridae	*Gafrarium pectinatum*			Benthic
Ostreidae	*Paphia malabarica*	Venus clams	Khube	Benthic
Ostreidae	*Paphia textilis*	Venus clams	Khube	Benthic
Ostreidae	*Crassostrea madrasensis*	Oyster	Kalva	Benthic
Ostreidae	*Crassostrea gigas*	Oyster	Kalva	Benthic
Ostreidae	*Crassostrea gryphoides*	Oyster	Kalva	Benthic
Ostreidae	*Saccostrea cucullata*	Oyster	Kalva	Benthic
Mytilidae	*Perna viridis*	Asian green mussel	Shenanyo	Benthic
Mytilidae	*Modiolus sp.*		Shenanyo	Benthic
Tellinidae	*Tellina sp.*			Benthic
Littorinidae	*Littorina scabra*			Benthic
Littorinidae	*Littorina intermedia*			Benthic
Melongenidae	*Hemifususpugilinus*	Sea snail	-	Benthic
Turritellidae	*Turritella acutangula*	Screw shell	Congali	Benthic
Rostellariidae	*Tibia curta*	Indian tibia	Congali	Benthic
Cerithiidae	*Cerithium echinatum*			Benthic
Burside	*Bufonaria rana*	Frog shell	-	Benthic
Muricidae	*Murex aduncospinosus*	Spine murex	-	Benthic
Naticidae	*Natica picta*	Moon snail		Benthic
Naticidae	*Notocochlis tigrina*	Moon snail		Benthic
Babyloniidae	*Babylonia spirata*	Whelks	-	Benthic

Conidae	*Conus* sp.	Cone shell	-	Benthic
Potamididae	*Pirenella cingulata*	Horn snail		Benthic
Potamididae	*Telescopium telescopium*	Horn snail		Benthic
Trochidae	*Umbonium vestiarium*	Button tops		Benthic
Astropectinidae	*Astropectenindicus*	Star fish	-	Benthic
Rhzostomatidae	*Rhopilema* spp.	Jelly fish	Zar	Pelagic

3.12 Reptiles & Mammals

Mandovi Estuary supports a variety of reptiles and mammals such crocodiles, snakes, turtles, otters and dolphins. The estuarine crocodile *Crocodylus palustris* is found along the banks of Mandovi estuary. The Indian Ocean humpback dolphin and the Finless porpoise are found in the coastal waters off Mandovi and are a major tourist attraction. The smooth coated otter is also spotted on the banks of Mandovi especially around Chorao Island. Sea snake such as *Enhydrina schistosa and Hydrophis curtus* are also found commonly in the Mandovi estuary. Mammals are mainly represented by Otters, jackals and Indian flying fox.These mammals visit mangroves for shelter, breeding or feeding on molluscs, crabs, fishes and other crustaceans (Table 3.14). The animals that belong to the Schedule I species are the highly protected species and falls in the priority list. Hunting of scheduled species is strictly prohibited and animal trading, trophies and buying and possession of wild animals is illegal (Wildlife Protection Act, 1972).

Table 3.14: List of Reptiles and Mammals around Mandovi Estuary

Sr. no.	Common name	Scientific name	IUCN status	Wildlife Protection Act (1972)
1	Indian flapshell turtle	*Lissemyspunctate punctata*	Least concern	Schedule I
2	Mugger crocodile	*Crocodylus palustris*	Vulnerable	Schedule I
3	Indian rock python	*Python molurus*	Near threatened	Schedule I
4	Beaked sea snake	*Enhydrina schistosa*	Least concern	Schedule IV
5	Short sea snake	*Hydrophis curtus*	Least concern	Schedule IV
6	Finless porpoise	*Neophocaena phocaenoides*	Vulnerable	Schedule I
7	Indian ocean humpback dolphin	*Sousa plumbea*	Endangered	Schedule I

8	Smooth-coated otter	*Lutrogale perspicillata*	Vulnerable	Schedule II
9	Asian small-clawed otter	*Aonyx cinereus*	Vulnerable	Schedule I
10	Indian flying fox	*Pteropus medius*	Least concern	Schedule IV
12	Dog faced water snake	*Cerberus rynchops*	Endangered	Schedule II
13	Bengal monitor lizard	*Varanus bengalensis*	Least concern	Schedule I (Part II)
14	Checkered keelback	*Xenochrophis piscato*	Least concern	Schedule II (Part II)
15	Indian jackal	*Canis aureus indicus*	Least concern	Schedule II (Part I)

3.13 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, and Egrets etc. were found feeding in the mangrove mudflats. Mandovi estuary is a 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 shore birds like Gulls were observed off the coast. Mandovi 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 and river islands in the upper estuary. Eroded vertical banks of the upper stretches of the banks have burrow nests mostly by kingfishers and bee-eaters. List of birds found in and around Mandovi estuary (Table 3.15). Hunting of birds which falls under Schedule-I species is strictly prohibited (Act No.09 of wildlife Protection Act, 1972) Eurasian spoonbill falls under schedule I species in the list. All birds of prey in India are categorized has Schedule-I Species which includes, White bellied sea Eagle, Brahminy kite, Black kite and Osprey.

Table 3.15: List of Bird species around Mandovi Estuary

Sr.No.	Common name	Scientific name	IUCN status	Wildlife Protection Act 1972
1	Collared Kingfisher	*Todiramphus chloris*	Least Concern	Schedule IV

2	Pied kingfisher	*Ceryle rudis*	Least Concern	Schedule IV
3	Brahminy Kite	*Haliastur indus*	Least Concern	Schedule I
4	Black kite	*Milvus migrans*	Least Concern	Schedule I
5	White wagtail	*Motacilla alba*	Least Concern	Schedule IV
6	Indian Cormorant	*Phalacrocorax fuscicollis*	Least Concern	Schedule IV
7	Little Cormorant	*Microcarbo niger*	Least Concern	Schedule IV
8	Chestnut-headed bee-eater	*Merops leschenaulti*	Least Concern	Schedule IV
9	Blue-bearded Bee-eater	*Nyctyornis athertoni*	Least Concern	Schedule IV
10	Small green bee eater	*Merops orientalis*	Least Concern	Schedule IV
11	White-throated Kingfisher	*Halcyon smyrnensis*	Least Concern	Schedule IV
12	Stork billed kingfisher	*Pelargopsis capensis*	Least Concern	Schedule IV
13	White breasted waterhen	*Amaurornis phoenicurus*	Least Concern	Schedule IV
14	Striated Heron	*Butorides striata*	Least Concern	Schedule IV
15	Indian Pond-Heron	*Ardeola grayii*	Least Concern	Schedule IV
16	Purple Heron	*Ardea purpurea*	Least Concern	Schedule IV
17	Grey Heron	*Ardea cinerea*	Least Concern	Schedule IV
18	Black crowned night heron	*Nycticorax nycticorax*	Least Concern	Schedule IV
19	Lesser whistling duck	Dendrocygna javanica	Least Concern	Schedule IV
20	Black-tailed Godwit	*Limosa limosa*	Near threatened	Schedule IV
21	Eurasian curlew	*Numenius arquata*	Near threatened	Schedule IV
22	Yellow-wattled Lapwing	*Vanellus malabaricus*	Least Concern	Schedule IV
23	Red-wattled Lapwing	*Vanellus indicus*	Least Concern	Schedule IV
24	Common Redshank	*Tringa totanus*	Least Concern	Schedule IV
25	Intermediate Egret	*Ardea intermedia*	Least Concern	Schedule IV

26	Greater Racket-tailed Drongo	*Dicrurus paradiseus*	Least Concern	Schedule IV
27	Little Egret	*Egretta garzetta*	Least Concern	Schedule IV
28	White ibis	*Threskiornis melanocephalus*	Near Threatened	Schedule IV
29	Little grebe	*Tachybaptus ruficollis*	Least Concern	Schedule IV
30	Cinnamon bittern	*Ixobrychus cinnamomeus*	Least Concern	Schedule IV
31	Glossy ibis	*Plegadis falcinellus*	Least Concern	Schedule IV
32	Eurasian spoonbill	*Platalea leucorodia*	Least Concern	Schedule I
33	Ruddy Turnstone	*Arenaria interpres*	Least Concern	Schedule IV
34	Common Sandpipers	*Actitis hypoleucos*	Least Concern	Schedule IV
35	Caspian Gull	*Larus cachinnas*	Least Concern	Schedule IV
36	Heuglin's Gull	*Larus heuglini*	Least Concern	Schedule IV
37	Steppe Gull	*Larus (heuglini) barabensis*	Least Concern	Schedule IV
38	Pallas's Gull	*Ichthyaetus ichthyaetus*	Least Concern	Schedule IV
39	Brown headed Gull	*Chroicocephalus brunnicephalus*	Least Concern	Schedule IV
40	Black headed Gull	*Chroicocephalus ridibundus*	Least Concern	Schedule IV
41	Gull-billed tern	*Gelochelidon nilotica*	Least Concern	Schedule IV
42	Greater Crested Tern	*Thalasseus bergii*	Least Concern	Schedule IV
43	Greater spotted eagle	*Clanga clanga*	Vulnerable	Schedule IV
44	White bellied Sea Eagle	*Haliaeetus leucogaster*	Least Concern	Schedule I
45	Osprey	*Pandion haliaetus*	Least Concern	Schedule I
46	Common snipe	*Gallinago gallinago*	Least Concern	Schedule IV
47	Greater Painted snipe	*Rostratula benghalensis*	Least Concern	Schedule IV
48	Western Reef-egret	*Egretta gularis*	Least Concern	Schedule IV
49	Great Egret	*Ardea alba*	Least Concern	Schedule IV

50	Cattle Egret	*Bubulcus coromandus*	Least Concern	Schedule IV
51	Common Kestrel	*Falco tinnunculus*	Least Concern	Schedule IV
52	Kentish plover	*Charadrius alexandrinus*	Least Concern	Schedule IV
53	Lesser Sand Plover	*Charadrius mongolus*	Least Concern	Schedule IV
54	Greater Sand Plover	*Charadrius leschenaultii*	Least Concern	Schedule IV
55	Caspian Sand Plover	*Charadrius asiaticus*	Least Concern	Schedule IV
56	Common Redshank	*Tringa totanus*	Least Concern	Schedule IV
57	Common Greenshank	*Tringa nebularia*	Least Concern	Schedule IV
58	Common Sandpiper	*Actitis hypoleucos*	Least Concern	Schedule IV
59	Ruddy Turnstone	*Arenaria interpres*	Least Concern	Schedule IV
60	Terek sandpiper	*Xenus cinereus*	Least Concern	Schedule IV
61	Woolly-necked Stork.	*Ciconia episcopus*	Vulnerable	Schedule IV
62	Asian Openbill	*Anastomus oscitans*	Least Concern	Schedule IV
63	White stork	*Ciconia ciconia*	Least Concern	Schedule IV
64	Painted stork	*Mycteria leucocephala*	Near Threatened	Schedule IV
65	Lesser Adjutant	*Leptoptilos javanicus*	Vulnerable	Schedule IV
66	Brown fish owl	*Ketupa zeylonensis*	Least Concern	Schedule IV
67	Great cormorant	*Phalacrocorax carbo*	Least Concern	Schedule IV
68	Oriental darter	*Anhinga melanogaster*	Near Threatened	Schedule IV
69	Blue Tailed bee-eater	*Merops Philippnus*	Least Concern	Schedule IV
70	Indian spot-billed duck	*Anas poecilorhyncha*	Least Concern	Schedule IV
71	Brahminy duck	*Tadorna ferruginea*	Least Concern	Schedule IV
72	Common teal	*Anas crecca*	Least Concern	Schedule IV
73	Northern pintail	*Anas acuta*	Least Concern	Schedule IV
74	Northern Shoveler	*Spatula clypeata*	Least Concern	Schedule IV

75	Garganey	*Spatula querquedula*	Least Concern	Schedule IV
76	Eusrasian Wigeon	*Mareca penelope*	Least Concern	Schedule IV
77	Cotton Pygmy-goose	*Nettapus coromandelianus*	Least Concern	Schedule IV
78	Gadwall	*Marcea strepera*	Least Concern	Schedule IV
79	Spotted Owlet	*Athene brama*	Least Concern	Schedule IV
80	Ashy Prinia	*Prinia socialis*	Least Concern	Schedule IV
81	Plain Prinia	*Prinia inornata*	Least Concern	Schedule IV
82	Common Tailor bird	*Orthotomus sutoris*	Least Concern	Schedule IV
83	White rumped munia	*Lonchura striata*	Least Concern	Schedule IV
84	Tricoloured munia	*Lonchura malacca*	Least Concern	Schedule IV
85	Scaly breasted munia	*Lonchura punctulata*	Least Concern	Schedule IV
86	Wire tailed swallow	*Hirundo smithii*	Least Concern	Schedule IV
87	Red rumped swallow	*Cecropis daurica*	Least Concern	Schedule IV
88	Black winged Stilt	*Himantopus himantopus*	Least Concern	Schedule IV
89	Pied Avocet	*Recurvirostra avosetta*	Least Concern	Schedule IV
90	Wood sandpiper	*Tringa glareola*	Least Concern	Schedule IV
91	Marsh sandpiper	*Tringa stagnatilis*	Least Concern	Schedule IV
92	Red avadavat	*Amandava amandava*	Least Concern	Schedule IV
93	White browed wagtail	*Motacilla maderaspatensis*	Least Concern	Schedule IV
94	Western yellow wagtail	*Motacilla flava*	Least Concern	Schedule IV
95	Ruddy breasted crake	*Zapornia fusca*	Least Concern	Schedule IV
96	Common moorhen	*Gallinula chloropus*	Least Concern	Schedule IV
97	Watercock	*Gallicrex cinerea*	Least Concern	Schedule IV
98	Temminck's stint	*Calidris temminckii*	Least Concern	Schedule IV
99	Ruff	*Calidris pugnax*	Least Concern	Schedule IV

100	Whimrel	*Numenius phaeopus*	Least Concern	Schedule IV
101	Black-capped Kingfisher	*Halcyon pileata*	Least Concern	Schedule IV

3.14 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 estuary 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 estuary, the vegetation and plantations are unsuccessful in protecting the banks from erosion. In the stretches of the estuary 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 estuary 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 estuary. The present land use of the riparian zone of the estuary in shown in Figure 3.20.

The riparian vegetation along the banks of the estuary 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-goa.pdf). The area is predominantly planted with *Cocos nucifera* and mostly represented by species of *Terminalia* spp., *Ficus* spp., *Careya arborea, Mangifera indica, Anacardium occidentale, Xylia xylocarpa, Caesalpinia* spp. and *Bombax ceiba* along with several species of bamboos, shrubs, herbs and grasses.

The estuary bank in the upstream areas (with mostly narrow mudflats) has grasses 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-goa.pdf).

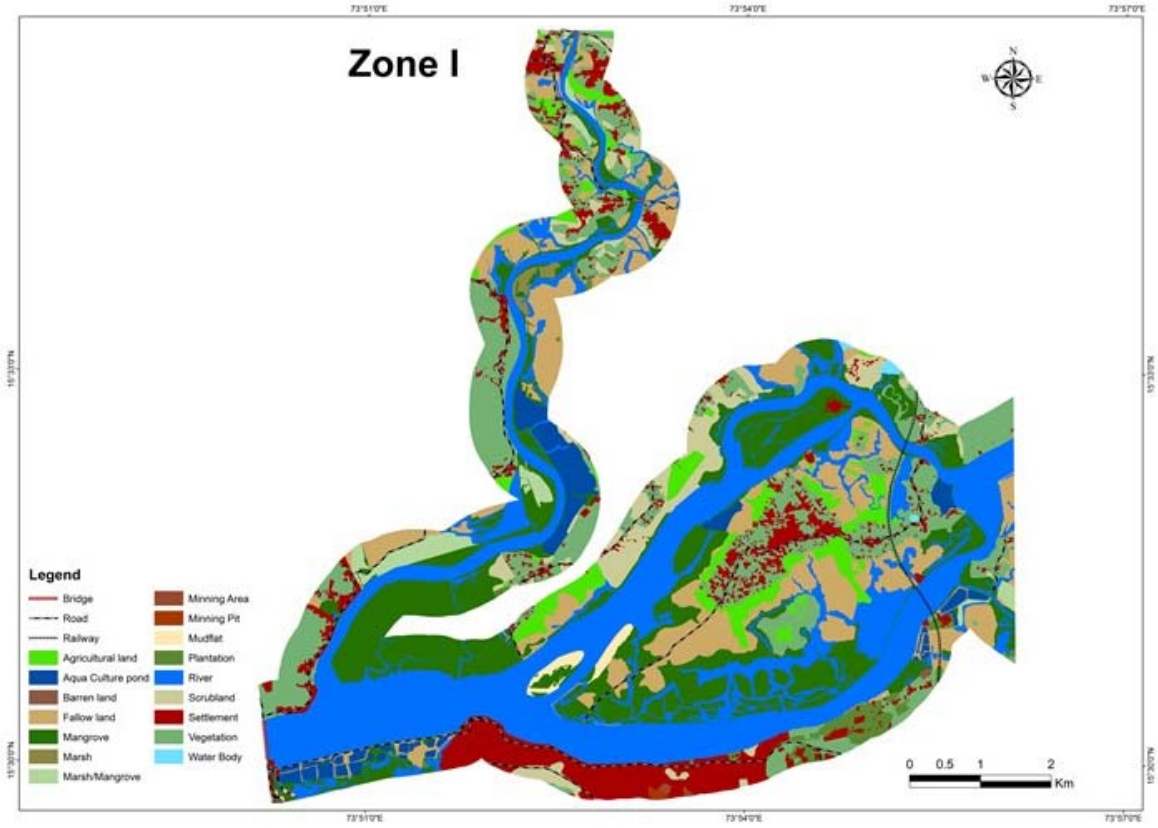
Khazan Land

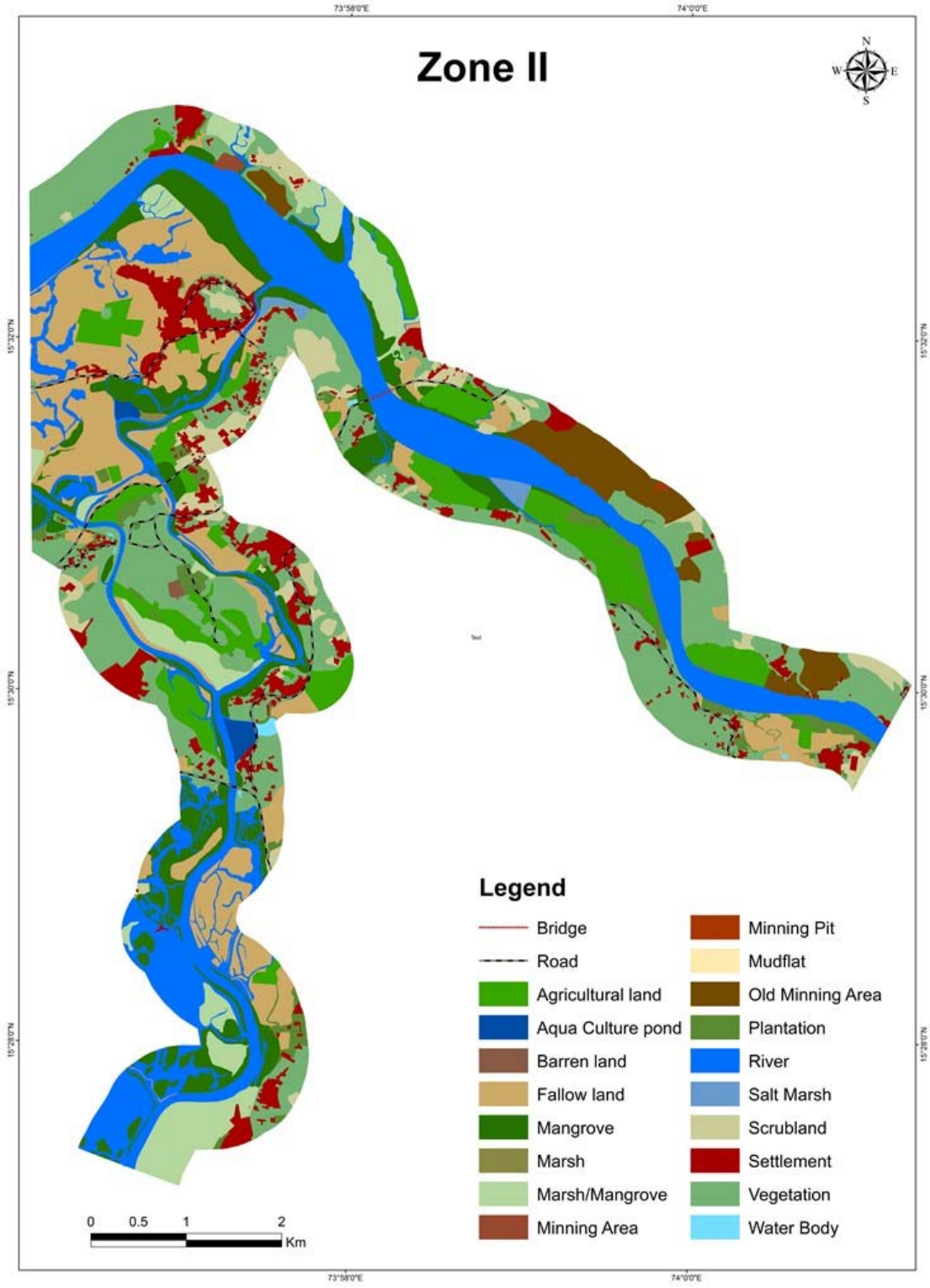
Khazans are low lying agricultural lands that have been reclaimed by using salinity control structures from mangrove fringed estuaries. These saline low-lying, flat lands were originally mangrove swamps or mudflats lying along both the banks of the rivers of Goa. The presence of peat deposits at depths of 1.5- 2.5 m in these fields suggests they were covered with a thick growth of mangrove forests some 6000 years ago (Mascarenhas and Chauhan 1998). The

early settlers who came to this place reclaimed these fertile lands by constructing bundhs all along the estuary and cultivating it. Similar coastal lands like khaznam with paddy cultivation and fish farming are found in other parts of India such as Khar in Maharashtra, gazzani in Karnataka and Pokkali in Kerala.

Khazan lands are carefully designed topo-hydro-engineered agricultural ecosystem. The important aspects of the structure of the land are based on the principle of salinity regulation and knowledge of tidal clock as well as distance from nearest watershed and tidal estuary. It is dependent upon the availability and flow of fresh water and saline water. Excess freshwater can cause growth of weeds and unwanted vegetation leading to eutrophication while surplus saline water flow makes the land useless for agriculture. The balance of these factors promotes a system that allows for agriculture, fishing as well as a balanced flow to the land (Kamat, 2004).

The Mandovi Estuary supports a number of Khazan lands along its banks in various places such as Chorao, Divar and St. Estevam and Vanxim (Kamat and Bhonsle, 2007). These promote the economic upliftment of the local community through various economic activities such as agriculture, horticulture, fisheries, and food production such as dried fish, salt production recreation and tourism. These activities promote self-sufficiency to the local people who are dependent on them.


Zone I
N
W
E
S
Legend
Bridge
Road
Railway
Agricultural land
Aqua Culture pond
Barren land
Fallow land
Mangrove
Marsh
Marsh/Mangrove
Minning Area
Minning Pit
Mudflat
Plantation
River
Scrubland
Settlement
Vegetation
Water Body
0 0.5 1 2
Km


Zone II
N
W
E
S
Legend
Bridge
Road
Agricultural land
Aqua Culture pond
Barren land
Fallow land
Mangrove
Marsh
Marsh/Mangrove
Minning Area
Minning Pit
Mudflat
Old Minning Area
Plantation
River
Salt Marsh
Scrubland
Settlement
Vegetation
Water Body
0 0.5 1 2
Km

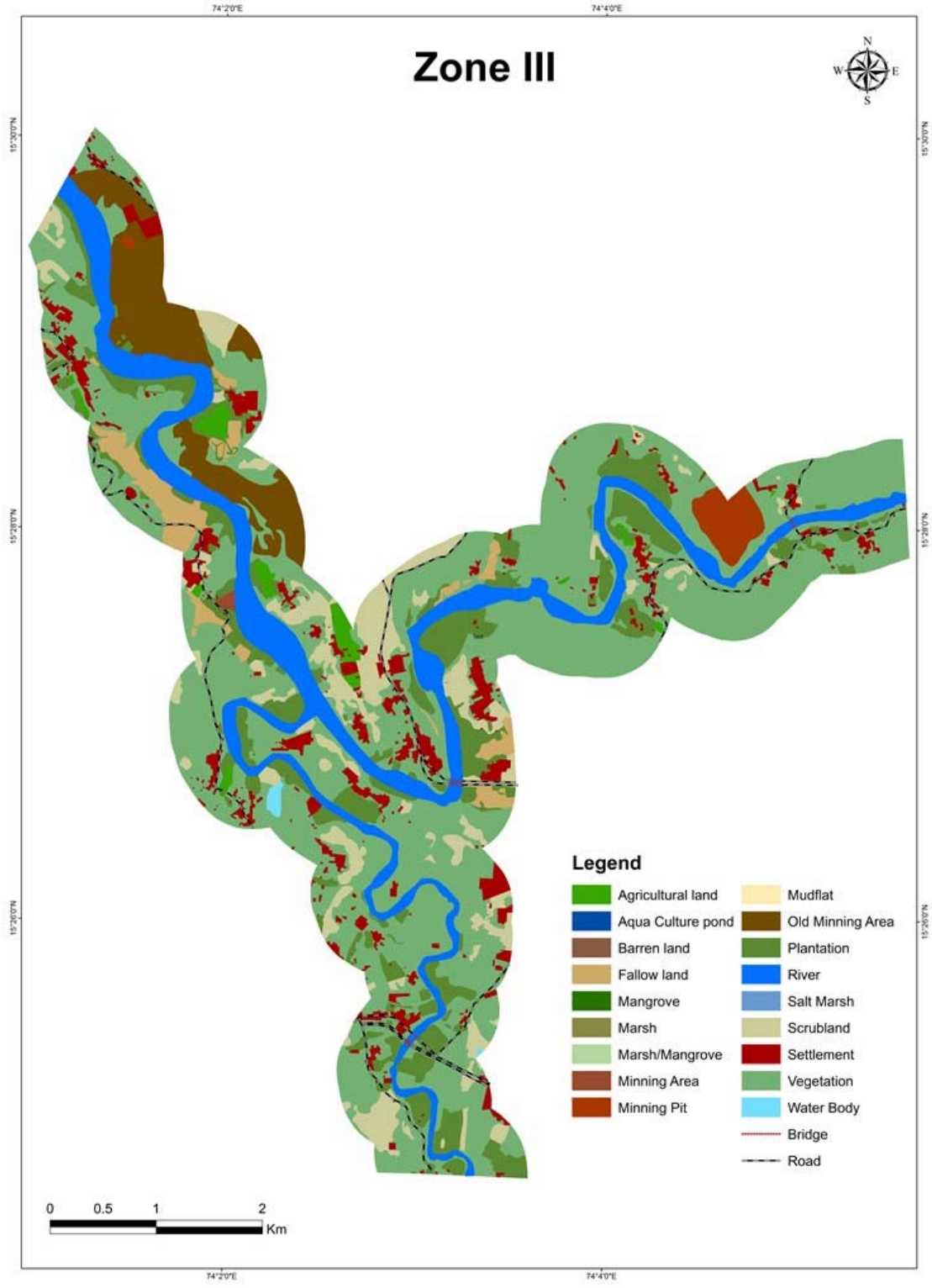


Figure 3.39: LULC Map of Mandovi Estuary (Divided in 3 zones, image used LISS-IV, December 2019)

Table 3.16. LULC Mandovi estuary			
Sr. no.	**LULC Class**	**Area (Km^2)**	**Percentage Area**
1	Agricultural land	5.35	4.7
2	Aqua Culture Pond	1.68	1.5
3	Barren land	0.04	0.0
4	Fallow land	12.32	10.9
5	Mangrove	12.98	11.5
6	Marsh	0.17	0.2
7	Marsh/Mangrove	2.76	2.4
8	Mining Area	0.09	0.1
9	Mining Pit	0.37	0.3
10	Mudflat	0.26	0.2
11	Old Mining Area	2.68	2.4
12	Plantation	4.42	3.9
13	River (Mandovi)	27.2	24.1
14	Salt Marsh	0.12	0.1
15	Scrubland	5.63	5.0
16	Settlement	8.44	7.5
17	Vegetation	28.38	25.1
18	Water Body	0.15	0.1
Total		113.04	100.0

3.15 Seaweeds & Grass (Halotolerant)

Coastal regions are among the most vulnerable to future climate change. Current climate change scenario could restructure the coastal foundation communities mainly the inter-tidal habitants i.e., seaweed (macrophytes). Macrophytes including seaweeds, seagrass and mangroves act as blue-carbon sink as they capture atmospheric CO_2, sequester and store it in live tissue or sediment for longer durations. Macrophytic blue-carbon system is considered more efficient than terrestrial systems. The 2009 UNEP blue-carbon report states that coastal macrophytes account for less than 0.5% of the seabed community structure and sequester between 114 and 328 teragrams of carbon per year, or 1.6 to 4.6% of total anthropogenic emissions (7,200T g/year). Therefore, protecting and restoring the ocean's fringing vegetation should be a high priority. Seaweeds are the primary producers of marine ecosystem and have wider utility in agrichemicals, cosmetics, biomaterials, energy molecules in addition to their conventional utilization as edible food, feed ingredients and hydrocolloids. Macroalgae are the primary producers for marine ecosystem. The carbon they produce in photosynthesis

enters the different trophic levels in food chain via microbial assimilation. Many of the vertebrates and invertebrates such as herbivorous fish, crabs and sea urchins are directly dependent on macroalgae mainly for shelter. The small seagrass Halophila beccarii Aschers. is distributed along the coasts of south and south-eastern Asia. *Halophila beccarii* is monoecious and the flowers are strongly protogynous.

Halophila beccarii is most abundant in shallow, sheltered localities in estuarine and marine environments inhabiting sandy and muddy substrates. Plants exhibiting the monoecious condition, with either male and female flowers occurring in successive lateral shoots or even distantly, have a mature female flower or a fruit and a male flower in bud condition. In the estuarine environments of Cuddalore, Pichavaram and Portonovo the plants mostly occur in shallow open areas from near shore to a depth of 1.2 m. In the marine environment of Tuticorin they were found down to a depth of 1.7 m. In the Mandovi Estuary, Goa, Jagtap and Untawale (1981) reported that the biomass of *H. beccarii* varied from 2.5 to 26 g wet weight m^{-2}.

Table 3.17: List of Grass found in Mandovi Estuary

Sl. No.	**Species**
1	*Padina* sp.
2	*Cyperus* sp
3	*Halophila beccarii*

Table 3.18: List of Seaweeds found in Mandovi Estuary

Sl. No.	**Seaweeds**
	Rhodophyta
1	*Acanthophora muscoides*
2	*Amphiroa fragilissima*
3	*Catenella repens*
4	*Centroceras clavulatum*
5	*Ceramium cimbricum*
6	*Caloglossa leprieurii*
7	*Ceramium fastigiatum*
8	*Chondracanthus acicularis*
9	*Gelidium pusillum*
10	*Gracilaria corticata*

11	*Hypnea musciformi*
12	*Hypnea spinella*
13	*Hypnea valentiae*
14	*Pterocladia capillacea*
	Chlorophyta
15	*Boodlea composita*
16	*Bryopsis plumosa*
17	*Caulerpa verticillata*
18	*Chaetomorpha spiralis*
19	*Chlorodesmis hildebrandtii*
20	*Cladophora socialis*
21	*Cladophoropsis sundanensis*
22	*Rhizoclonium riparium*
23	*Ulva clathrata*
24	*Ulva compressa*
25	*Ulva fasciata*
26	*Ulva flexuosa*
27	*Ulva lactuca*
	Phaeophyta
28	*Canistrocarpus cervicornis*
29	*Chnoospora minima*
30	*Dictyota dichotoma*
31	*Dictyota pinnatifida*
32	*Padina gymnospora*
33	*Padina apavonica*
34	*Padina tetrastromatica*
35	*Sargassum cinctum*
36	*Sargassum glaucescens*
37	*Sargassum ilicifolium*
38	*Sargassum tenerrimum*
39	*Spatoglossum asperum*
40	*Sphacelaria rigidula*
41	*Vaucheria longicaulis*



Plate 3.9: Representative grasses on the upper banks of Mandovi Estuary

3.16 Sand Dune Vegetation

Sand dunes are a mount, 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 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 depend 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.

In the Mandovi estuary sand dunes are observed below Mandovi bridge. The dominant species of dune vegetation was *Ipomoea pes-caprae* as well as large trees like *Cocos nucifera* and *Casuarina equisitifolia* (Table 3.19).

Table 3.19: Sand dune vegetation along Mandovi estuary

Sr. No.	Scientific name
1	*Ipomoea Pes-caprae*
2	*Spinifex littoreus*
3	*Cyperus arenarius*
4	*Saccharum spontaneum*
5	*Sporobolus virginicus*
6	*Dactyloctenium aegyptium*
7	*Eragrostis unioloides*
8	*Clerodendrum-inerme*
9	*Pedalium murex*
10	*Physalis minima*
11	*Triumfetta rhomboidea*
12	*Vitex trifolia*

13	*Calotropis gigantea*
14	*Casuarina equisetifolia*
15	*Anacarduium oxydentrum*
16	*Cocos nucifera*

3.17 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 states. 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 ten mangrove species and eight mangrove associates have been recorded from the Mandovi estuary (Table 3.20).

From the historic images (Courtsey: 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 Mandovi 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.

Table 3.20: Mangroves and associated species found in Mandovi estuary.		
Sr. No.	True mangrove species	Mangrove associate species
1	*Sonneartia alba*	*Acrostichum aureum*
2	*Acanthus ilicifolius*	*Derris heterophylla*
3	*Brugiera cylindrica*	*Derris trifoliata*
4	*Rhizophora mucronata*	*Cleredendron inerme*
5	*Avicennia marina*	*Doliochandrone spathacea*
6	*Avicennia officinalis*	*Ipomoea grandiflora*
7	*Aegicerus corniculatum*	*Operculina turpethum*
8	*Caesalpinia crista*	*Cyperus malaccensis*
9	*Volkameria inermis*	
10	*Exoecaria agallocha*	



Plate 3.10: Mangroves from Mandovi Estuary

CHAPTER- 4 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.

Mandovi originates in the Western Ghats and flows down the entire width of the State of Goa to discharge into the Arabian Sea (Figure 4.1). The Mandovi watershed receives abundant rainfall from the southwest monsoon during the months of June to September.

Climate:

Goa has warm tropical climate with average annual temperature of 26.4 °C. December to February are coolest months. The difference between mean annual winter temperature and mean annual summer temperature is 0.4 °C. The temperature is extreme in months of April and May and lowest month of January. Due to closeness of the State to the Arabian Sea, the humidity is excessive from beginning to end of the year. The relative humidity varies from 60% to 90%.

Winds:

Winds are 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 north-west. Sometimes associated with cyclonic storms in the Arabian Sea in the post-monsoon months and to a lesser extent in May, the region experiences strong winds, occasionally reaching gale force with widespread heavy rain.

Soil:

Soil is one of the predominant non – renewable basic natural resources of the earth. The total geographical area of the state has been digitized (NBSS soil map), and reclassified. Goa has about 25 soil classifications and it is divided two major classes based on landform viz. Konkan

coast soil and Central Sahydris soils groups. Konkan consists beaches, Mudflats, swamps and marshes, salt pans, fluvio – littoral plains and islands, conical hills, flat topped hills, hillside slope, undulating lands, narrow valleys. Central Sahydris comprises high hills, low hills, interhilly basins, and narrow valleys.

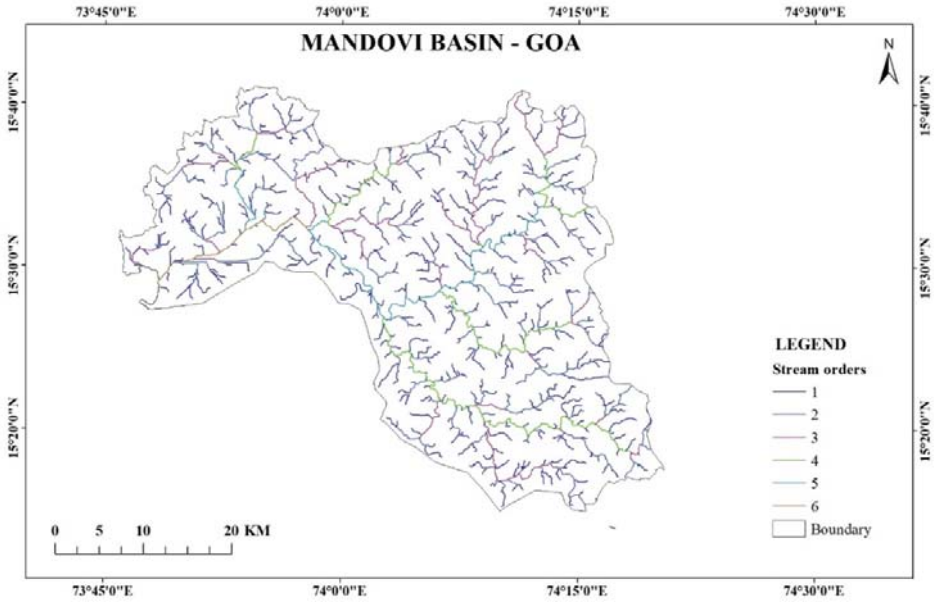


Figure 4.1: Stream orders in Mandovi basin, Goa

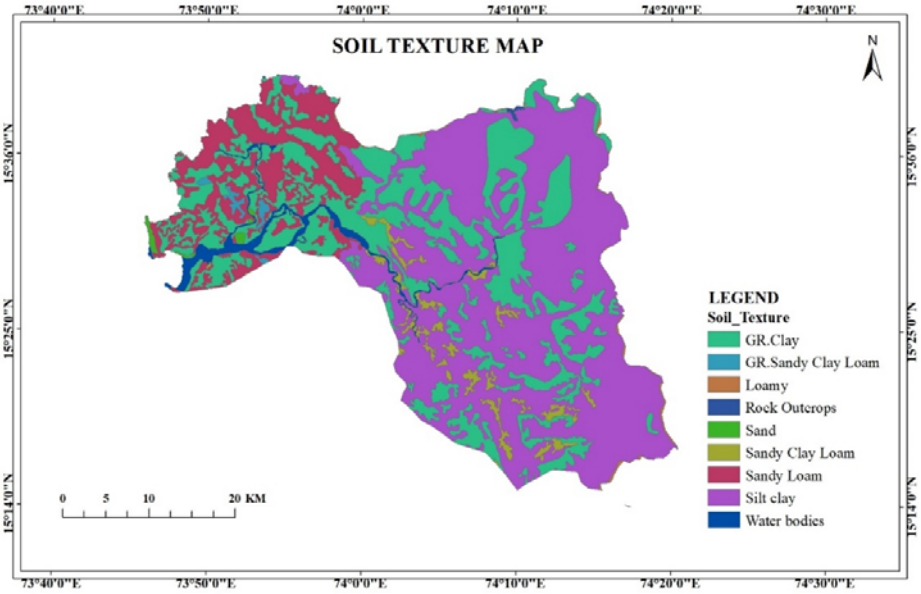


Figure 4.2: Soil texture map of Mandovi basin, Goa

Figure 4.2 shows reclassified soil texture distribution of the Mandovi basin. loamy, sand, sandy clay, sandy loam, silt clay, gravelly clay, and gravelly sandy clay distributed over the study area. The western Ghats regions occupied loamy and silt clay soils formations. Around 85% of the area is covered with silt clay and gravelly clay soils, these textures are dominant along the eastern part of the Mandovi basin. Loamy, sand, and silt clay soil types are excessively drained and very less in drainage capacity. Sandy loam soil is widely distributed in the Mapusa region, along with gravelly clay also partially distributed.

Rainfall:

Eleven rainfall Stations were chosen for the Study. Daily Rainfall data for 10 consecutive years have been collected for the years from 2010 to 2019. IMD Rainfall data has been analysed and accordingly seasonal and annual mean calculated (Figure 4.3).

The Sahydris hills plays significant role in the rainfall distribution in Goa. The State receives high rainfall during south-west monsoon period. The long term mean annual rainfall of the state is 3295.91mm, which may vary from 4195.3mm (Valpoi) to 2984mm (Panaji). Topography of the study area under direct influence of Western Ghats and about 90% of the annual rainfall receives during south–west monsoon period.

Winter Season

Winter Season starts after the north-east monsoon season i.e., in the last week of December or first week of January and continues up to the end of February. This season, study area receives very less amount of rainfall distribution. The maximum rainfall during this season had recorded at Sanguem (19.52mm) and the minimum rainfall were recorded at Panaji (0.34mm). The average rainfall of winter season is 4.03mm. South, south-east and eastern part of study area receive comparatively good amount of rainfall during winter season.

Summer season

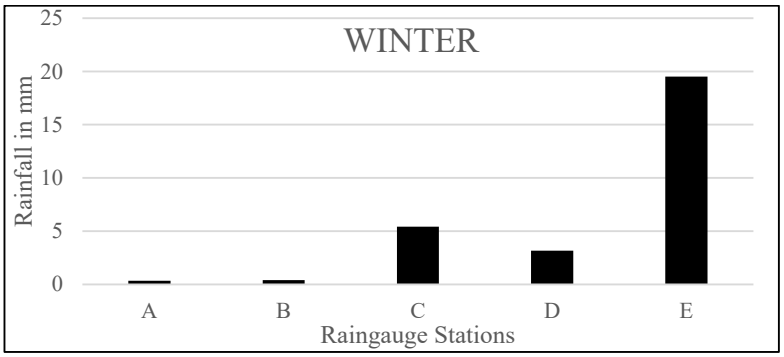
Summer Season begins March and it's continues till May, during this season study area experiences hot weather condition. The average rainfall of this season is 56.32mm. The highest rainfall recorded at Valpoi with 62.1mm and lowest rainfall recorded at Mapusa with 44.16mm.

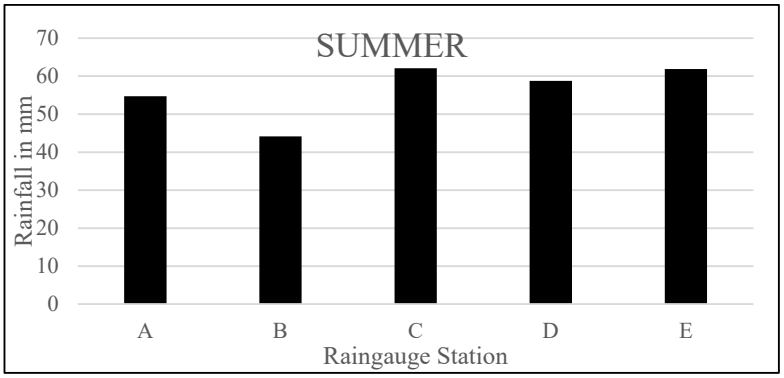
South – West Monsoon (SWM)

The State receives rainfall mainly from the June to September. Valpoi and Sanguem stations record maximum rainfall. Highest rainfall is received during the month of July followed by a gradual decrease in subsequent monsoon months. Western, central and south western portions receive very high amount of rainfall.

North – East Monsoon (NEM)

During post-monsoon the study area experiences adequate rainfall as compared to winter season and summer season. Eastern part of the study area rainfall intensity gradually increases and coastal region receives less amount of rainfall distribution. Maximum rainfall has been recorded in Valpoi which is located in the North eastern part of the study area and very low rainfall has been recorded at Panaji and Mapusa station which lies in the Eastern part of study area.





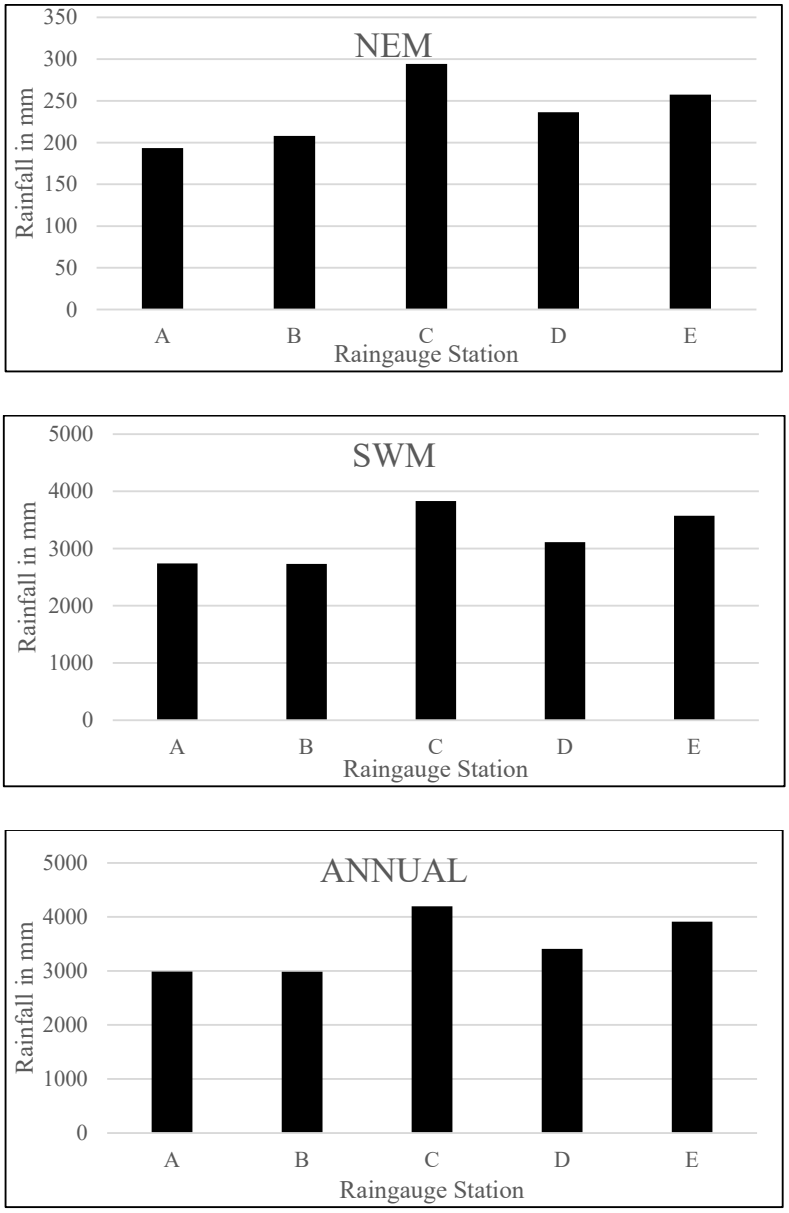


Figure 4.3: Mean rainfall distribution at Panaji (A), Mapusa (B), Valpoi (C), Ponda (D) and Sanguem (E).

Physical parameters

This chapter comprises of the physical measurements carried out at Mandovi Estuary for the validation of numerical model.

Results

The results of the current measurements carried out in the study region are presented in this section. Water level measurement results are presented and validated in the next chapter.

Currents

Current measurement was carried out at locations MC1 and MC2 in Mandovi Estuary during August-September 2020, November-December, 2020 and March-April 2021. The current meter was placed at mid-water depth. The measured current speed and direction during monsoon are shown in Figure 4.4. The current is mainly towards north-west (NW) with maximum current speed 1.41 m/s and average current speed 0.54 m/s during measuring period at MC1. In Figures 4.5 and 4.6, the measured current speed and direction are presented for MC2 during post and pre-monsoon respectively. From the Figures, it is observed that the maximum current speeds were 0.77 m/s and 0.87 m/s and the average current speeds were 0.33 m/s and 0.35 m/s at MC2 during post and pre-monsoon measuring period respectively. The current is mainly towards south-west (SW) and north-east (NE) at MC2.

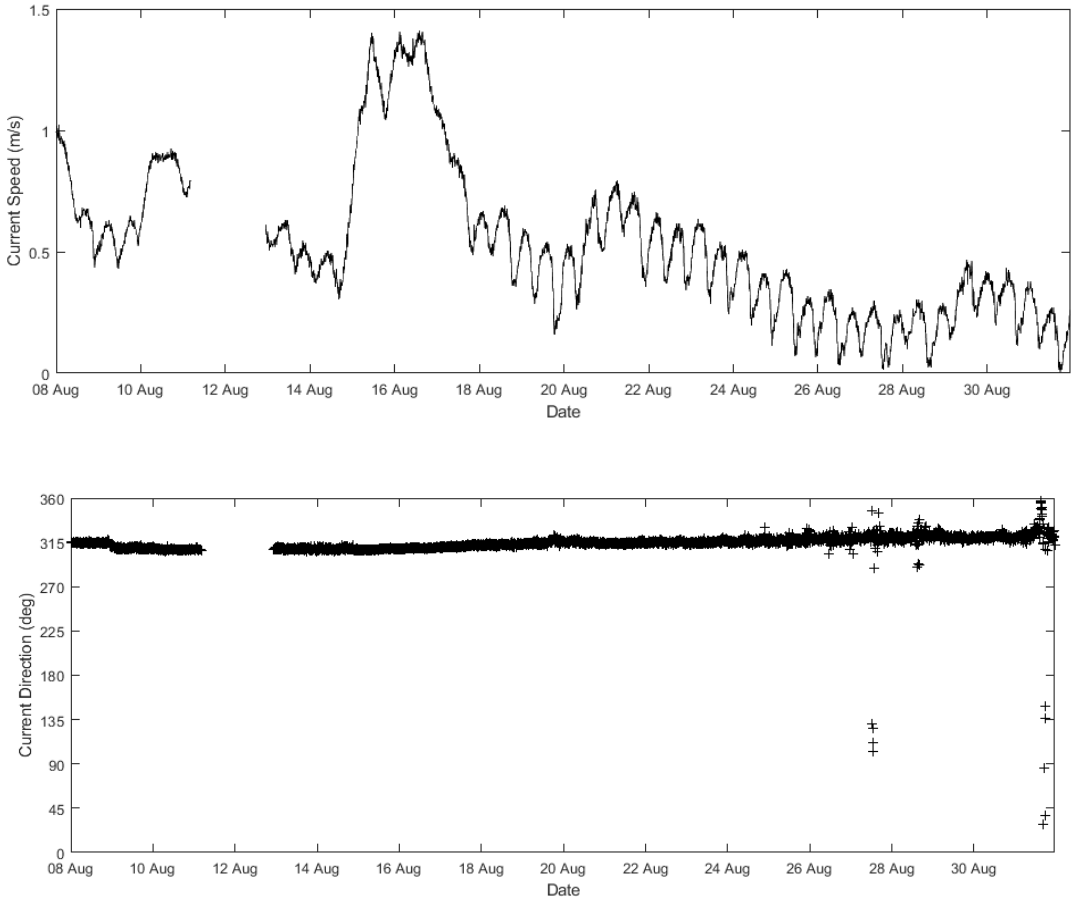


Figure 4.4: Variation of measured current speed and directions at MC1 in monsoon, 2020.

Table 4.1: Maximum and average value of Current speed (m/s) in Mandovi

Current Parameter	Location	Maximum Speed (m/s)	Average speed (m/s)
Current Speed (m/s) (monsoon)	MC1	1.41	0.54
Current Speed (m/s) (post-monsoon)	MC2	0.77	0.33
Current Speed (m/s) (pre-monsoon)	MC2	0.87	0.35

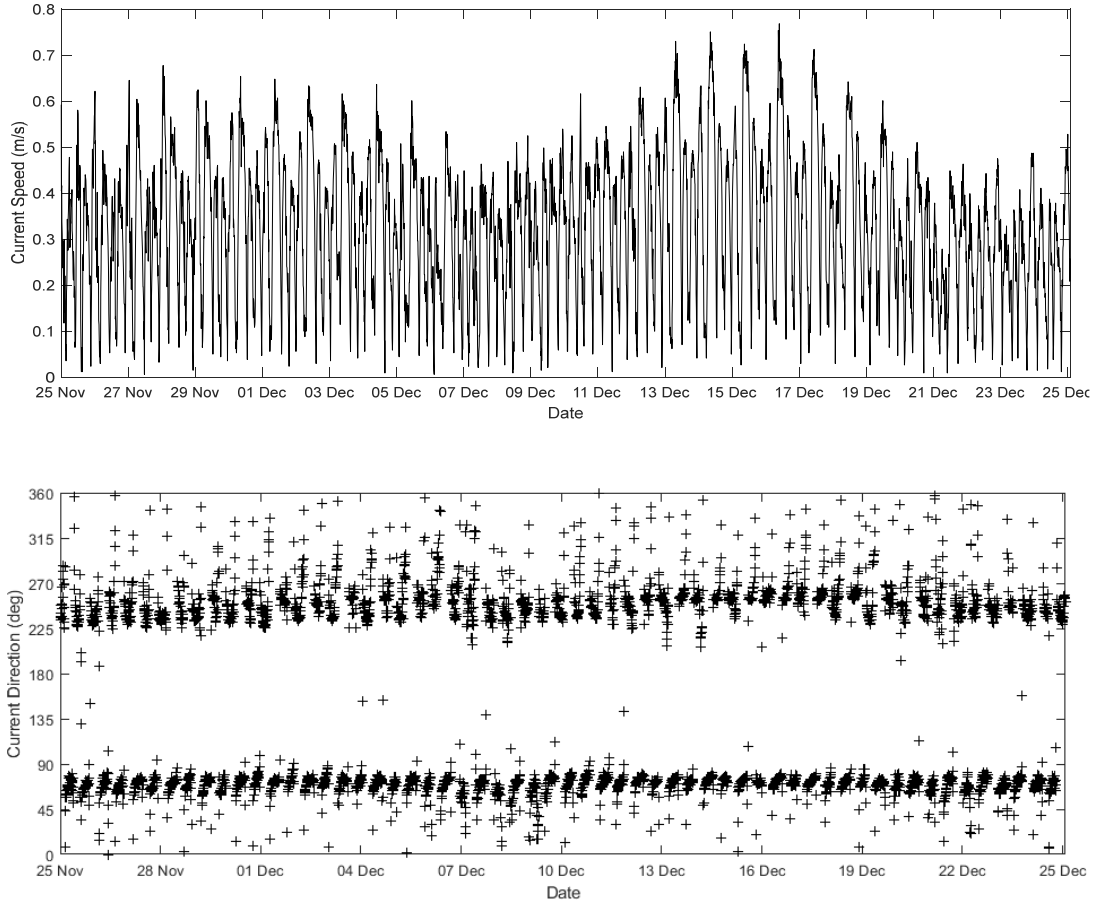


Figure 4.5: Variation of measured current speed and directions at MC2 in post-monsoon 2020.

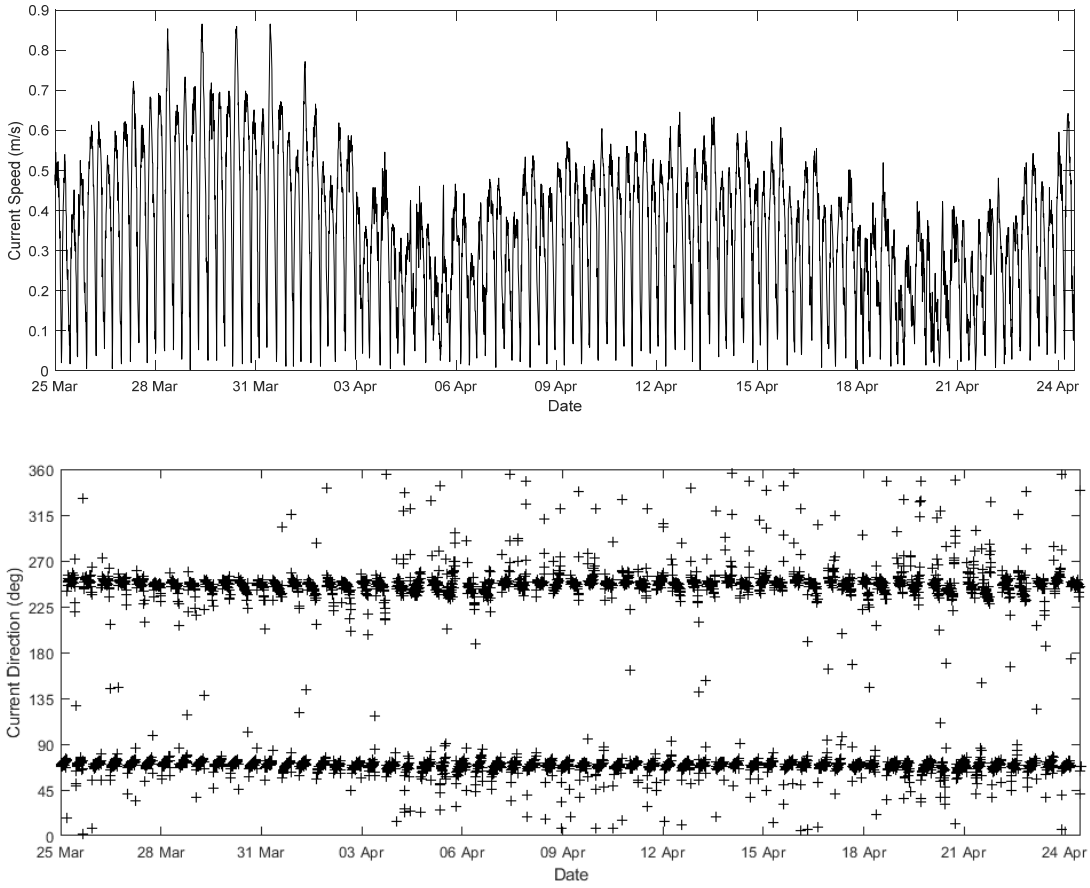


Figure 4.6: Variation of measured current speed and directions at MC22 in pre-monsoon 2021.

CHAPTER 5: 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. 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 5.1. This model domain was further used for all simulations. In this study, a sand mining case scenario is studied by modifying existing bathymetry at different sections (A-I) (see Figure 5.2) along Mandovi estuary. The model domain for post sand mining case is shown in Figure 5.3.

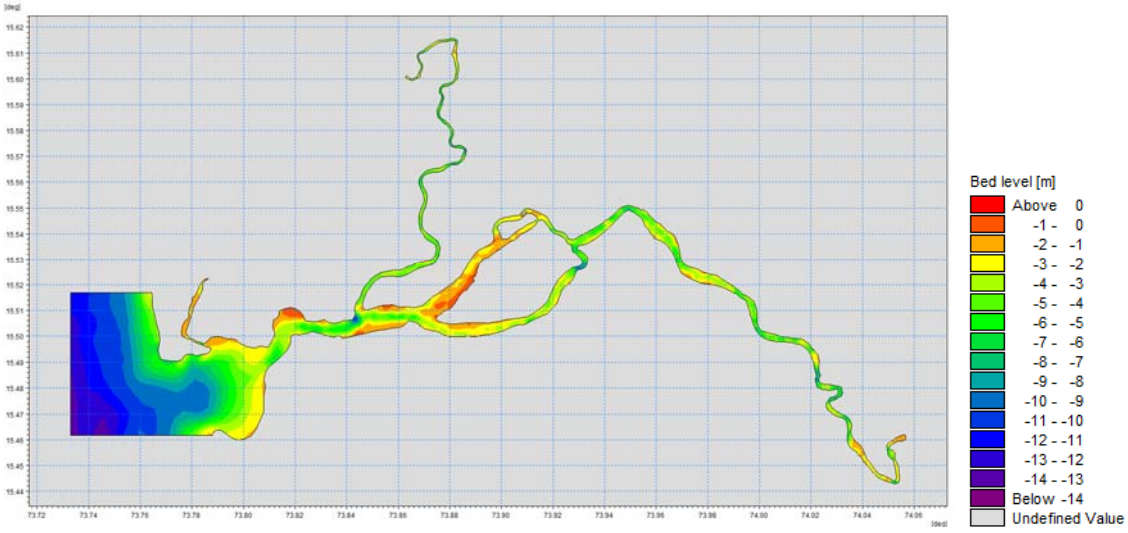


Figure 5.1: Model domain for original bathymetry of the Mandovi estuary

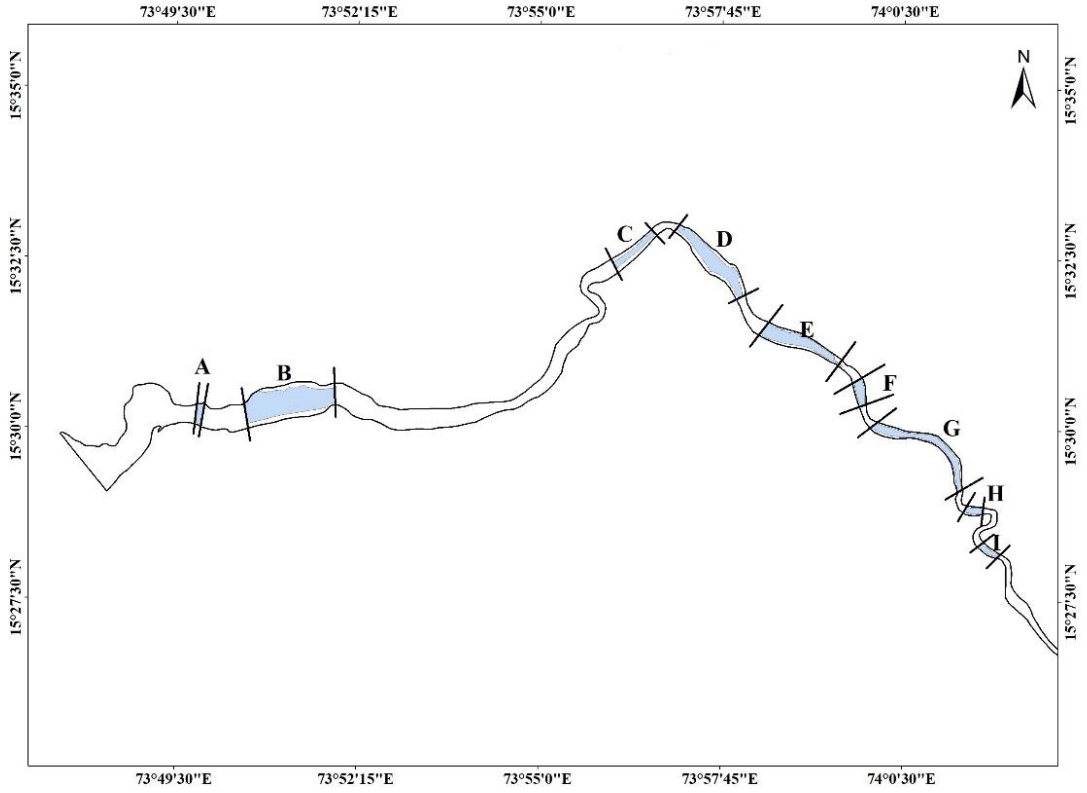


Figure 5.2: Figure showing nine different sections (A-I) in the model domain.

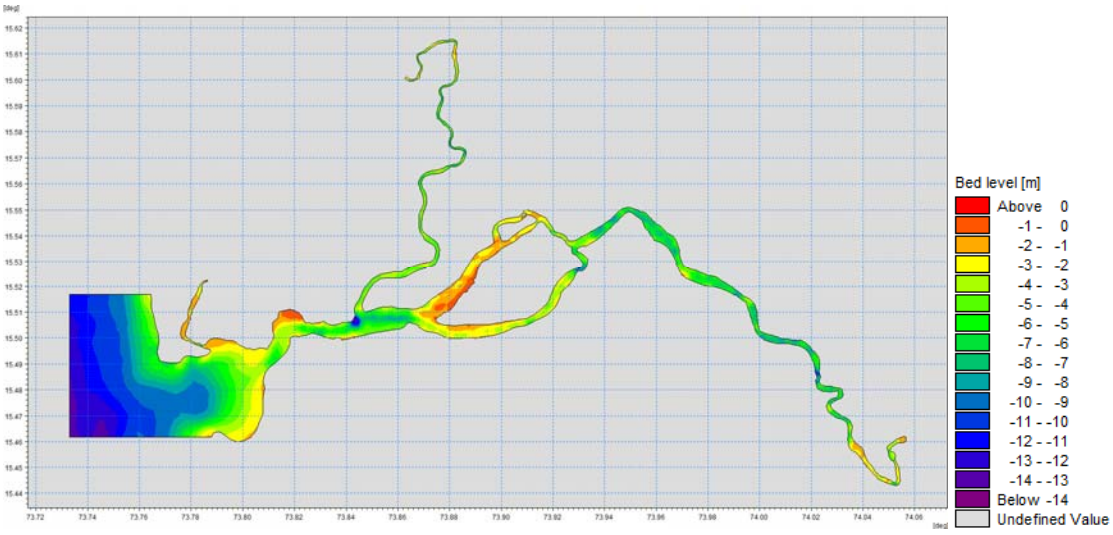
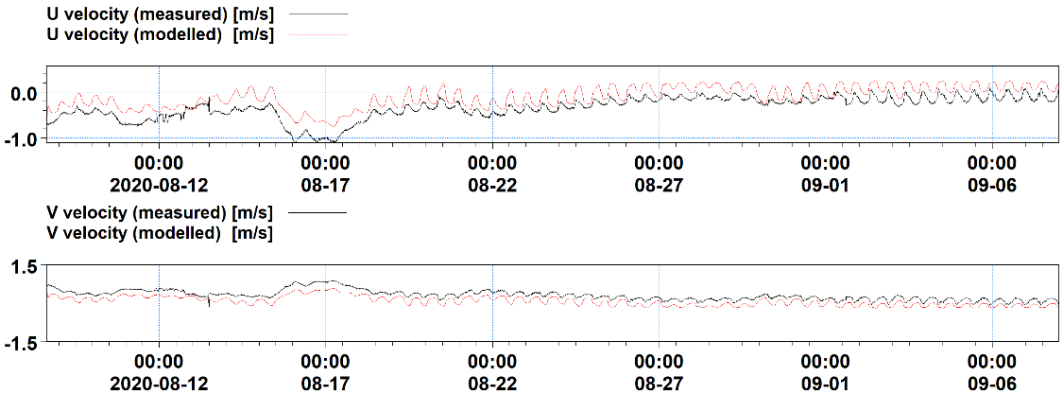
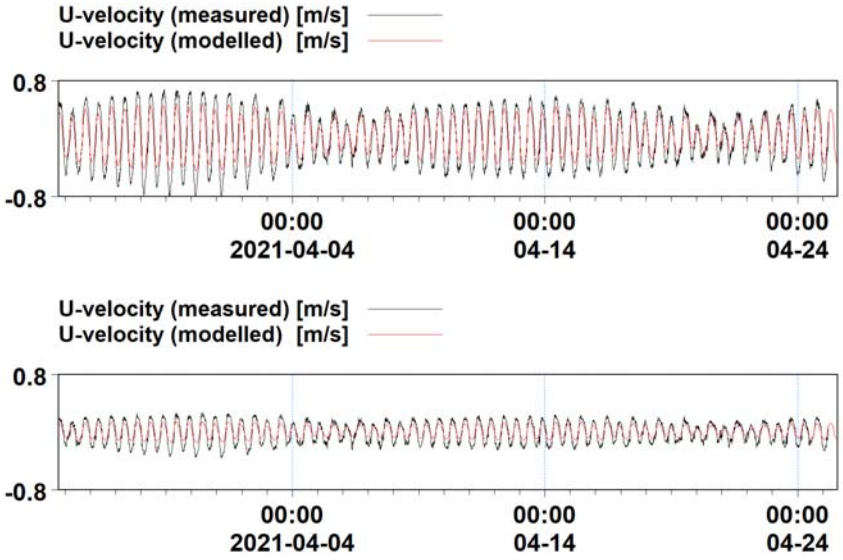


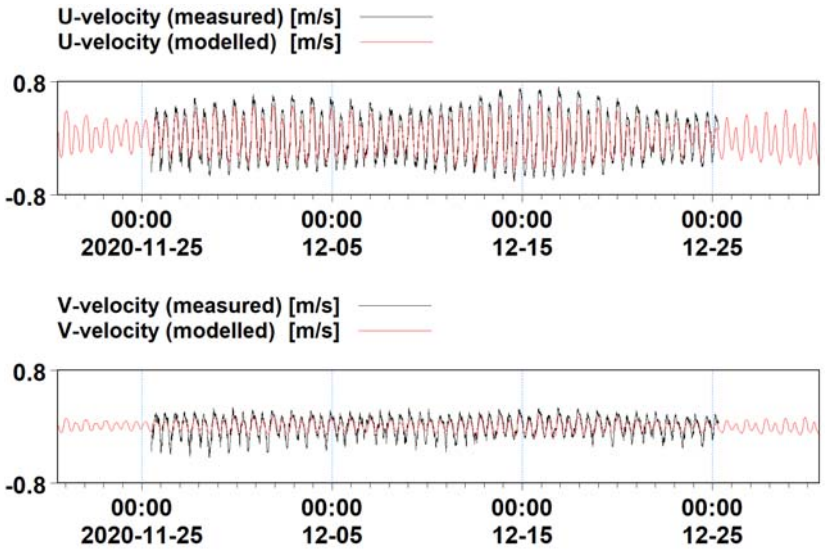
Figure 5.3: Model domain for modified bathymetry increasing depth by 3 m at different sections (A-I)


U velocity (measured) [m/s]
U velocity (modelled) [m/s]
0.0
-1.0
00:00 2020-08-12
00:00 08-17
00:00 08-22
00:00 08-27
00:00 09-01
00:00 09-06
V velocity (measured) [m/s]
V velocity (modelled) [m/s]
1.5
-1.5
00:00 2020-08-12
00:00 08-17
00:00 08-22
00:00 08-27
00:00 09-01
00:00 09-06

(a)


U-velocity (measured) [m/s]
U-velocity (modelled) [m/s]
0.8
-0.8
00:00 2021-04-04
00:00 04-14
00:00 04-24
U-velocity (measured) [m/s]
U-velocity (modelled) [m/s]
0.8
-0.8
00:00 2021-04-04
00:00 04-14
00:00 04-24

(b)


U-velocity (measured) [m/s]
U-velocity (modelled) [m/s]
0.8
-0.8
00:00 2020-11-25
00:00 12-05
00:00 12-15
00:00 12-25
V-velocity (measured) [m/s]
V-velocity (modelled) [m/s]
0.8
-0.8
00:00 2020-11-25
00:00 12-05
00:00 12-15
00:00 12-25

(c)

Figure 5.4. Comparison between measured and modelled U&V component of current during (a) monsoon at MC1, (b) Pre-monsoon at MC2 and (c) Post-monsoon at MC2.

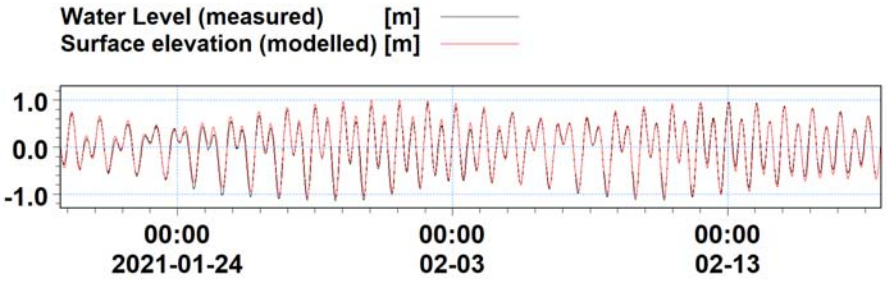
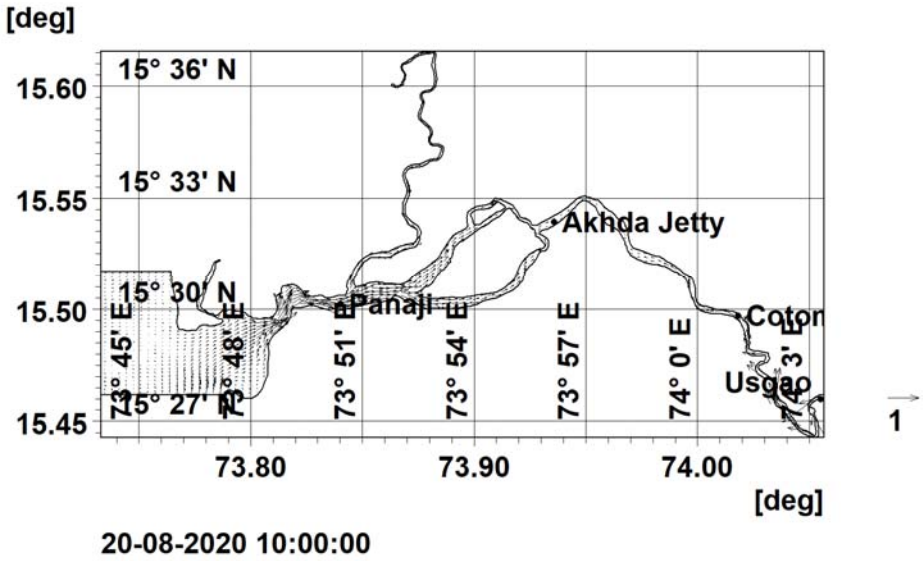


Figure 5.5. Comparison between measured and modelled surface elevation at ML1.

A comparison between the model derived and measured surface elevations (at ML1), currents (at MC1 & MC2) have been carried out in Figure 5.4 and 5.5. In Figure 5.5, 0 line is considered as Mean Sea Level (MSL). It is observed that the surface elevations and currents are well predicted by the model.

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.



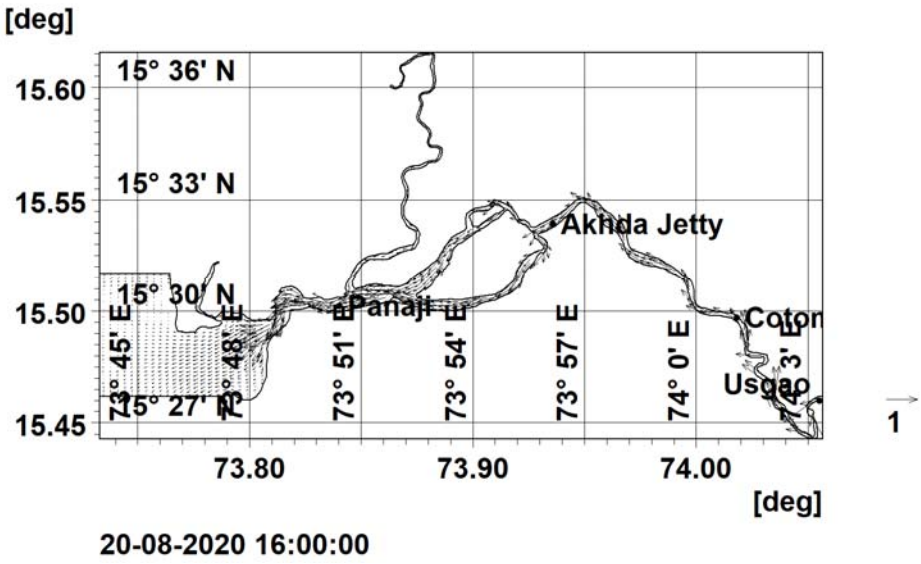


Figure 5.6: Typical flood and ebb current.

Results

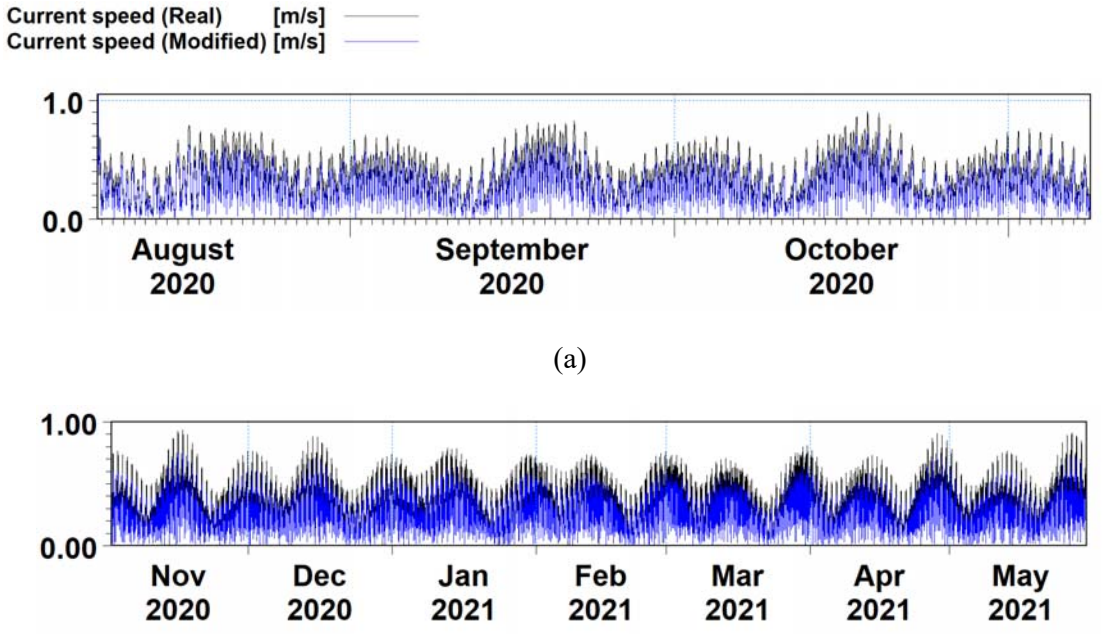
The numerical model study results are presented in the following sections. The flow patterns in the study region for the Case 1 and Case 2 are presented in the hydrodynamic model results. The comparisons of the current speed during both monsoon and non-monsoon period, 2020-21 between Case 1 and Case 2 at each section A-I are presented. The comparisons of the bed level changes between Case 1 and Case 2, are also 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 5.4-5.5. The model simulated water levels, and the current flow components well for both the east-west and north-south components. The typical flood and ebb currents are shown in Figure 5.6.

A comparison of current speeds between the Case-1 and Case-2 is carried out. A total of 9 points covering the nine sections A to I as in Figure 5.2 are considered for comparing the currents. The comparison figures are presented in Figure 5.7-5.15. Higher current speeds

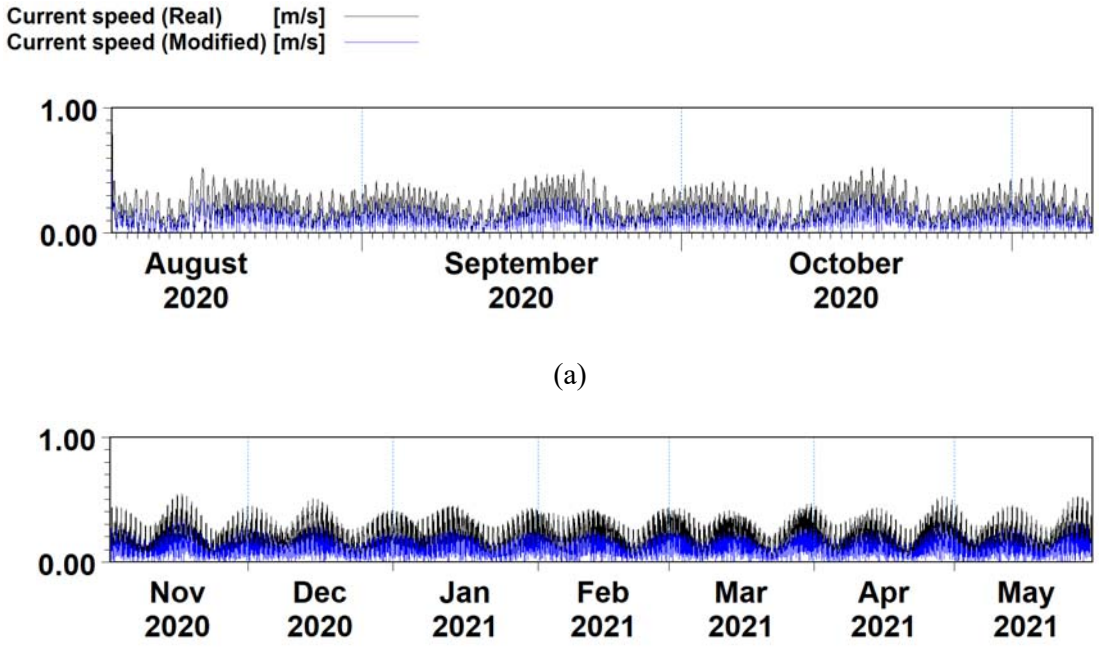
are observed for Case-1, than the Case-2 at the different sections A-I. The reduction in current speeds at these sections is mainly due to the change in the water depths.



(a)

(b)

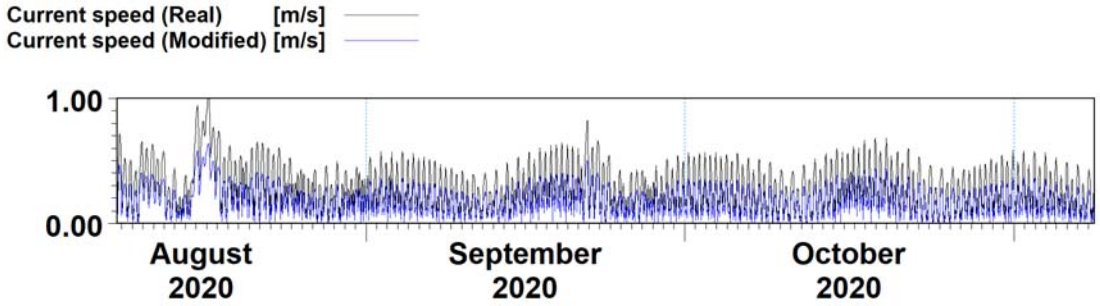
Figure 5.7: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section A for case 1 (real) and case 2 (modified)



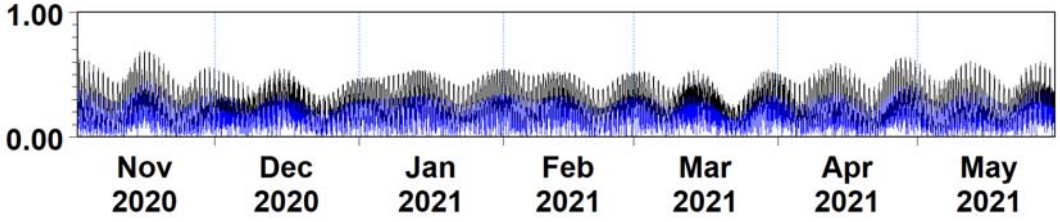
(a)

(b)

Figure 5.8: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section B for case 1 (real) and case 2 (modified)

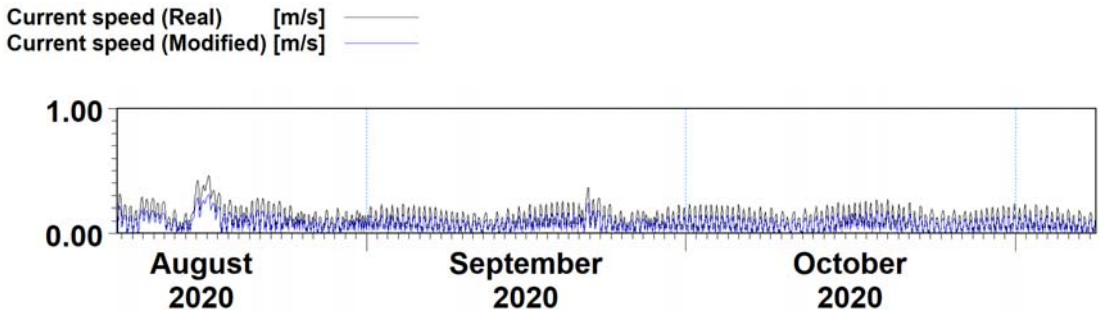


(a)

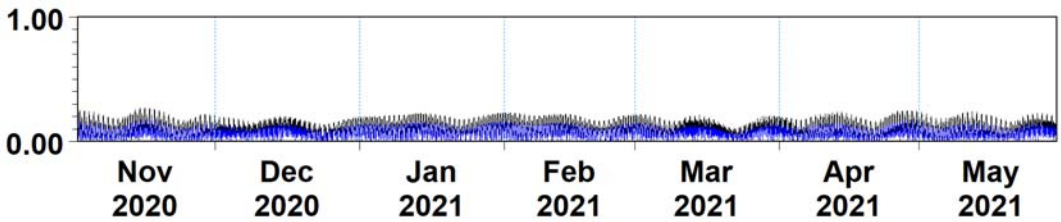


(b)

Figure 5.9: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section C for case 1 (real) and case 2 (modified)

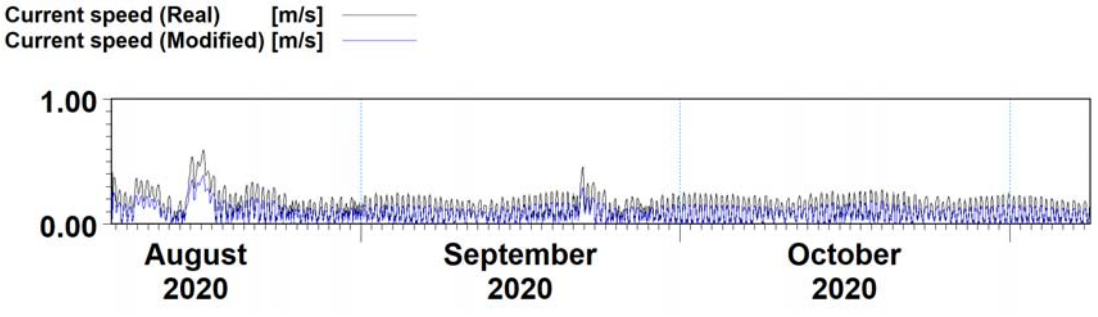


(a)

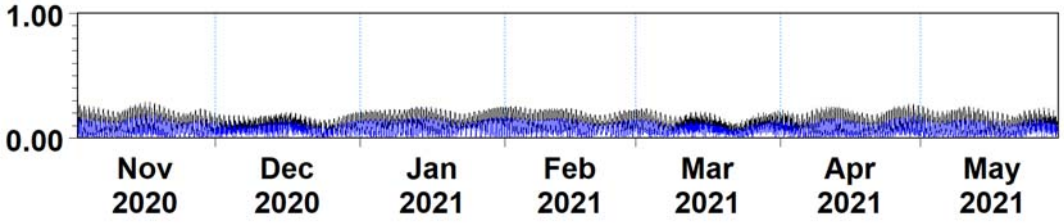


(b)

Figure 5.10: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section D for case 1 (real) and case 2 (modified)

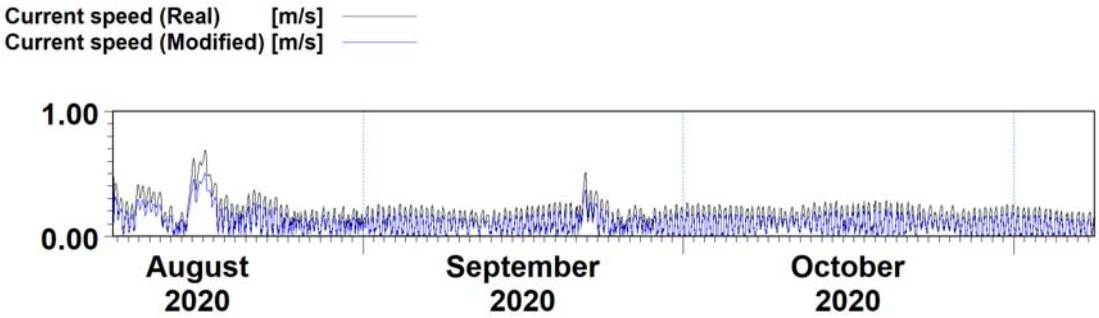


(a)

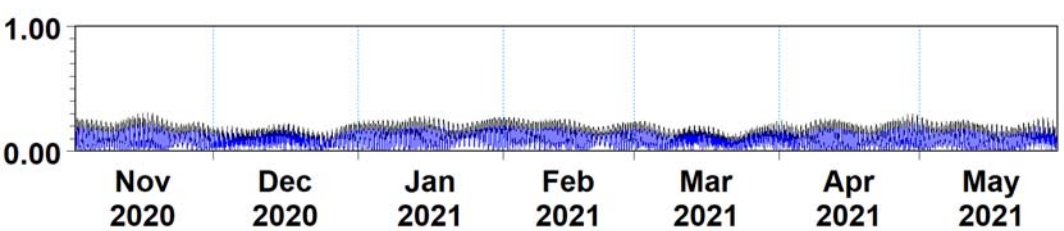


(b)

Figure 5.11: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section E for case 1 (real) and case 2 (modified)

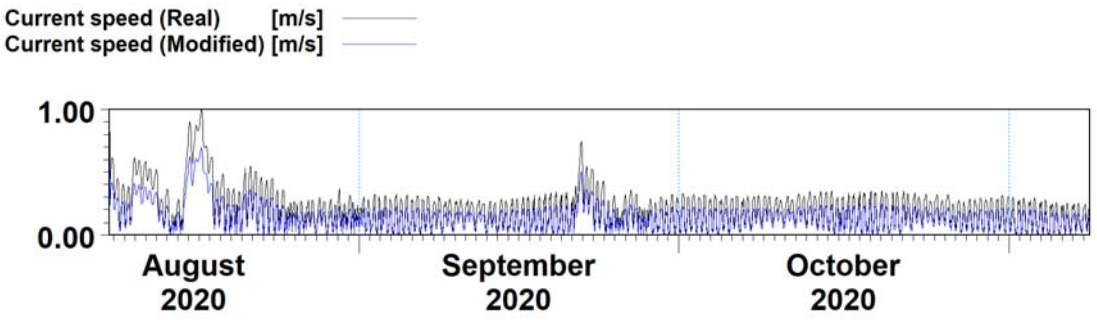


(a)

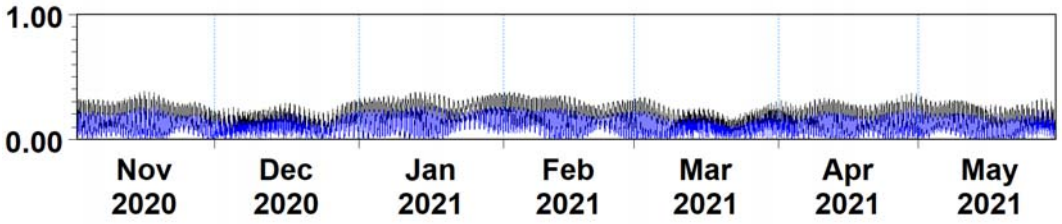


(b)

Figure 5.12: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section F for case 1 (real) and case 2 (modified)

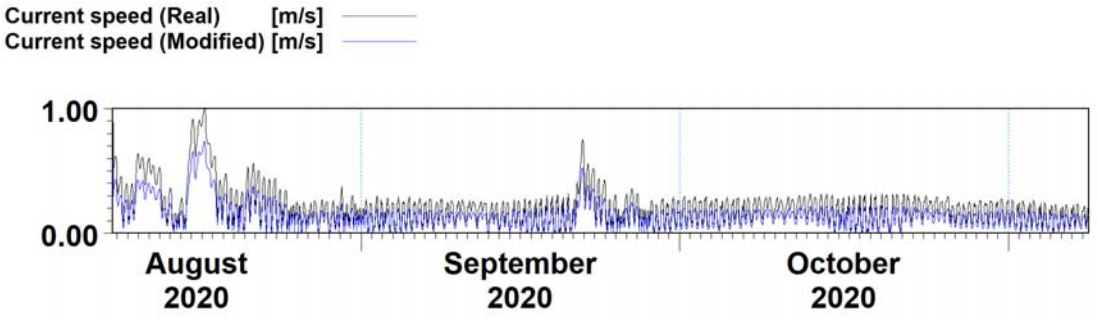


(a)

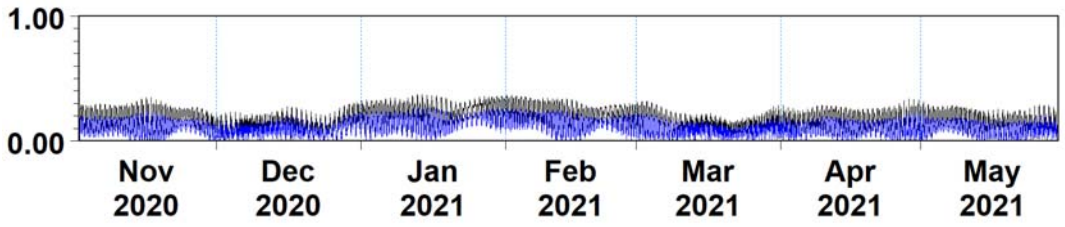


(b)

Figure 5.13: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section G for case 1 (real) and case 2 (modified)

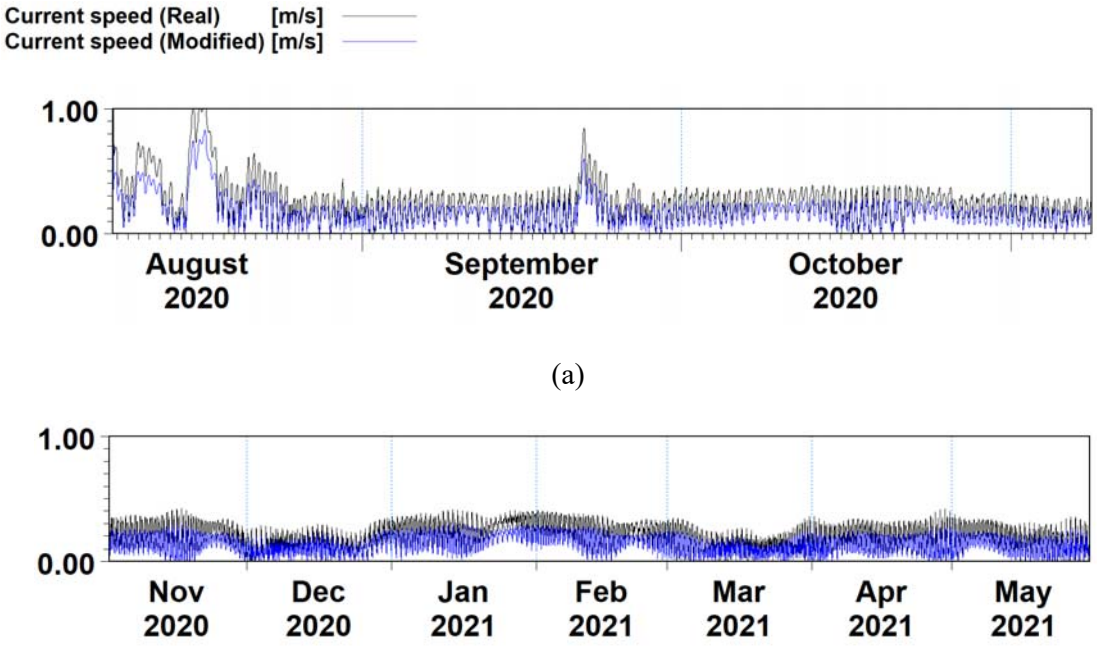


(a)



(b)

Figure 5.14: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section H for case 1 (real) and case 2 (modified)



(a)

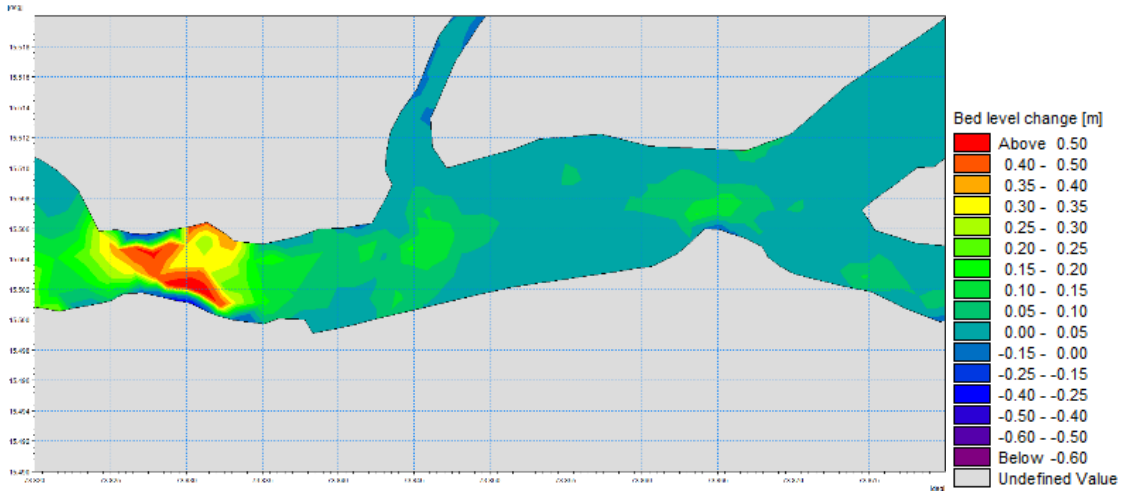
(b)

Figure 5.15: Comparison of U, V and current speed during (a) monsoon and (b) non-monsoon at section I for case 1 (real) and case 2 (modified)

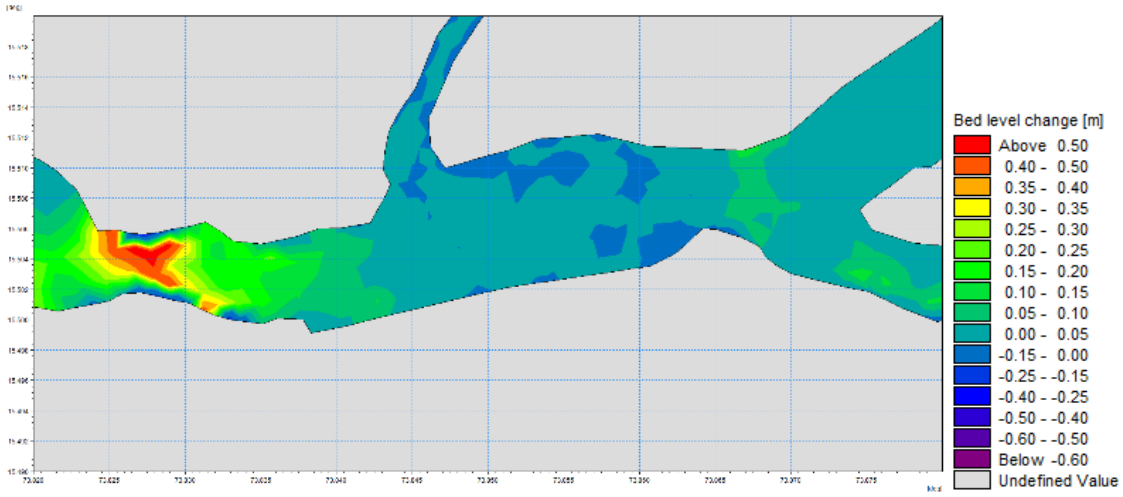
Bed level changes

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. For the sake of clarity, the sections A-B and C-I are divided and the comparisons of bed level changes between the between the Case-1 and Case-2 models are shown. The changes in bed morphology at different sections of the river are highly dynamic and patchy in nature. In

Figure 5.16, It is observed that high sediment deposition occurs at around section A of Mandovi estuary. During non-monsoon period, the sediment deposition around section A is more than the monsoon period. In Figure 5.17, it is observed that for Case-2, erosion occurs at section B. In Figures 5.18-5.19, the upstream of Mandovi receives higher sediment deposition at monsoon than non-monsoon. During monsoon, at and around sections G, H and I, more sediment deposition is observed in Case 1 than Case 2 while intense erosion is observed at sections D and E for Case 2. During non-monsoon period, there is not much difference between Case 1 and Case 2 at sections D and E. It is important to note that localized bed level changes may happen due to abrupt change in the bed morphology.

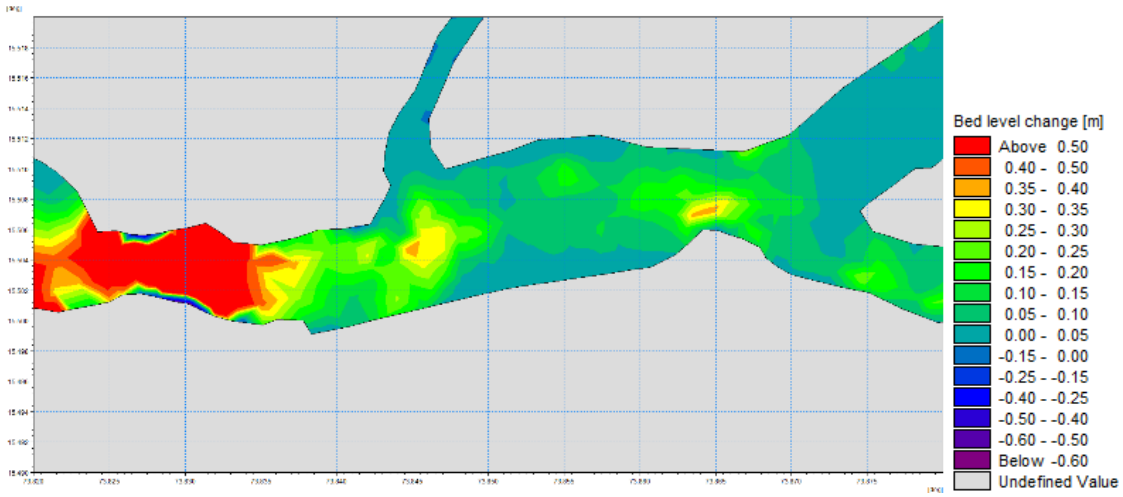


(a)

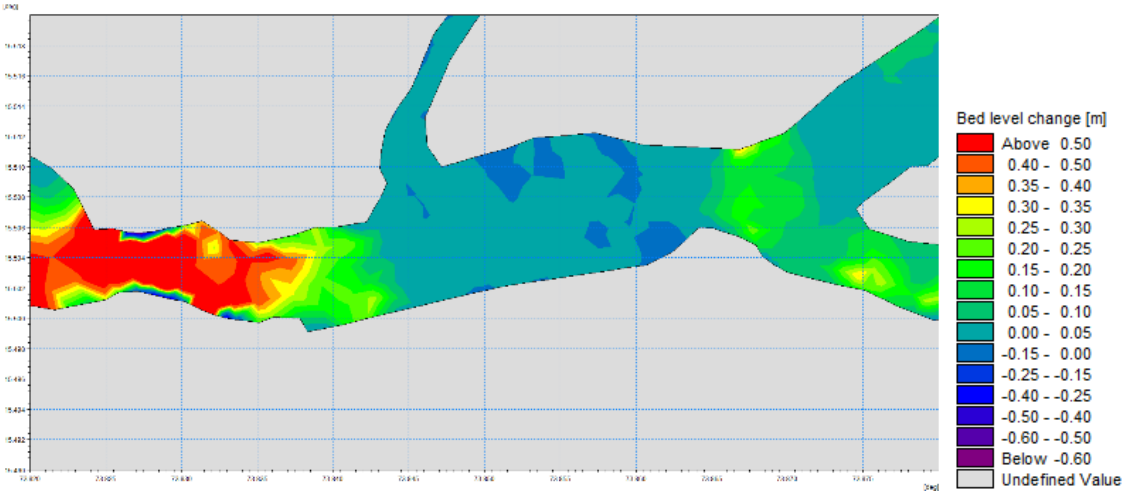


(b)

Figure 5.16: Bed level change at sections A and B with (a) Case 1, (b) Case 2 during Monsoon.

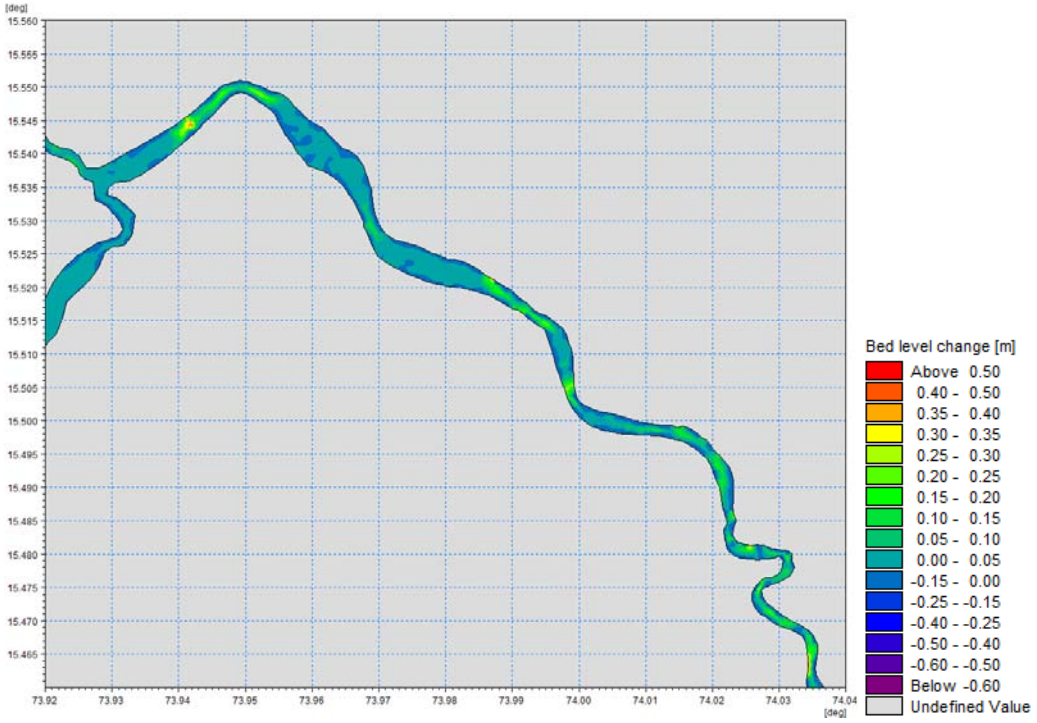


(a)

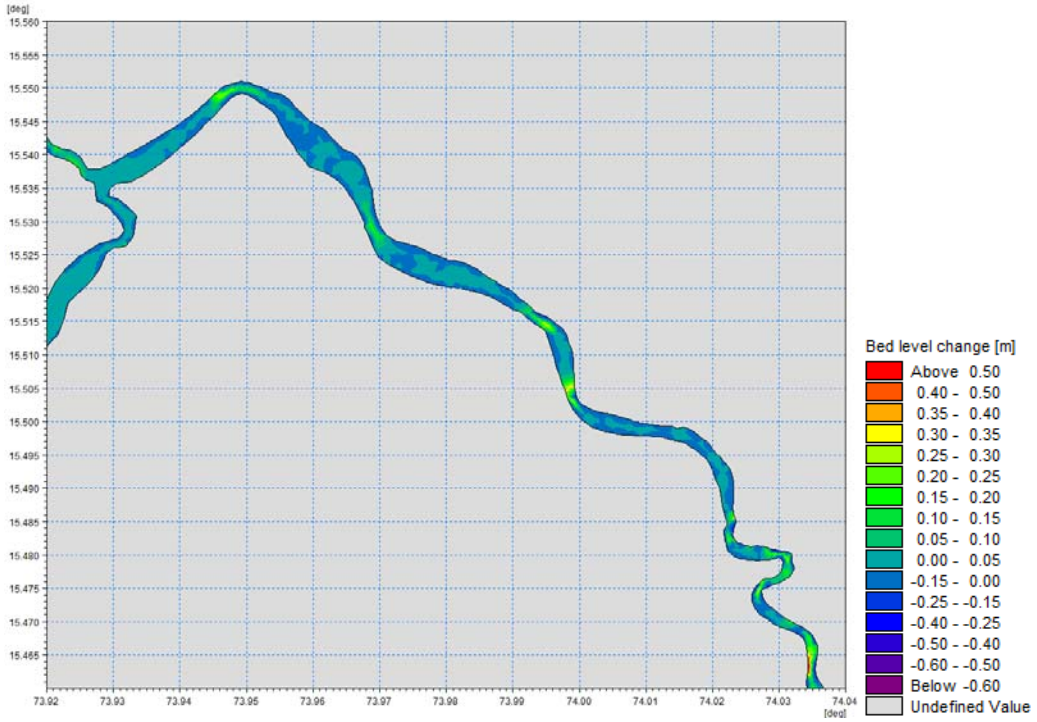


(b)

Figure 5.17: Bed level change at sections A and B with (a) Case 1, (b) Case 2 during Non-Monsoon.

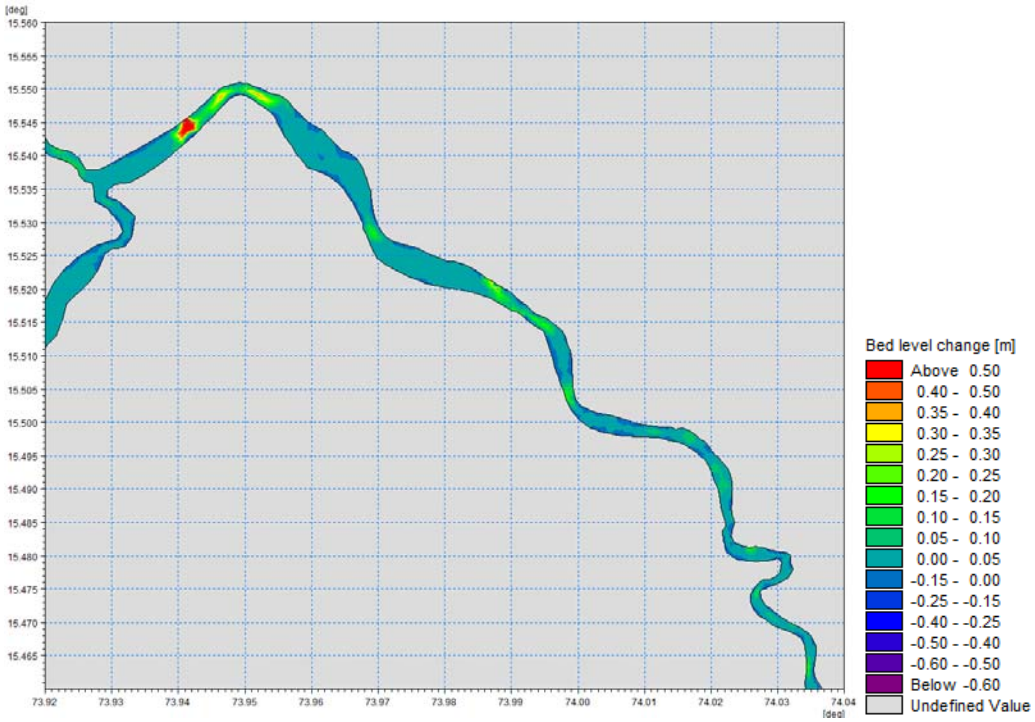


(a)

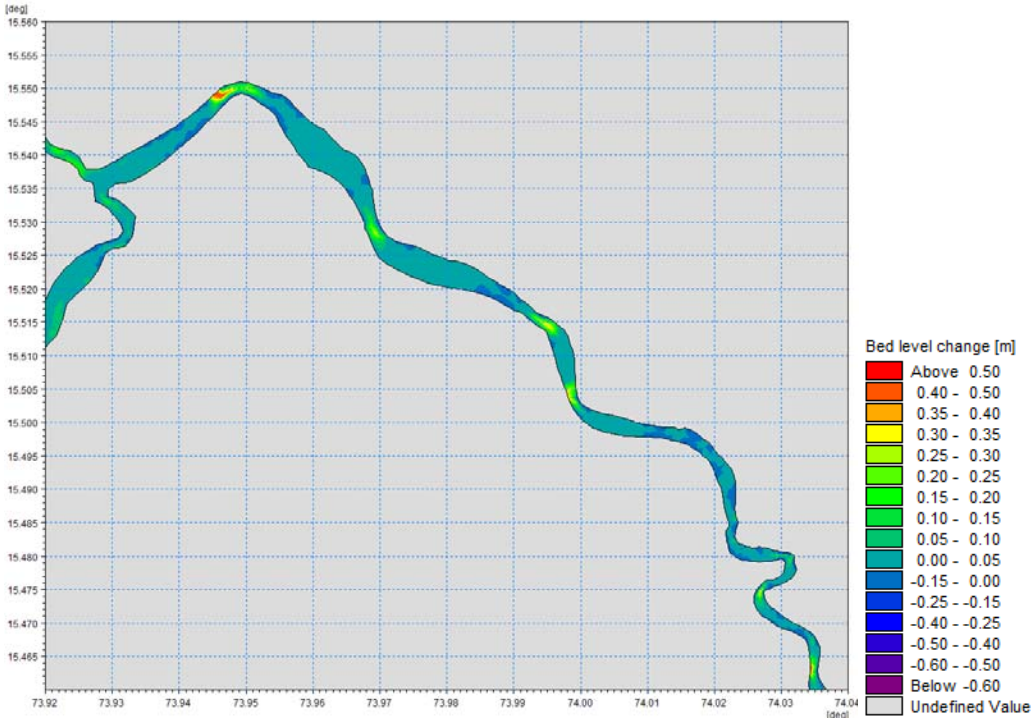


(b)

Figure 5.18: Bed level change at sections C, D, E, F, G, H and I with (a) Case 1, (b) Case 2 during Monsoon.



(a)



(b)

Figure 5.19: Bed level change at sections C, D, E, F, G, H and I with (a) Case 1, (b) Case 2 during Non-Monsoon.

CHAPTER 6: 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 is used for making concrete, filling roads, construction of buildings, 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 mining areas.

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 Mandovi Estuary. The projects seek to understand the geomorphology, bathymetry, sand budget and flow dynamic of the estuary and the impact of sand mining on environment and biodiversity of the estuary. 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.

6.1 Prediction & Assessment of impacts

Development projects such as sand mining have an impact on their surrounding environment. These impacts beneficial or harmful, depending 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 substance 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 major threats to the environment in the study area of the estuarine system have been identified.

6.1.1 Impact on physical environment

- Large-scale 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 sediment transported from upstream to deposit at mine site.
- Alteration of the bed can have a high erosive effect on the river banks.
- It can result bank erosion and damages to existing structures in the downstream.

6.1.2 Impact on traffic

- Mining contractor uses the same main roads to transport product out of the zone and through road networks. This may result in an increase in the number of trucks utilising 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.

6.1.3 Impact on Air Environment

- Dust generation may occur due to loading, screening and transportation operations. This dust becomes air borne and gets carried away to surrounding areas.

- The impact on air will be localized in nature as large sized dust particles settle down after travelling short distance.
- Combined impact of air borne dust from the mining lease areas may give a relatively larger picture of fugitive dust emission in the area.
- Collection and lifting of material are to 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.

6.1.4 Impact on Water environment

- Sand mining activities may have 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 may 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.

6.1.5 Plume generation

- At the proposed sites of river/estuary, 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 changes the nutrient regime of the water column and results in increased pollutant such as particulate associated pollutants, Polyhydrocarbons (PHC), oil and grease (O&G), heavy metals, organic matter and other contaminants and toxins from the sediment.

- The turbidity plume generated may have localized dispersal due to tidal action and riverine flux, thus the overall impacts may be localized and not of chronic nature.
- The size and duration of plume depends on the scale and periodicity of the mining.

6.1.6 Impact on Pelagic environment

- The increased turbidity leads to decrease in dissolved oxygen (DO) in the water column during sand mining operations. These sediments contain highly variable levels of nutrients, typically an order of magnitude several hundred to several thousand.
- Increase in suspended sediment loads and turbidity level due to sand mining could 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 but also affects filter feeding organisms such zooplankton and bivalves.
- Reduced DO can cause the loss of micro-eukaryotic biomass, decrease aerobic bacteria and increase sulphate-reducing bacteria.
- Loss or reduction of bacteria means the 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 will increase surface phytoplankton bloom that may clog membranes of filter feeding zooplankton and larval fish.

6.1.7 Impact on planktons

- Sand mining causes resuspension of sediments in the water column during 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 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 dependant, these are generally of low significance and temporary. However, the release of contaminants such as heavy metals associated with suspended sediments can lead to increased accumulation of contaminants in the food chain.

6.1.8 Impact on Fishery

- Common fish found in Mandovi Estuary are *Etroplus suratensis*, *Mugil cephalus, Sillago sihama, Lates calcarifer* and the overall fishery yield from the river is high. Thus the mining may have negative effects on fish population.
- Sand mining affects the area by limiting the ability of mined areas to function as a nursery area, and/or feeding ground for the 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.
- Increased turbidity and organic matter may change the microbial water quality at nearby sites and thus may affect the fish fauna. Increase in the population of undesirable species such as viruses and parasites.

6.1.9 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 may result in complete removal of benthic surface biota at mining sites.

- Excessive and unplanned riverbed sand mining results in the destruction 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 in mining sites 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.

6.1.10 Impact on channel

- 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.
- 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.

6.1.11 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 can lead to damage to embankments which cause saline water intrusion into fields which leads to abandonment of fields that are further colonized by mangroves.
- Damage to mangroves can also affect species (eg: *Meretrix* spp*, Polymesoda* spp*.,* other oysters and clams) that depend on mangroves for resources.
- However, the overall impacts to mangrove in the study area are of low concern as mangrove cover has shown steady increase in-turn showing indications of increasing its expanse.

6.1.12 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 on mudflats.

6.1.13 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. Crustacean 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 may include undercutting and collapse of river banks, loss of adjacent land and/or structures, upstream erosion and uprooting of flora 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 bandhs leading to salt water intrusions into paddy field.

6.1.14 Others

- The most likely adverse impact might be of cumulative nature and it will be hard to discern from any singular impact of 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. These species can face increased threats and can be harmed due to disturbance.
- Mandovi Estuary has a good diversity and abundance of avifauna. Birds gather on the mud flats of River Mandovi 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.
- Oil spills due to any unplanned eventuality is one of the major long-term threats to the marine biota and can have a major long term irreversible loss depending on the extent, quantity and expanse of spillage. The likeliness of this occurrence will be very low if proper precautions and contingency plans are in place.

6.1.15 Positive anticipated impacts

- Sand mining can help the economy directly by generating jobs for extraction of sand and income from sale of sand.

6.2 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.

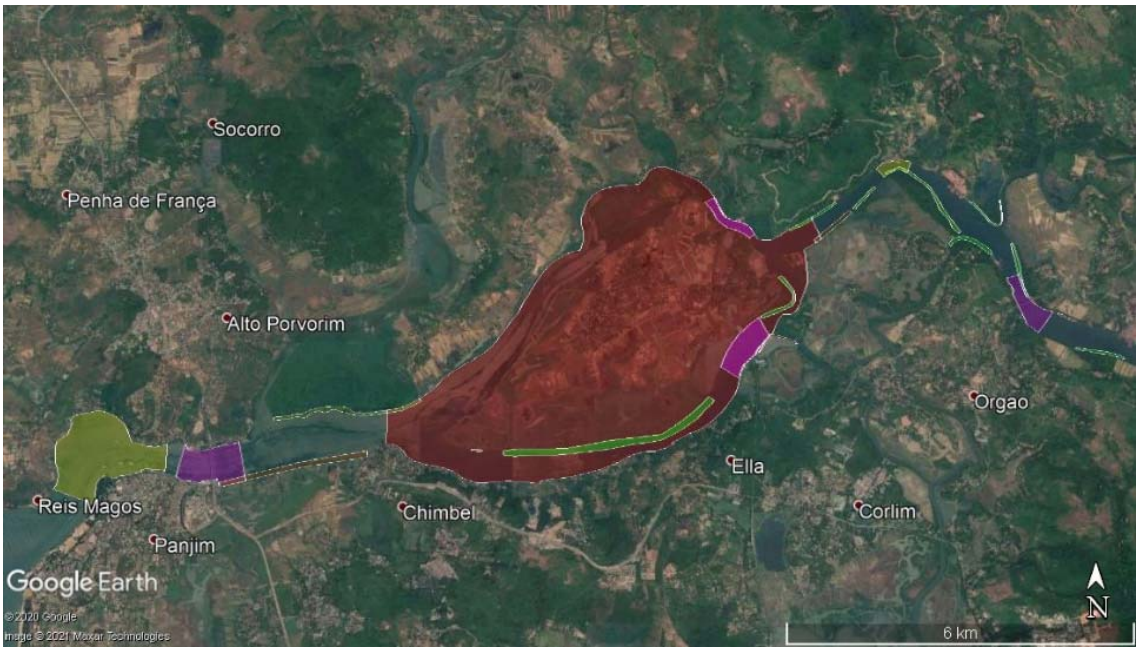
To preserve and protect these habitats areas have been demarcated based on importance and in accordance with Sustainable Sand Mining and Management Guideline (2016). The entire region is divided into three different zones. Zone –I (Fig 6.1) (and Legends as per Table 6.1) is located at the mouth region, it ends at Candola village jurisdiction. The area consists of sensitive regions *viz.* embankment to protect paddy fields, sand flat, Mangroves, riverside urban areas and bridge. Shallow sand and mud flats provide feeding habitat to a lot of migrating and local birds, if sand is excavated from zone-I (Fig 6.1) it is predicted to impact shoreline, change in geo-morphology, beach profile and grain size of sandy beach, which will potentially have adverse impact on birds feeding grounds. Further a bridge is present connecting Panjim and Porvorim, mining might damage this structure, stability or strength of the bridge. As per SSMMG, 2016, to avoid structural damage to any bridge, an area of 500 meters on both the sides of bridge is restricted for mining. North to the bridge an Island (East of Ribander 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. An embankment exists to protect salt water intrusion as well as to secure paddy field on Ribander side. Beside this embankment lies mangrove forest, and 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 Gaundalim to Khandepar which consists of two adjacent islands towards east end, bridge and meandering towards west. The order of Hon'able NGT order (28/2015 (WZ) has been followed for excluding an area of 1000m upstreams and down-streams of Chorao Island is applied to all the islands of this river. Thus, 1000m upstream and downstream area from these islands 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 (Fig 6.1) falls between Khandepar to Ganjem, it consists of an Island and meander towards Ganjem. On the westward 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-I



ZONE-II



ZONE-III

Figure 6.1: Depicting Mining Sensitive Zones for the Mandovi Estuary (Zone I to III)

Table 6.1: Depicting type of sensitivity, colour code, width and guidelines referred.			
Colour	**Sensitive Areas**	**Width**	**Guideline**
	Mudflats and Mangrove	50 m	Sustainable Sand Mining Management Guideline 2016
	Bridges	500 m	Sustainable Sand Mining Management Guideline 2016
	Islands	1000 m	Sustainable Sand Mining Management Guideline 2016/ National Green Tribunal.
	Meandering	200 m	Sustainable Sand Mining Management Guideline 2016
	Embankment	25 m	Sustainable Sand Mining Management Guideline 2016

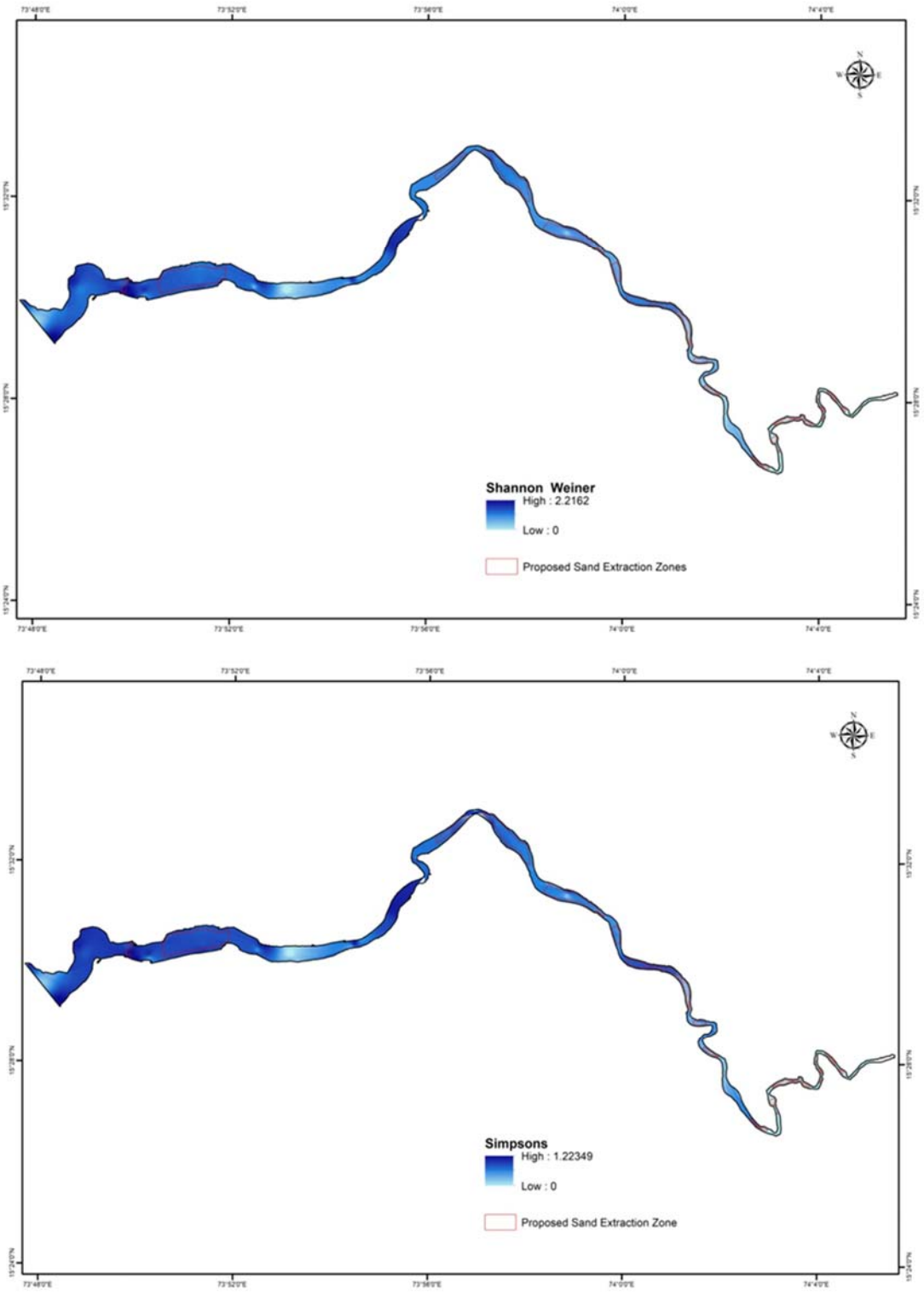


Figure 6.2: Shannon-Wieners and Simpsons Index depicted on the river stretches with encircled proposed sand extraction zones.

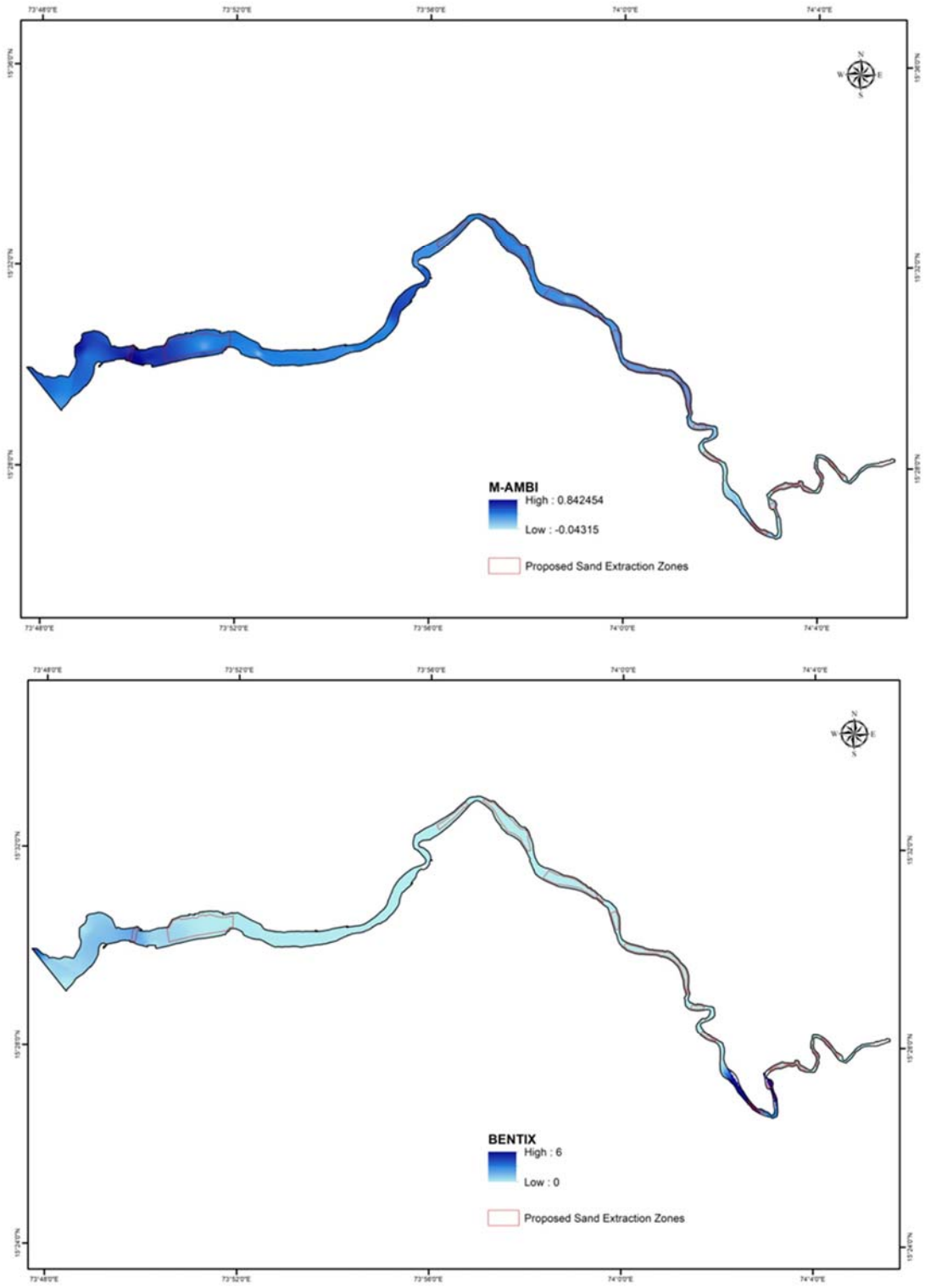


Figure 6.3: M-AMBI and BENTIXindices depicted on the river stretches with encircled proposed sand extraction zones.

CHAPTER 7: 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 it's 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).

7.1 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 Hon'able 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.

7.2 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 25 Ha. After every year, a mandatory audit of the quantity extracted and quantity permitted along with the replenishment rate.

7.3 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. 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 ¼th or river width and should not be less than 7.5 meters.

7.4 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.

7.5 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.

7.6 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 auditsneed 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.

7.7 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 Mandovi river and has not found significant change in water quality (Action Plan Report on River mandovi river, 2019) wherein sand extraction was an on-going activity thus representing cumulative results. The report delineates several activities for the rejuvenation of Mandovi River and considering these proposed actions, the management aspects in this report have been proposed.

7.8 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 Mandovi river 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.

7.9 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 8 ENVIRONMENTAL CONSERVATION AND MANAGEMENT PLAN

8.1 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 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.

8.2 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 proposed activites

- 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

8.3 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 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.

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.

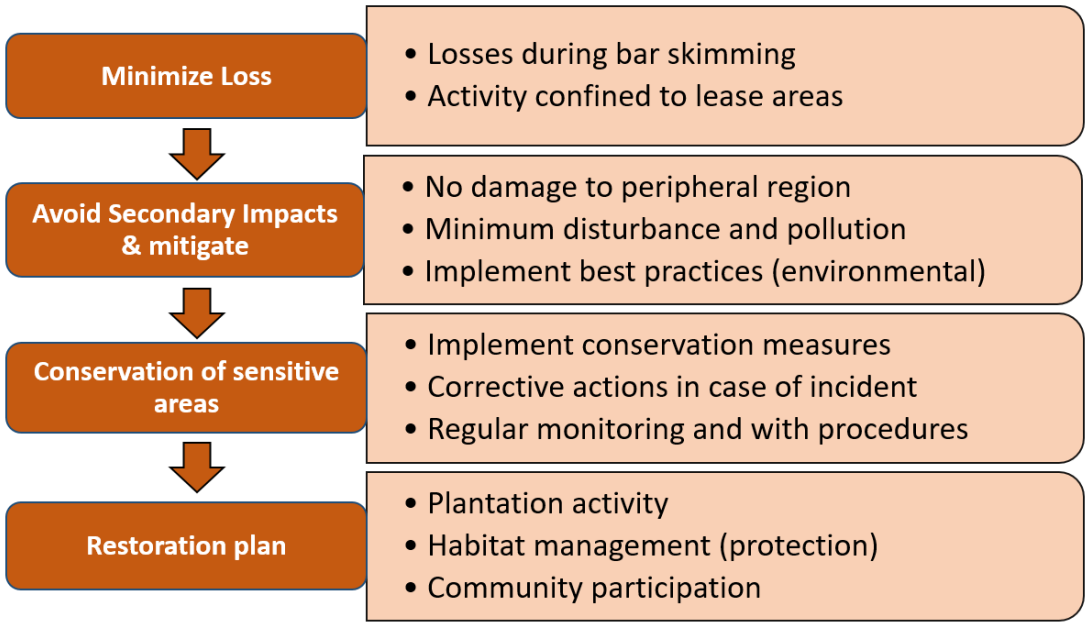


Figure 8.1: Schematic diagram of management of sand mining

8.4 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. Stretches shall be identified for species of significant importance in the river ecosystem. Such stretch with adequate buffer should 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. (Fig.8.1).

8.5 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.

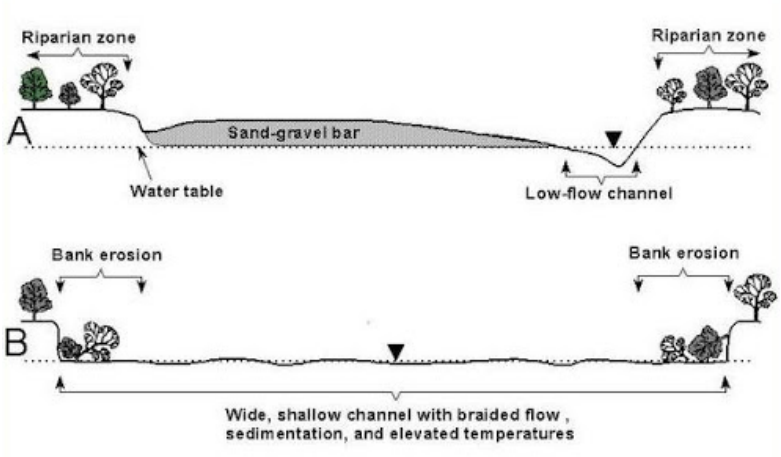


Figure 8.2: A typical sand-gravel bar in relation to the low-flow channel, riparian zone and water table, and (B) the wide shallow channel that results from unrestricted mining and that is characterized by bank erosion, braided flow, sedimentation, and increased water temperatures. (Source:http://threeissues.sdsu.edu/three_issues_sandminingfacts01.html).

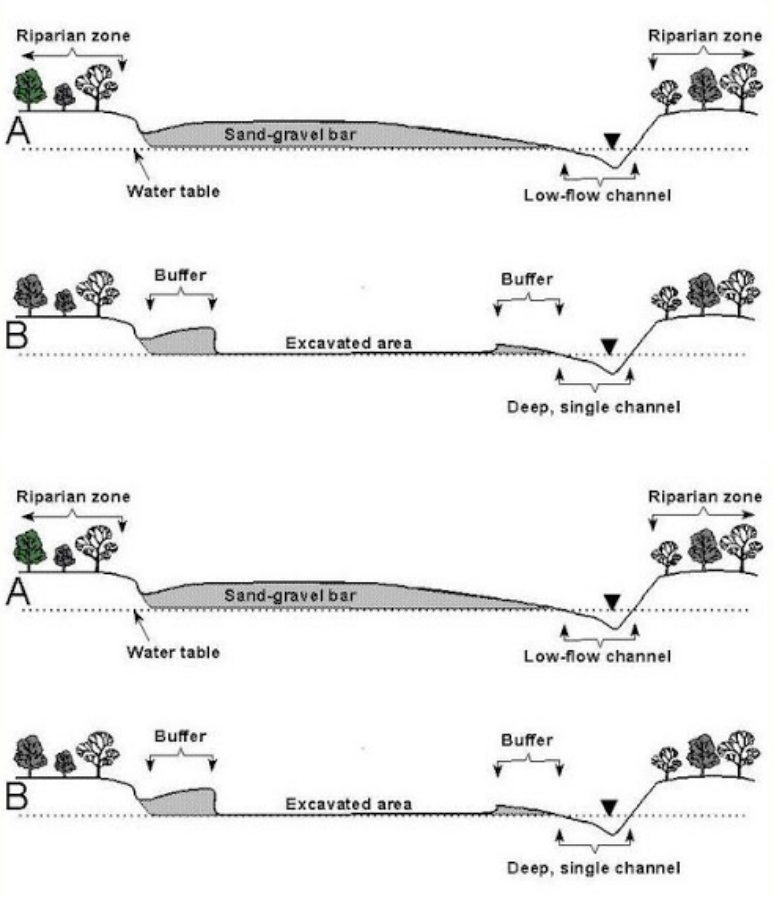


Figure 8.3: Diagram of channel cross sections showing
8.3 (A)- A typical sand-gravel bar in relation to the low-flow channel, riparian zone and water table, and (B) the protected deep, single channel and channel banks when mining is restricted within a buffer of designated width and above the water table. (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.

i) Minimise activities that release fine sediment to the river

No washing, crushing, screening, stockpiling, or plant operations should occur at or below the stream's 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) 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.

8.6 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).

8.7 Mangrove management and conservation

In Mandovi, the mangroves are well represented in the middle and 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.

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).

8.8 Embankment protection and restoration

This river is 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.
- The vulnerable (soft sediment bank walls of the river) areas should be protected and no sand extraction shall be permissible in these regions.
- Provision of funds for maintaining embankments is essential

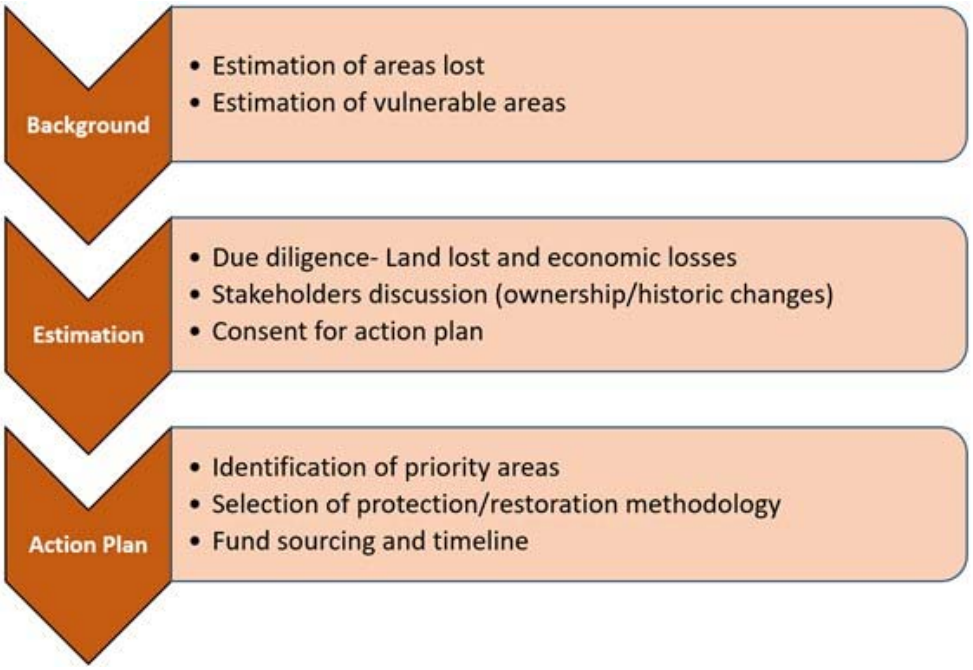


Figure 8.4: Schematic diagram of river bank protection and restoration plan

8.9 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.

8.9.1 Conservation plan for fauna

The estuarine region is a known habitat (based on secondary information) for Otters, Crocodiles, and Dolphins. 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) 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.

- 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 have 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.

8.9.2 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 hard substratum within the study area is good for the growth of green mussel (*P. viridis*) and oyster (*Crassostrea madrasensis* and *C. gigas*). 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 casta, Villorita ceprenoides, Anadra* sp. and *Polymesoda erosa* are found in the mudflats, sand flats and mangrove sediments in the study area. 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, 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.

8.9.3 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 are already formed by GSBB) 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 existing 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.

8.10 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 off, 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 protection by embankments is 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. 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.

8.11 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, Johnieops* sp., *Sardinella* sp., *Secutor* sp., *Leiognathus sp., Parastromateus niger, Pampus chinensis, Pampus argenteus, Rastrelliger karagurata, Stolophorus indicus, Chirocentrus dorab, Opisthopterus tardoore, Lutjanus campechanus, Etroplus suratensis, Lates calcarifer, Polydactylus plebeius, Scomberomorus commerson, Scomberomorus guttatus, Arius sp., Cynoglossus arel, Penaeus monodon, Fenneropenaeus merguensi, Metapenaeus affinis, Metapenaeus dobsonii, Scylla serrata, Portunus pelagicus, Charybdis feriatus, Loligoduvauceli, Villorita cyprinoides, Polymesoda erosa, Meretrix meretrix, Meretrix casta, Paphia malabarica, Paphia textilis, Crassostrea madrasensis, Crassostrea gigas*

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*), Pearlspot (*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 8.1).

Table 8.1: Schemes for aquaculture in Goa (Source: Fishery department)

1.	Financial Assistance to Brackish Water Aquaculture Pond	A. Financial Assistance for Construction and Renovation of Farms 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. B. Financial Assistance for purchase of farming equipments: 50% subsidy limited to Rs.1.00 lakh per ha. Up to 2 ha after 5 years. C. Financial Assistance for purchase of feed: 25% subsidy of the cost of feed limited to Rs. 30000/- per crop per ha for 2 crops in a yr. Eligible every year.
2.	Financial Assistance for setting up of Crab farming Unit in Goa	A. Financial Assistance for setting up of the crab culture unit: 25% of the actually cost limited to Rs.1,50,000/- per ha. Farmer will be eligible to 2 ha. B. Financial Assistance for purchase of seed and feed: 50% of the actual cost limited to Rs.75, 000/- ha. Limited to 2ha per yr.
3.	Financial Assistance to Freshwater Aquaculture farm	A. Financial Assistance for Construction and Renovation of Farm: 25% subsidy limited to Rs. 2.00Lakh per ha. Eligible every after 5 yr.

		B. Financial Assistance for purchase of seed and feed: 25% subsidy limited to Rs.50,000/- per ha. Limited to 2 ha. Eligible on seed and feed once in every year. C. Financial Assistance for purchase of Farm Equipments: 50% limited to Rs. 60,000/- per ha. Eligible after every 5 years.
4.	Financial Assistance to Mussel Culture and Oyster Farming in Goa	A. Setting up of unit in estuarine waters: 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. B. Setting up of unit in open sea 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.
5.	Financial Assistance for setting up of Ornamental Fish Unit in Goa	A. For setting up of Breeding unit-50% of the actual cost limited to Rs.1, 50,000/-. B. For setting up of Rearing unit-50% of the actual cost limited to Rs.1, 50,000/-. C. For setting up of Rearing unit and Breeding unit- 50% of the actual cost limited to Rs.2,50,000/-.

Following are some of the known aquaculture species that are well suitable for considering as small-scale business model.

8.11.1. 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 ate stoked after the harvesting of rice crops. This will provide 6-7 months of rearing fishes.

9.11.2. 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 s*sp.

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.

8.11.3. 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 ain 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.

8.11.4. 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: ***Villorita cyprinoides, Paphia malabarica, Meritrix casta, Anadara granosa*.**

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.

8.11.5. 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 m^2 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 have 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 mossambi*cus**).** 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.

8.11.6. 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. Costal 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 *Penaeusindicus,* White leg shrimp *P. vannamei* and tiger prawn *P. monodon*. Apart from these candidate species other commercially important species such as *Metapenaeusensis*, *M. monoceros*, *M. brevicornis*, *P. semisulcatus* and *P. merguiensis* 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, soilconditions. 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/m^2. 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 should be acclimatized to prevailing 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.

8.11.7. 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. s. These 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.

8.11.8. 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.

8.11.9. Pearlspot fish culture

Pearlspot, *Etroplus suratensis* (locally known as “Kalundhar”) is another important candidate species for culture in ponds, cages and tanks. Polyculture of pearlspot 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.

8.11.10. 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.

8.11.11. 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.

8.11.12. Ornamental fish culture

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.

8.11.13. 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.

8.11.14. Integrated Multi-Trophic Aquaculture (IMTA)

Coastal brackishwater 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.

8.12. 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 Mandovi 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 Reis Magos fort, Aguada fort, well-known tourist places such as Old Goa, Miramar, Chorao, Divar as well as the capital of Goa (Panaji). Mandovi 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 be encouraged. Spice garden plantations and picnic spots can 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.

8.13. 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 undertaken 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 a generic structure that 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 (Fig. 8.5).

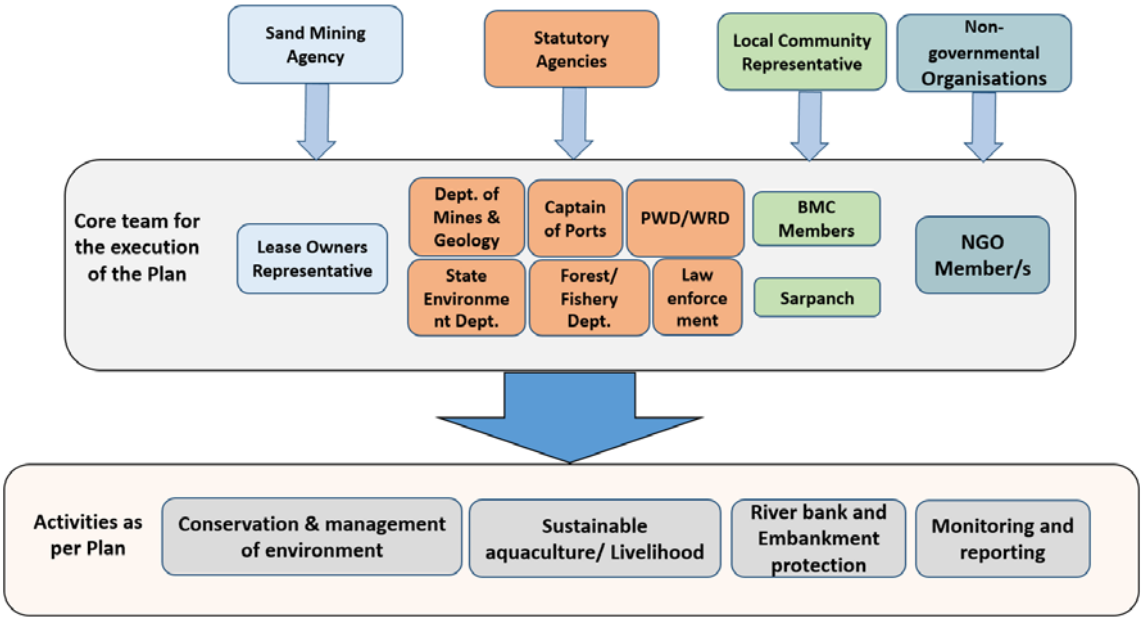


Figure 8.5. Schematic diagram depicts execution of management plan

8.13.1. 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.

8.13.2 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 (eg: 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 con-conformance and keep its record.

8.13.3 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).

8.13.4 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.

8.13.5 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 (Fig 8.8).

8.13.6 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.

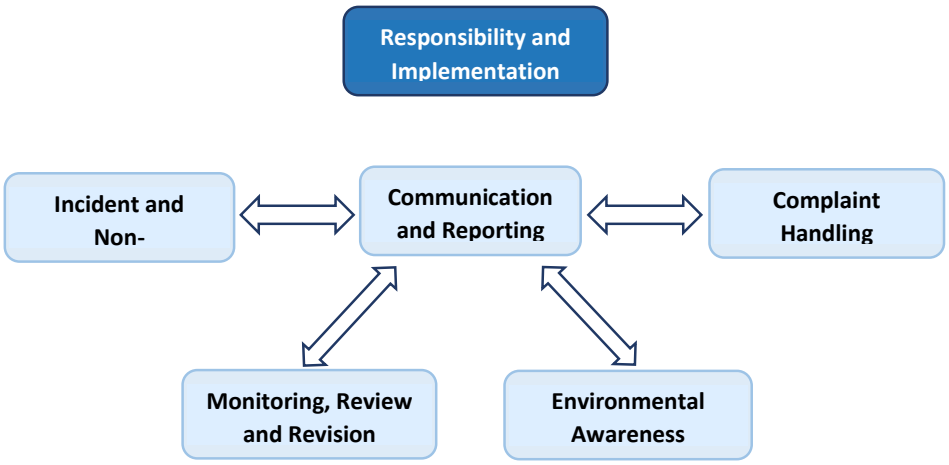


Figure 8.6. Schematic diagram of development and functioning of team

9.13.7 Attempts to deal with the illegal trade (WWF, 2018)

The Directorate of Mines & Geology, the Costal 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)

Alternatives 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.

8.13.8 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 9 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.

9.1 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 year, 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.

9.2. 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.

9.3 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.

9.4. 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 (PM_{10}), Particulate Matter 2.5 ($PM_{2.5}$), Sulphur dioxide (SO_2), Oxides of Nitrogen (NOx), 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.

9.5. 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.

9.6. 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.

9.7. 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 9.1.

Table 9.1: Water quality monitoring parameters and schedule.

Sr. No	Cluster	Parameters measured	Locations	Operation Phase
1	Sea Water	Temperature, Salinity, DO, BOD, OC, Nutrients	15 locations	Once every six months
2	Sediment	Texture, Grain Size, OC	15 locations	Once every six months
3	Plankton & Benthos	Phytoplankton, Zooplankton, Meio & Macro- fauna	15 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

9.8 Embankment 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.

9.9 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

9.10 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.

9.11 Integrated Aquaculture and eco-tourism

The discharge of nutrients, sediment, BOD, bacteria, and pathogens into estuarine waters is one of the problems 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 tourist/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.

RECOMMONDATIONS

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 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, Mandovi estuary has been influenced 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 rainfall and upstream water flow.
- The salinity intrusion has also changed the land use, converting many paddy fields and riparian zones and mudflats into un productive areas or mangrove areas.

- 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.
- Based on the side scan sonar imaging, single beam echosounder bathymetry and high resolution seismic (HRS), morphological features of river bed have been interpreted across a stretch of 38 km of Mandovi river. The side scan sonar image shows various geomorphological features like ripple marks (associated with sand), rock outcrops, river banks, erosion features, mud zones and shadow zones of the road and railway bridges across the Mandovi river. Apart from this, active sand mining zones in different regions of Mandovi river have also been identified. The single beam echo sounding data is used for estimating the depth of the river bed and the high-resolution seismic data is utilized for the estimating the sediment thickness.
- The microscopic grain size analysis shows a decrease in grain size when moving from Khandepar to the river mouth. The bulk sediment grain size in most of the samples is dominated by sand fraction. Most of the stations contain a considerable amount of quartzite, iron oxide, and fewer lithic fragments. Based on the analysis, the region is divided into three zones. Zone1: Khandepar to Navelim (sampling point 86-100), characterised by poorly sorted, semi rounded pebbles and large size sediment along with silt clay pockets; Zone2: Piligao to Navelim (sampling points 81-85), characterised by poor to moderately sorted, admixture of pebbles and fine to medium grain sand and Zone3: River mouth to Piligao (sampling point 67-81), characterised by well-sorted and highly angular grain distribution (Fig.33).
- The comparative analysis reveals that Khandepar, Cotombi, Volvoi, Navelim, and Betqi, are the locations where mid-channel/point bars erosion and deposition of non-cohesive sediment in the nearby downstream region is prominent. Whereas, Navelim-Betqui, Amona, Piligaon, Narve are the regions where the morphological changes are not prominent, except sand mining signatures and mining patterns. Integrated analysis of SSS and HRS data at respective locations revealed that a local redistribution

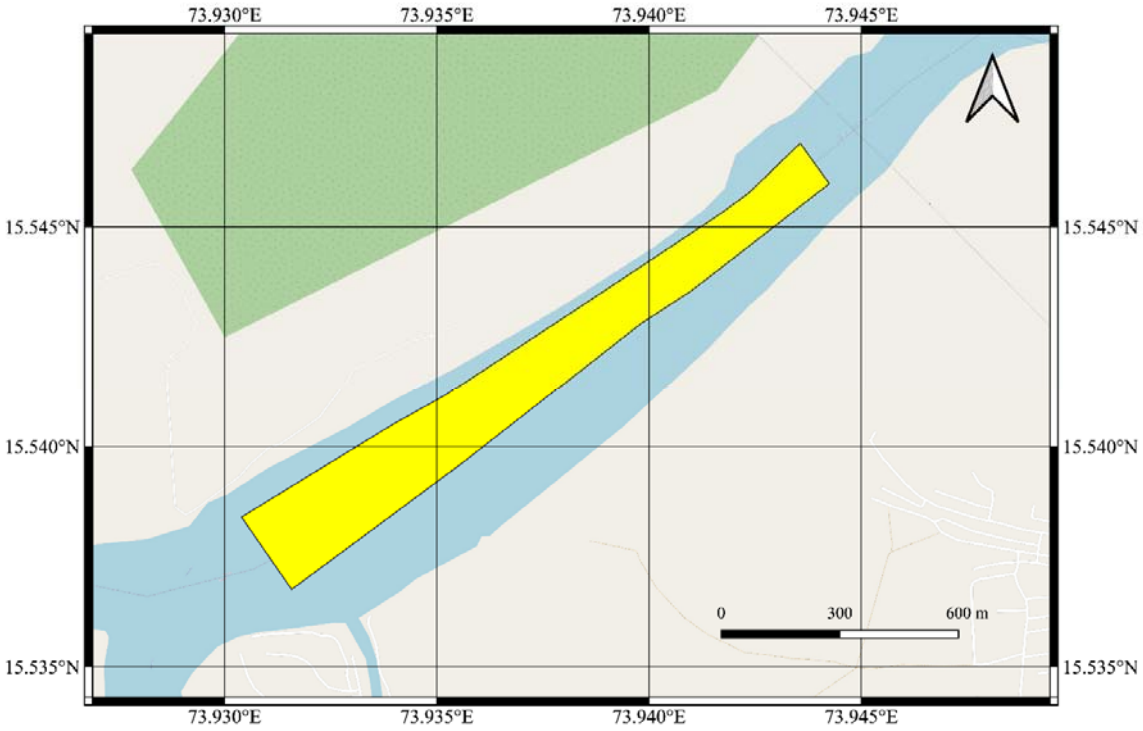
of the sediment in most of the region. It also suggests that the erosion and depositional processes are simultaneously working at very local scale in the river.

- In the Mandovi estuary the bed level changes for the post-mining scenario are mostly around -0.15 m to 0.25 m during both simulated monsoon (August-November, 2020) and non-monsoon period (November, 2020 - May, 2021) of Mandovi estuary. 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 below 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.

Mandovi minable zones

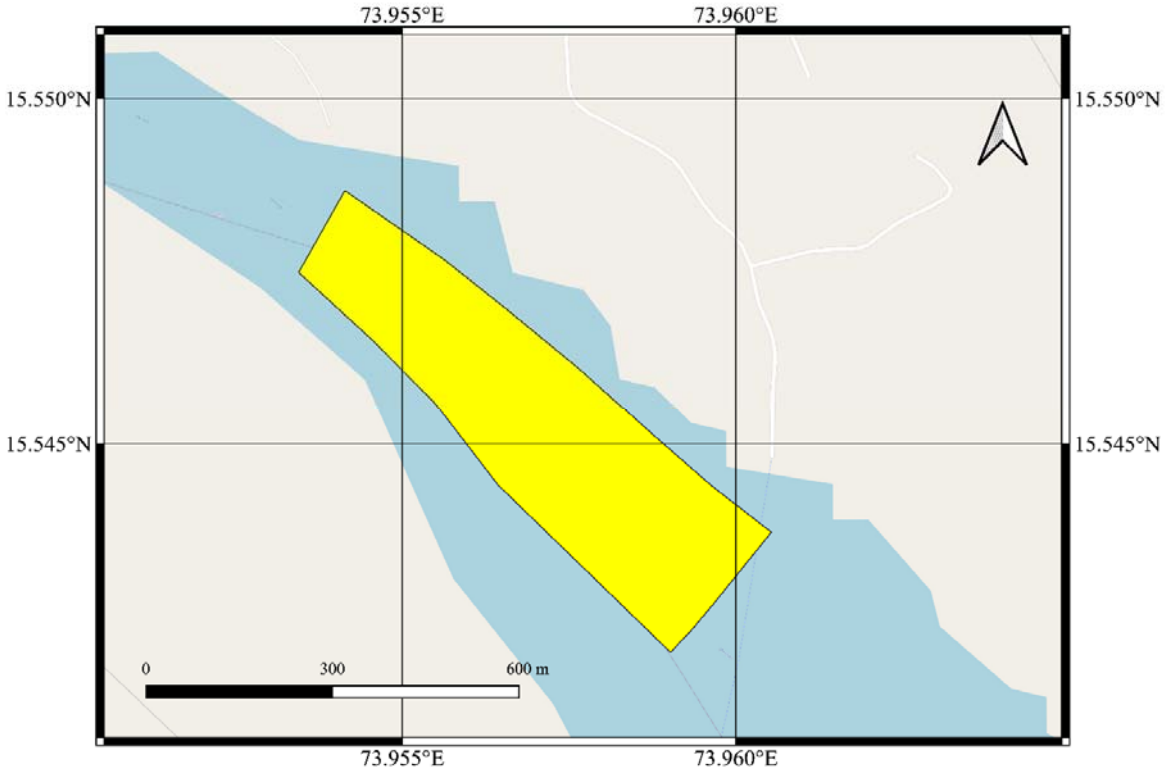
Zone1: Near Narve



Total area = 24.95 Hectares

S. No.	Latitude	Longitude
1	73.93040011	15.53839865
2	73.93397843	15.54050647
3	73.93517328	15.54117788
4	73.93868399	15.5433992
5	73.94170389	15.54531537
6	73.94234393	15.54578507
7	73.94353926	15.54688973
8	73.9442248	15.54597298
9	73.94205713	15.54432797
10	73.94099757	15.54355989
11	73.93980786	15.54282511
12	73.93558787	15.53963007
13	73.93159109	15.53676197
14	73.93040011	15.53839865

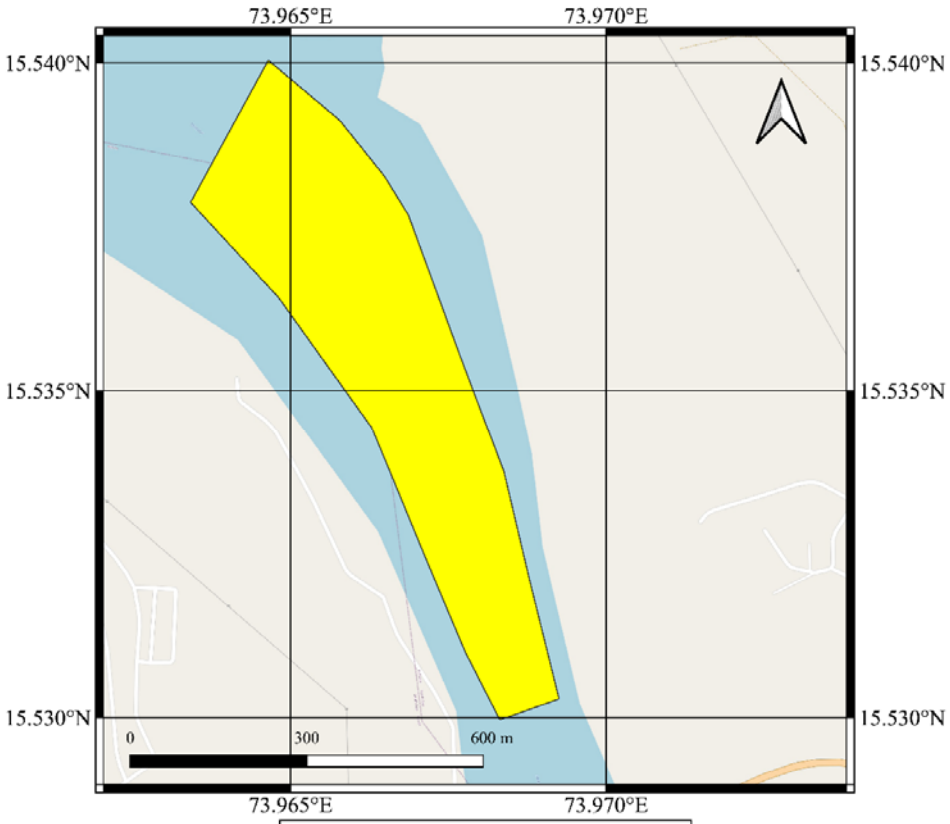
Zone2a: Piligoa



Total area = 17.9 Hectares

S. No.	Latitude	Longitude
1	73.95413929	15.54867194
2	73.95563673	15.54766858
3	73.9565364	15.54697898
4	73.95763968	15.54610435
5	73.95878787	15.5451048
6	73.9596285	15.54439833
7	73.96053434	15.54372241
8	73.95965537	15.54267371
9	73.95931027	15.542282
10	73.95901916	15.54199034
11	73.95643052	15.54440565
12	73.95546112	15.54562615
13	73.95452331	15.54653204
14	73.95344795	15.54748692
15	73.95413929	15.54867194

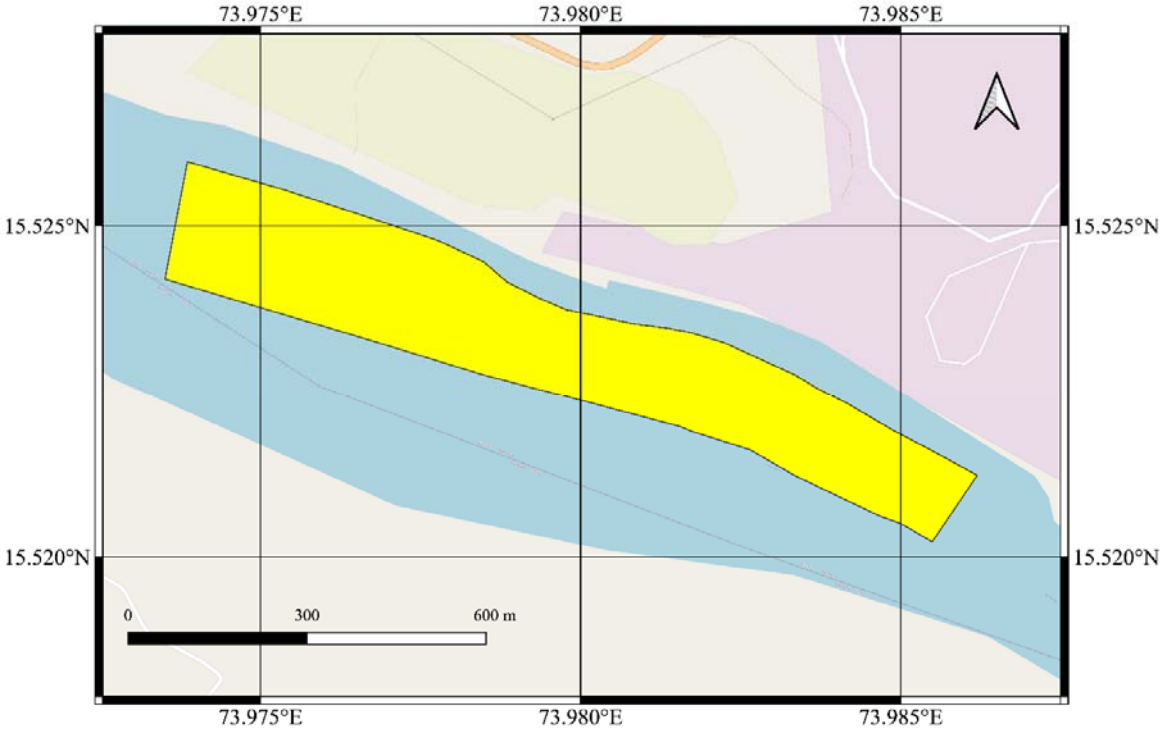
Zone2b: Near Amona Bridge



Total area = 22.7 Hectares

S. No.	Latitude	Longitude
1	73.96464811	15.54004303
2	73.96577397	15.53912512
3	73.96649154	15.53826973
4	73.96686798	15.5376735
5	73.96768748	15.53553086
6	73.96837961	15.53374982
7	73.96877363	15.53214469
8	73.96925404	15.53027964
9	73.96831599	15.52996466
10	73.96777034	15.53099188
11	73.96715354	15.53240515
12	73.96627723	15.53444013
13	73.96480669	15.53642424
14	73.96341506	15.53787096
15	73.96464811	15.54004303

Zone3: Vedanta Pig Iron Plant

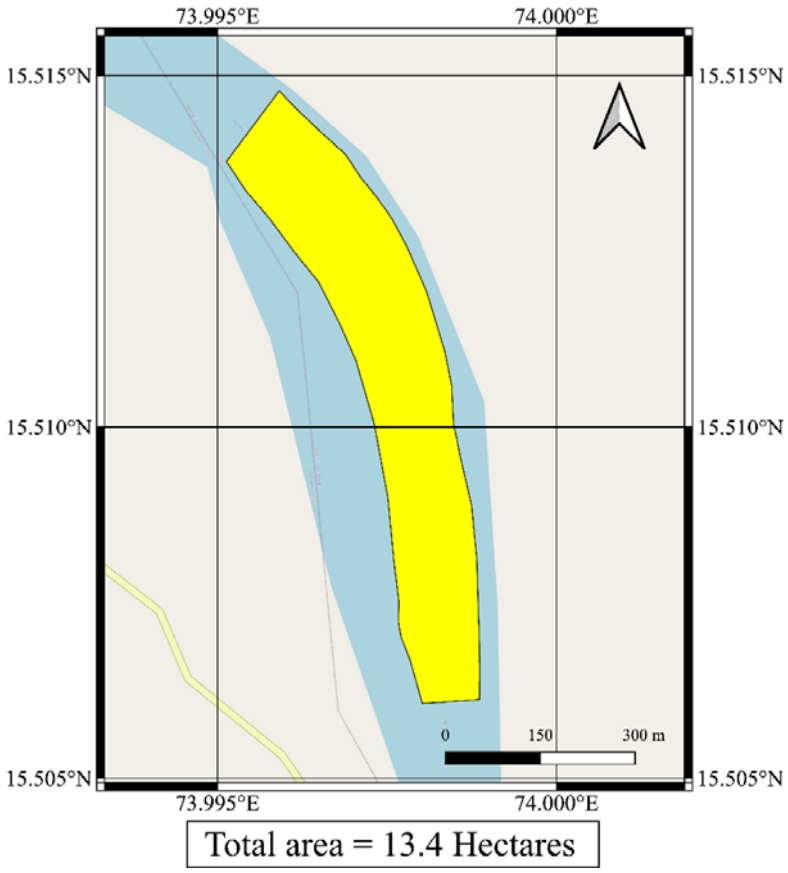


Total area = 23 Hectares

S. No.	Latitude	Longitude
1	73.97385439	15.52595822
2	73.97534001	15.52552959
3	73.97667398	15.52512641
4	73.97777606	15.52477284
5	73.97850539	15.52445255
6	73.97883334	15.52416303
7	73.97933071	15.523917
8	73.97978737	15.52374653
9	73.98016972	15.52365325
10	73.98085334	15.52351467
11	73.98131277	15.52345676
12	73.98168924	15.52339959
13	73.98207046	15.52329352
14	73.98224883	15.52322748
15	73.98336367	15.52275402
16	73.98370286	15.5225405
17	73.98417664	15.52230278
18	73.98487017	15.52191055
19	73.9855492	15.521566
20	73.98618416	15.52122532
21	73.98546811	15.52022787

22	73.98498165	15.52050213
23	73.98466057	15.52061711
24	73.98333637	15.52122109
25	73.98264506	15.52160685
26	73.98173843	15.52188387
27	73.98155428	15.52196947
28	73.9798778	15.52238958
29	73.97843792	15.52275956
30	73.97677637	15.52325783
31	73.97349585	15.5241897
32	73.97385439	15.52595822

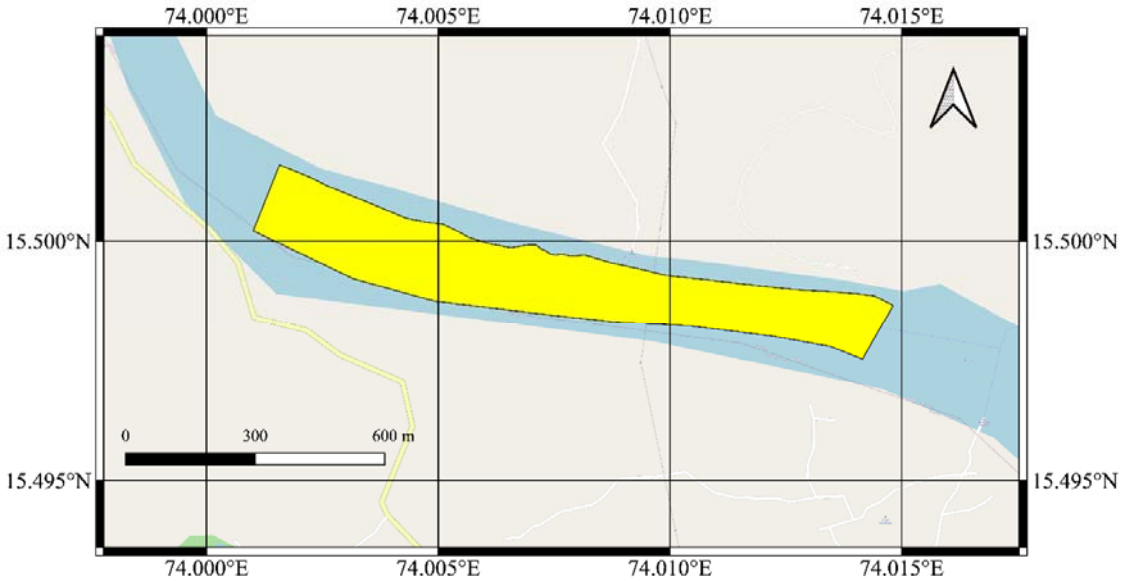
Zone4: Navelim-Betqui



S. No.	Latitude	Longitude
1	73.99591061	15.51478392
2	73.99618497	15.51451037
3	73.99648948	15.51423129
4	73.99689068	15.51388054
5	73.99711122	15.51355411

6	73.99732818	15.51330015
7	73.99756662	15.51297635
8	73.99777943	15.51258667
9	73.99796099	15.51220714
10	73.99808914	15.51192535
11	73.99835151	15.51107269
12	73.99845352	15.51059751
13	73.9984837	15.51004277
14	73.99859198	15.50954838
15	73.99875221	15.50887239
16	73.99882489	15.50810855
17	73.99884062	15.50760361
18	73.99886135	15.50690859
19	73.99886831	15.50663077
20	73.99886913	15.50638239
21	73.99886684	15.50612107
22	73.99802353	15.50605872
23	73.99784478	15.5066689
24	73.99770823	15.50700728
25	73.99767049	15.50722373
26	73.99767865	15.50751176
27	73.99760494	15.50806543
28	73.99751387	15.50898741
29	73.99731111	15.51007178
30	73.99704236	15.51094506
31	73.99680533	15.51145667
32	73.99649654	15.51205831
33	73.99614175	15.51248236
34	73.99576255	15.5129764
35	73.99542085	15.51336244
36	73.99513279	15.5137801
37	73.99591061	15.51478392

Zone5: Navelim-Volvoi

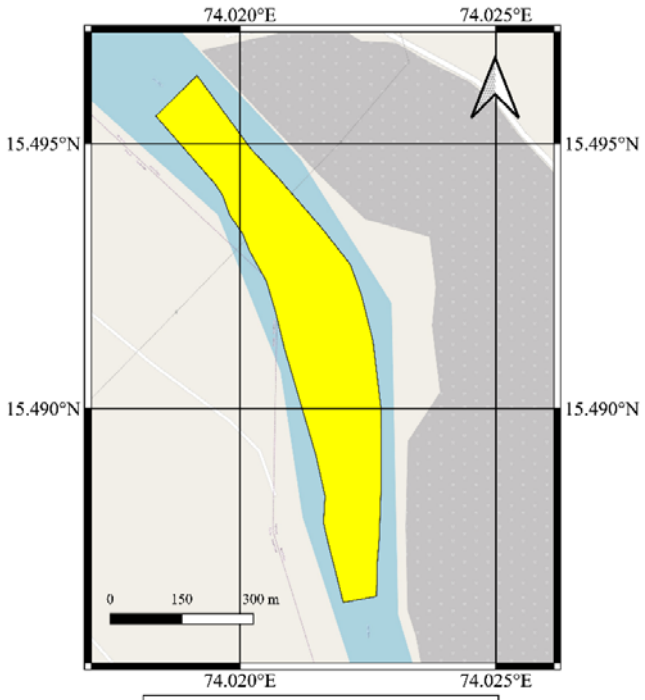


Total area = 21 Hectares

S. No.	Latitude (deg)	Longitude (deg)
1	74.00157344	15.50158318
2	74.00221491	15.50133654
3	74.0026005	15.5011491
4	74.00320357	15.50091366
5	74.00431078	15.50047308
6	74.00478767	15.50038561
7	74.00509921	15.50035338
8	74.00542237	15.50020463
9	74.00565763	15.50007507
10	74.00606188	15.49995426
11	74.00656479	15.49985869
12	74.00694501	15.49992281
13	74.00710602	15.49991956
14	74.00722705	15.49982903
15	74.00731319	15.49979758
16	74.00741548	15.4997312
17	74.00751574	15.49970749
18	74.00767061	15.49972764
19	74.00782622	15.49969447
20	74.00797199	15.49969376
21	74.00815915	15.49970673
22	74.00874971	15.49954028
23	74.00940887	15.4994025
24	74.00990756	15.49928573
25	74.01090874	15.49917769
26	74.01167428	15.49909071

27	74.01264671	15.49899062
28	74.01364885	15.49893215
29	74.0140134	15.49889934
30	74.01441054	15.49886002
31	74.01479138	15.49867191
32	74.01482116	15.49864917
33	74.01415575	15.49752263
34	74.01346137	15.49778648
35	74.01215015	15.49801295
36	74.01185023	15.4980422
37	74.0104559	15.49821744
38	74.0088557	15.49829895
39	74.00711074	15.49848756
40	74.00567265	15.49865363
41	74.00492093	15.49874526
42	74.00317171	15.49920652
43	74.00100644	15.50021183
44	74.00157344	15.50158318

Zone6: Volvoi-Cotombi

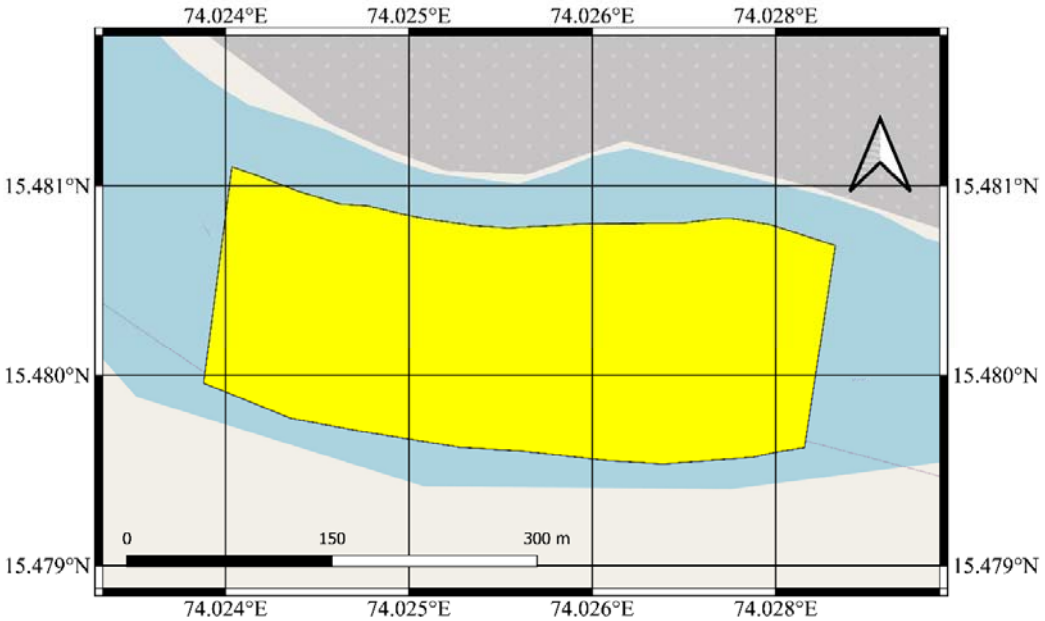


Total area = 15.9 Hectares

S. No.	Latitude	Longitude
1	74.01915915	15.49628202
2	74.01958833	15.49572064
3	74.02021631	15.49489229

4	74.02073048	15.49436683
5	74.0215887	15.49341209
6	74.02215317	15.49272037
7	74.0223729	15.49214196
8	74.02259451	15.49128187
9	74.02275259	15.49002243
10	74.02275799	15.48858818
11	74.02271956	15.4875319
12	74.02267567	15.4870268
13	74.02266829	15.48646095
14	74.02202122	15.48634419
15	74.0218486	15.48697145
16	74.02172575	15.487432
17	74.02162979	15.48784072
18	74.02166249	15.48834543
19	74.0214828	15.48912703
20	74.02124128	15.48987018
21	74.02086768	15.49111532
22	74.02068854	15.49182161
23	74.02051465	15.49239059
24	74.02018192	15.49298203
25	74.0200557	15.49328778
26	74.01979646	15.49365203
27	74.01966166	15.49401219
28	74.01951964	15.49422276
29	74.01835571	15.49551668
30	74.01915915	15.49628202

Zone7: Khandepar



Total area = 7.4 Hectares

S. No.	Latitude	Longitude
1	74.02379439	15.48137362
2	74.02400279	15.48130388
3	74.02424511	15.48121387
4	74.02453181	15.4811299
5	74.02471476	15.48111875
6	74.02491854	15.48107181
7	74.02513025	15.4810302
8	74.02543563	15.48098837
9	74.02567769	15.48097211
10	74.02593426	15.48099595
11	74.02620998	15.48099961
12	74.02657148	15.48100285
13	74.02688094	15.48100635
14	74.02711249	15.48103552
15	74.02719828	15.48103509
16	74.02746925	15.48099335
17	74.02790732	15.4808566
18	74.02769746	15.47952197
19	74.0275112	15.47949502
20	74.02734573	15.4794602
21	74.02673126	15.47941604
22	74.02632602	15.47944159
23	74.02579328	15.47949954
24	74.02534538	15.47952561

25	74.02465596	15.47963355
26	74.02419447	15.47971339
27	74.02360237	15.47994658
28	74.02379439	15.48137362

Area (hectares), Volume (Cubic m) and Weight (Ton) in selected regions and volume (cubic m) and weight (ton) within 3 meter mining dept.

S. No	Region	Area (hectares)	Volume (m^3)	Weight (Tons)	Volume (m^3) for 3m thickness	Weight (Tons) for 3m thickness
1	Near Narve	24.95	655737	1049180	360298	574475
2a	Piligao	17.9	390930	625488	166880	267008
2b	Near Amona Bridge	22.7	521240	833984	222507	356011
3	Vedanta Pig Iron plant	23	855419	1368670	406744	650792
4	Navelim-Betqui	13.4	631923	1011078	321393	514229
5	Navelim-Volvoi	21	443788	710061	321675	514680
6	Volvoi-Cotombi	15.9	372501	596002	293024	468839
7	Khandepar	7.4	151039	241662	151039	241662

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Annexure E

Minutes of the 138th meeting of Goa State Expert Appraisal Committee (Goa-SEAC) held on the 22nd September 2021 at 03.30 p.m. in the conference hall, 4th Floor, Dempo Towers, Patto - Panaji, Goa.

The 138th meeting of the Goa-SEAC was held on 22nd September 2021 in the Conference room 4th floor of the Dempo Towers, Patto-Panaji at 03.30 p.m. under the Chairmanship of Shri. Gautam Desai. The list of members who attended the meeting is at "*Annexure – 1*".

The Chairman welcomed the members and requested Secretary, SEAC to proceed as per the agenda items (*refer Annexure – 2*).

1. **To decide on application for Environmental Clearance for sand extraction in Chapora river received from District Collector, North Goa.**

Member Secretary stated the that Committee inspected the site on 06th September 2021. The Representative of the Department of Mines and Geology , Shri Abir Hede , Dy Director and Shri Sudhir Mandrekar, Assistant Geologist explained the details of sand mining in Goa as available in the records in their Department which is as follows:-

Sand extraction by manual means i.e use of canoes is a traditional practice in Goa which has history even prior to its liberation during erstwhile Portuguese regime. Transportation of sand by use of bullock carts was a practice of which records are found.

The member Secretary explained that Post Liberation of Goa the Goa Daman and Diu Minor Mineral Extraction and Removal Rules, 1974 and Amendment rules 1978 came into force under which leases for extraction of Sand were granted by Directorate of Industries and Mines. Certificates were issued by the Mamlatdar of each taluka to certify that the extractor is a traditional extractor. As per available records/notings about 161 traditional extractors were issued licenses from 1980 onwards.

The Goa Minor Mineral concession Rules, 1985 were framed and which are presently governing the grant of quarrying leases and permits for all types of minor minerals including sand. The permissions for sand extraction were being granted on yearly basis. However after the CRZ Notification 2011, no permission for sand extraction was granted after 2011-12 onwards.

It is further explained that as per the office memorandum dated 08/11/2011 of the Dy. Director, Ministry of Environment and Forest, the Government constituted two District Committees under the Chairmanship of the respective District Collectors to deal with the grant of permit for sand extraction. The said committees are notified in the official gazette series II no. 37 dated 13th December, 2012.

The North Goa District Committee identified some zones in North Goa along river Mandovi, Chapora and Terekhol which are notified in the official gazette series II no. 18

dated 1st August, 2013, and Application "A1" for sand extractors was also notified in said official Gazette. Applications from sand extractors were invited for North Goa District. Total numbers of 596 applications were received till 30/08/2013 being last date of receiving applications.

It was brought to the notice by the members that prefeasibility Reports as per guidelines were prepared by the respective District Committees which was verified by the Directorate of Mines & Geology. As per letter no. 3-181-2010/STA-DIR/159 dated 01/10/2015 received from the Goa State Environment Impact Assessment Authority recommended the proposal for obtaining Environment Clearance (EC) for sand extraction from 14 stretches of 2,00,000 sq. mts. i.e. 08 stretches from Mandovi estuary, 02 stretches from Terekhol estuary and 04 stretches from Chapora estuary with total capacity of 1,68,00,000 m3/year (i.e. 60,000 m3/year 10,000 sq. mts.) in North Goa. The Goa State Environment Impact Assessment Authority recommended the proposal for obtaining Environment Clearance (EC) for sand extraction from 6 riverine stretches of 36,775.66 sq. mts. i.e. 02 stretches from Dudhsagar River, 01 stretch from Ragada river, 01 stretch from Kushavati river 01 stretch from Ugvem river and 01 stretches from Sangem river with total capacity of 60,000 m3/year and from 4 Estuarine stretches of 28,523.54sq mts i.e. 3 Stretches in Zuari Estuary and 01 stretch in Sal Estuary in South Goa.

It is to be noted that in terms of the Goa Minor Mineral Concession Rules, 1985 the grant of quarrying leases for extraction of minor mineral including ordinary sand is vested with the Director of Mines and Geology. However as per Office Memorandum No. 11-83/2005-IA-III (Vo. III) dated 8th November, 2011 from ministry of Environment and Forest, emphasis permission for removal of sand shall be under the control of District Collector. Additional Guidelines for obtaining environmental clearance for minor minerals were issued by Ministry of Environments and Forests vide Office Memorandum J-130/12/12/2013-IA-III (I) dated 24/12/2013. Prior Environmental Clearances as referred in the Paragraph above was obtained by the respective District Collector. The Collector, North Goa vide letter 39/8/13-MAG/DC-Sand-Ext-NG/9486 dated 04/12/15 forwarded the decision of the North Goa District Committee for the Directorate of Mines & Geology to issue permissions for removal of sand. A similar decision was taken by South Goa District Committee. As per office memorandum dated 08/11/2011 of the Dy. Director, Ministry of Environment and Forest, Sand permits can be renewed on the yearly basis. Accordingly in the year 2017-18 this Directorate issued/renewed 323 sand permits in North Goa and 11 sand permits in South Goa with each permit valid till 31st May 2018.

The royalty collected for sand for the period 2015-19 is as below:

Year	**Amount**
2015-16	24,780/-
2016-17	68,39,280/-
2017-18	1,93,06,452/-
2018-19	11,25,680/-
Total	**2,72,96,192/-**

It was informed to the Committee, that based on the prefeasibility reports submitted by the National Institute of Oceanography (NIO) for Chapora River, the District Collector North Goa has applied for the Environment Clearance and once the Environment clearance is granted the sand extraction permits will be granted in accordance to the Goa Minor Mineral Concession Rules 1985.

Thereafter the Scientist of the National Institute of Ocenanography, Dr Mandar Nanoskar and Shri Saurav Mondal made following recommendation to the committee in the presence of representative of the Department of Mines and Geology, Shri Abir Hede, Dy Director and Shri Sudhir Mandrekar, Assistant Geologist.

S. No	Region	Length (m)	Volume (Cubic m)	Weight (Tons)
1.	Estuary region	1570	524283	1389350
2.	Morjim jetty	1850	1674221	2678753
3.	Wadji Supermarket	1700	773160	1237057
4.	Sateri Temple	2300	1618575	2589720
5.	Camurlim Ferry Terminal	2441	1988240	3181185
6.	Our Lady piety Chapel	2170	1168952	1870323
7.	Sateri Temple Ambrewada	950	833393	1333429
8.	Railway Bridge Revora	1644	610894	977431
9.	Raneache Zuem	1620	5753126	9205002
10.	Near Sati Devi Temple	1900	544284	870855
11.	Pirna Ozarim bridge	1000	216771	346835
12.	Ozorim Tormas Bridge	1250	1028294	1645271
	Total	**20395**	**1,67,34,193**	**2,73,25,211**

- 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 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.

Taking into consideration the guidelines for sustainable sand mining and other environmental concerns the sand extraction using manual method can be carried out to the extent mentioned at the following locations has been recommended by the National Institute of Oceanography (NIO) Goa.

Area(hectares), Volume (Cubic m) and Weight (Ton) in selected regions and volume (cubic m) and weight (ton) within 3meter mining depth.

Sr.No	Region	Area	Volume	Weight	Volume for 3 meterThickness(Cubic m)	Weight (tons)for 3-meter thickness
1.	Estuary region	22.173	524283	1389350	357072	571316
2.	Morjim jetty	27.735	1674221	2678753	1037146	1659434
3.	Sateri Temple -Part1	21.738	404643	647430	127122	203395
4.	Sateri Temple -Part2	16.056	291343	517944	101698	162716
5.	Railway Bridge Revora	16.388	610894	977431	302923	484676
6.	Near Sati Devi Temple	18.581	544284	870855	341031	545650
7.	Ozorim Tormas bridge	11.165	1028294	1645271	1028294	1645271

The members deliberated and discussed the submissions made by the Department of Mines and Geology as well as the presentation made by the Scientist of National Institute of Oceanography and noted that the location 1 and 2 in the report is the mouth of the river where removal of sand is required in order to maintain the navigation channel.

It was also brought to the notice of the committee that MoEF&CC had issued a notification relating to minor minerals including sand mining, which stipulate that public hearing/consultation is not required for area from 0 to 25 ha.

However, the Hon'ble NGT order in respect of Deepak kumar v/s MoEF&CC states that project having area more than 5ha should be subjected to public hearing & therefore TOR is required.

Based on the above, MoEF&CC has issued relevant OM, which is followed in other States

On this matter the Member Secretary clarified that in other States Advance Mechanical equipment's are used for sand extraction which is not the case in Goa,where sand mining/extraction is carried through manual/traditional methods using canoes & therefore the above is not applicable.

The Committee proposed regular monitoring of sand mining, it was suggested that Mines department or any other designated dept could be designated for this work for timely monitoring the extraction.

Consequent to the above, the members decided to recommend extraction of sand by traditional (manual) method only at Locations 1, 2 and 6, 7 in the first instance with 50 and 10 percent respectively to be extracted annually subject to the compliance of the environmental management plan and monitoring plan recommended by NIO as well as the guidelines for Sustainable Sand Mining.

Specific Conditions:

1. PP to identify the central 3/4th part of river on map where there is a deposition of sand and remaining 1/4th area needs to be kept as no mining zone for the protection of the bank.

2. PP to install permanent boundary pillars at the identified area of the aggradation and deposition outside the bank of the river at a safe location for future surveying. The distance between boundaries on each side of the bank shall not be more than 100 meters.

3. PP to ensure that no mining activity is carried out below the depth as approved by the Competent Authority.

4. PP to make sure that the Environmental Management Plan as presented shall be included in the lease agreement to be signed with the lease holder and ensure its implementation.

5. PP to ensure that, the distance of mining activity area from the river bank shall be 1/4th of the river bed width and should not be less than 7.5 meters.

6. PP to ensure that, sand shall not be extracted up to a distance of 1 km from bridges and highways on both sides, or five times (5x) of the span (x) of bridge, public civil structure (including water intake point) on upstream side and ten times (10x) the span of such bridge on downstream side, subjected to a minimum of 250 meters on the upstream and 500 meters on the downstream side.

7. The District Collector shall define the transportation route from the mining lease considering the maximum production from the mines, size of mining lease, their

location, the quantity of mineral that can be mined safely etc considering the movement of trucks/ tippers/tractors for the villages having habitation shall be avoided.

8. PP to ensure following additional measures are to be provided by the leaseholder to prevent any vehicle from transporting sand out of the lease area bypassing the IT enabled system:

   a. To provide one entry and exit point for vehicles. In case it is necessary to have more than one entry/exit all such points have check points all digital monitoring facilities as mentioned in the Enforcement and Monitoring Guidelines issued by MoEF&CC in January 2020. All other possible ways of entry /exit shall be closed using barriers. 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 point shall have 24x7 CCTV coverage, the footage of which shall be submitted to the District Collector by the lease holder at mutually agreed frequencies.

9. The route of mineral transportation vehicle from source to destination shall be tracked through the system using checkpoints, Radio-frequency identification (RFID) tags, and GPS tracking.

10. PP shall carry out sand mining by manual method only. No mechanical /electrical/power driven devices shall be used for sand mining purpose under any circumstances.

11. PP to ensure no stream is diverted due to proposed sand mining activity.

12. PP to ensure that mining/ loading activity shall be restricted to day hours' time only. No mining activity shall be carried out after sunset and before sun rise.

13. PP to ensure that, no heavy vehicles like truck, dumper etc. should ply in the river bed.

14. PP to ensure that, there is no damage to any fauna and its nesting close to the sand mining any.

15. PP to ensure that adequate measures like maintenance of roads, sprinkling of water and plantation is carried out to reduce the dust particulate matter pollution.

16. PP to provide movable bio toilets to the workers working in the area and the sewage generated shall be properly collected and treated so as to confirm to the standards prescribed by MoEF&CC and CPCB.

17. PP to ensure that parking shall be done at designated place only and shall not be on Public roads or in the river bed.

18. The sand transportation shall be carried out through the covered vehicles only and the vehicles carrying the mineral shall not be overloaded.

19. PP to provide First Aid facility at the proposed mining site.

20. The District Collector to ensure strict compliance of all conditions stipulated in the Environment Clearance. The District Collector should strictly monitor the compliance of the conditions stipulated in the Environment Clearance letter.

21. PP to ensure strict compliance of Enforcement & Monitoring Guidelines published by the MoEF&CC in January 2020.

22. The District Collector and District Mining Officer shall ensure that there is no violation of any order with respect to the sand mining activity passed by the Competent Court. (Particularly, the directions given by 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 & 173/2018 be strictly followed.

2. Project proposal received from Goa Cricket Association, for "Construction of Cricket Stadium" Dhargalim, Pernem – Goa. Thia application dated 16th February 2021 received on Parivesh (website of MoEF).

Sr. No.	Description	Details
1	Name of the project Proponent	Mr.Vipul Vinod Phadke Hon Secretary Goa Cricket Association
2	Address for Communication	Goa Cricket Academy, Alto Porvorim, Bardez, Goa Tel: 091-832-2416844
	Name & location of the project	Proposed New Construction of Cricket Stadium at Dhargalim Village, Pernem Taluka, North Goa District
4	Plot Area	Plot Area-1,89,930 sq. m
5	Net plot Area	
6	FSI Area Non-FSI Area Total construction Area Building configuration & Height of the building	 48,139.46 sq.m Cricket Stadium Height-21.45 M
7	No. of shops	Seating capacity- 32490 Numbers
8	Total water requirement(Construction/operation phase)	Construction Phase -30 cmd Operation Phase-672 Cmd
9	Sewage generation	364 cmd
10	STP Capacity / Proposed Technology	STP Capacity : 2 STPs of 100 cmd Fluidized Aerobic Bioreactor- FAB Technology):

11	Total Solid Waste Quantities	7,310 kg/day
13	Energy Efficiency	Energy Efficient Lighting, Fans, Air conditioners with Controls (a) Use of LED lights (indoor and outdoor) (b) Use of all energy efficient fans and unitary ACs with minimum coefficient of performance (COP). Energy efficient Pumps, Lifts and other Equipment: (a) Providing energy efficient pumps and DG set. (b) Providing energy efficient/ regenerative lifts. Integration of controls with IBMS and sensors for lighting fixtures (a) Providing timer for lighting fixtures Generation of Renewable Energy (a) Utilization of solar energy through provision of solar PV panels. (b) Preliminary analysis of the site suggests that a total of 1,060 Solar Modules can be placed on the site. This site will be capable of generating 596.7 MWh annual
14	Parking 4 W and 2W	**Description** / **Number of cars** / **Number of TW** / **Number of Bus** Open Parking / 1849 / 1401 / 19 Total / 1852 / 1401 / 19
15	Power requirement	Connected Load: 4000 KVA
16	D.G set Capacity	Power back up for Stadium: DG sets: 3 x 1250 KVA (2+1) for various Utilities Transformers: 3 x 2000 KVA (2+1) with 1 as standby
17	RWH tank capacity	Proposed 2 tanks of 2,50,000 each near fire fighting tank
18	EMP cost (including DMP cost)	EMP Cost-1817.00 Lakhs DMP cost-
19	No. of tress on site	1,595 nos.
20	No. of trees to be cut	840 nos
21	No. of tress to be planted on site	2520 nos
22	CRZ status	Not applicable

In response to the query raised by this Committee on 16/09/2021 with regard to the study report of plant distribution by quadrant method on latertic plateau the PP has submitted Ecology and Biodiversity Report which is taken on record. However the PP has not submitted report on Faunal Diversity of latertic Plateau and has submitted that the same will conducted post monsoon prior to commencement of any construction work. The Committee decided to recommend the proposal for grant of prior environmental clearance (EC) to the Goa-SEIAA.

Project proponent has to comply with following **"General Conditions"**:-

i. The PP should develop an Urban Forest with local species in and around an area of at least 2000 sq mts.

ii. PP should prioritize the issues related to health and hygiene in complying with the matters related to waste disposal and treatment / air and water pollution / waste-water management.

iii. Sewage Treatment Plant (STP) contract should be with operation and maintenance contract after commissioning /completion of project with a minimum period of 5 years.

iv. PP needs to ensure that no treated water or any waste sewage shall be discharged into any water body.

v. E-waste shall be disposed through Authorised vendor as per E-waste (*Management and Handling*) Rules, 2011.

vi. Project Proponent (PP) should necessarily make appropriate provision while constructing the roof-tops at the time of construction stage only to enable installation of solar panels towards south facing walls as and when made applicable in future.

vii. The Project Proponent shall utilise fly ash bricks in masonry works.

viii. The PP shall use construction debris for land filling wherever applicable.

ix. To provide of the open spaces as required by the local building bye-laws shall be preserved. Use of Grass pavers, paver blocks with at least 50% opening, landscape etc. would be considered as preserved surface.

x. Compliance with the Energy Conservation Building Code (ECBC) of Bureau of Energy Efficiency shall be ensured. Buildings in the States which have notified their own ECBC, shall comply with the State ECBC. Outdoor and common area lighting shall be LED. Concept of passive solar design that minimizes energy consumption in buildings by using design elements, such as building orientation, landscaping, efficient building envelope, appropriate fenestration, increased day lighting design and thermal mass etc. shall be incorporated in the building design. Wall, window, and roof u-values shall be as per ECBC specifications.

xi. Use of water saving devices/ fixtures (viz. low flow flushing systems; use of low flow faucets tap aerators etc) for water conservation shall be incorporated in the building plan.

xii. Installation of dual pipe plumbing for supplying fresh water for drinking, cooking and bathing etc and other for supply of recycled water for flushing, landscape irrigation, car washing, thermal cooling, conditioning, etc. shall be done.

xiii. Separation of grey and black water should be done by the use of dual plumbing system. In case of single stack system separate recirculation lines for flushing by giving dual plumbing system be done.

xiv. Solar based electric power shall be provided to each unit for at least two bulbs/light and one fan. As proposed, central lighting and street lighting shall also be based on solar power.

xv. The project proponent will provide landscape bed of 600mm wide X 600mm deep along the periphery of the plot to carry out plantation of trees. The treated water from the sewage treatment plant will be pumped through high flow drips on these beds to prevent outflow of treated sewage water outside the premises.

xvi. PP shall make provision for charging points for electronic vehicles in the parking area.

3. **Project Proponent should implement Dust mitigation measures for construction activities such as:**

a. Roads leading to or at construction sites must be paved and blacktopped (i.e. metallic roads).
b. No excavation of soil shall be carried out without adequate dust mitigation measures in place.
c. No loose soil or sand or Construction & Demolition Waste or any other construction material that causes dust shall be left uncovered.
d. Wind-breaker of appropriate height i.e. 1/3rd of the building height and maximum up to 10 meters shall be provided.
e. Water sprinkling system shall be put in place.
f. Dust mitigation measures shall be displayed prominently at the construction site for easy public viewing.
g. New serial number '107' has been inserted which relates to Mandatory Implementation of Dust Mitigation Measures for all Construction and Demolition Activities:
h. Grinding and cutting of building materials in open area shall be prohibited.
i. Construction material and waste should be stored only within earmarked area and road side storage of construction material and waste shall be prohibited.
j. No uncovered vehicles carrying construction material and waste shall be permitted.
k. Construction and Demolition Waste processing and disposal site shall be identified and required dust mitigation measures be notified at the site.
l. Further, progress will be reviewed after six months *(minimum 3 times in a year) depending upon progress of the work.* Further, the compliance to these conditions as and when submitted by PP will be verified /ascertained by the authority to propose additional conditions if any.

4. Further, the Authority has decided that PP needs to comply to the following **"General Conditions"**:-

a. The PP should use Ready-Mixed Concrete (RMC) to minimize air / water / land pollution and water usage during the construction phase.

b. ***Solar power generation*** - Every major consumer of conventional power will have to generate and opt for certain percentage of power generation from non-conventional sources. In this context, Project Proponent (PP) should necessarily make appropriate provision while constructing the roof-tops at the time of construction stage only to enable installation of solar panels as and when made

applicable in future. In addition, south-facing walls to be utilized to install solar panels to harness optimum solar energy. Use of solar panels may be done to the extent possible like installing solar street lights, common solar water heater system. PP should install, after checking feasibility, solar-plus-hybrid non-conventional source as source of energy.

c. PP should adopt roof-top rainwater harvesting / conservation measures to optimally utilize the water availability by constructing sumps for collection of rainwater as per the site-specific location details provided.

d. PP should not disturb the natural drainage and as far as possible, maintain the original topography while designing for landscape development by planting local plant species and which are not alien to the prevailing environment.

e. PP should clarify any issue related to public objections, if any, and should not conceal the scientific facts in light of the proposed developmental activity vis-à-vis its land use categorization / zoning.

f. PP should submit half-yearly compliance report(s) in hard as well as soft copy format to the Authority for the period upto project completion.

g. This environmental clearance is issued subject to land use verification. Local authority / planning authority should ensure this with respect to Rules, Regulations, Notifications, Government Resolutions, Circulars, etc. issued if any, from time to time. Judgments / Orders issued by Hon'ble High Court, NGT, Supreme Court regarding DCR provisions, environmental issues applicable in this matter should be verified by the competent authorities.

h. PP should ensure and ascertain that '**civil plans**' which were submitted to the Committee/ Authority during the process of project appraisal be submitted to other line Departments / agencies concerned while seeking NOC / Consents/ Permissions, as applicable. If any discrepancy is found in the plans submitted or details provided may be reported to this Authority. This environmental clearance is issued with respect to the environmental considerations and it does not mean that Goa-SEIAA approved the proposed land.

i. E-waste if any shall be disposed through Authorised vendor as per E-waste (*Management & Transboundary Movement*) Rules, 2016.

j. This environmental clearance is issued subject to obtaining NOC from the Forestry & Wildlife angle including clearance from the Standing Committee of the National Board for wildlife, if applicable. The grant of environmental clearance does not necessarily imply that Forestry & Wildlife clearance has been granted to the project, which has to be dealt separately by the competent authorities in accordance with law.

k. The height, construction gross built up area of proposed construction is **26,765.50 Sq.mts** shall be in accordance with the existing FSI/ FAR norms of the local body and planning authorities and it should ensure the same along with survey number before approving layout plan and before according commencement certificate to

proposed work, Plan approving authority should also ensure the zoning permissibility for the proposed project as per the approved development plan of the area.

l. All required sanitary and hygienic measures should be in place before starting construction activities and to be maintained throughout the construction phase.

5. Further, the PP is required to comply with the following **"General Conditions" during construction phase:-**

a. 'Consent to Establish' shall be obtained from the Goa State Pollution Control Board (GSPCB) under Air Act and Water Act, as applicable and a copy shall be submitted to the Authority within 30 days of starting construction work at site.

b. Permission to draw groundwater, as applicable, shall be obtained from the Groundwater Cell of the Water Resources Department (WRD) Government of Goa.

c. Project proponent shall not make any change in the Surface Layout Plan / Civil Plan submitted to the Authority without its prior permission. **In case of any change(s) in the scope of the project and/or otherwise, the project proponent needs to inform this Authority.**

d. Project proponent shall make suitable provisions for sewage / wastewater disposal and storm water release independently.

e. CNG powered generating sets to be used during construction .

f. The installation of the Sewage Treatment Plant (STP) if any should be certified by the GSPCB and a report in this regard should be submitted to the Authority before the STP is commissioned.

g. Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche and first aid room etc.

h. Adequate drinking water and sanitary facilities should be provided for construction workers at the site. Provision should be made for mobile toilets. The safe disposal of waste water and solid waste generated during the construction phase should be ensured.

i. The solid waste generated should be properly segregated. Dry /inert solid waste should be disposed off to the approved sites for land filling after recovering recyclable material.

j. Disposal of muck during construction phase should not create any adverse effect on the neighbouring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved site with the approval of competent authority.

k. Arrangements shall be made that waste water and storm water do not get mixed.

l. All the top soil excavated during construction activities should be stored if or used in horticulture/landscape development within the project site.

m. Additional soil for levelling of the proposed site shall be generated within the sites (to the extent possible) so that natural drainage system of the area is protected and improved.

n. Green-belt development shall be carried out considering CPCB guidelines including selection of plant species and in consultation with the State Forest / Agriculture Department.

o. Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contaminants.

p. Construction spoils, including bituminous material and other hazardous materials must not be allowed to contaminate water courses and the dump sites for such materials must be secured so that they should not leach into ground water.

q. Any hazardous waste generated during construction phase should be disposed off as per applicable rules and norms with necessary authorisation of the GSPCB.

r. Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emission standard and should be operated during non-peak hrs.

s. Ambient noise levels should conform to residential standards both during day and night. Incremental pollution load on the ambient air and noise quality should be closely monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level construction phase, so as to conform to the stipulated standard by CPCB/ GSPCB.

t. The approval of competent authority shall be obtained for structural safety of the buildings due to any possible earthquakes, adequacy of fire fighting equipments etc. as per National Building Code (NBC) including measures from lighting.

u. Storm water controlled and its re-use as per Central Ground Water Board (CGWB) and Bureau of Indian Standards (BIS) for various applications.

v. Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred.

w. The groundwater level and its quality should be monitored regularly in consultation with ground water authority of the Water Resources Department (WRD), Government of Goa.

x. The installation of the sewage treatment plant (STP) should be certified by an independent expert and a report in this regard should be submitted to the GSPCB before the project is commissioned for operation. Treated effluent released from STP shall be recycled / reused to the maximum extent possible. Discharge of this

unused treated effluent, if any should be discharged in the sewer line. Treatment of 100% grey water through centralised treatment should be done. Necessary measures should be adopted to mitigate the odour problem from STP.

y. Use of glass may be reduced upto 40% to reduce electricity consumption and load on air-conditioning. If necessary, use high quality double glass with special reflective coating in windows.

z. Roof should meet prescriptive requirement as per energy conservation building code by using appropriate thermal insulation material.

aa. Energy conservation measures like installation of LEDs' for lighting the areas outside the building should be integral part of the project design and should be in place before project commissioning. Use of CFLs / TFLs, if any, should be properly collected and disposed off / sent for recycling as per the prevailing guidelines / rules of the regulatory authority to avoid mercury contamination.

ab. CNG powered generating sets proposed as source of backup power for elevators and common area illumination during operation phase should be of enclosed type and conform to rules made under the Environment Protection Act 1986. The height of stack of CNG powered generating sets should be equal to the height needed for the combine capacity of all proposed CNG sets.

ac. Noise should be controlled to ensure that it does not exceed the prescribed standards. During night time the noise levels measured at the boundary of the building shall be restricted to the permissible levels to comply with the prevalent regulations.

ad. Traffic congestions near the entry and exit points from the roads adjoining the proposed project site must be avoided. Parking should be fully internalised and no public place should be utilised.

ae. Opaque wall should meet prescriptive requirement as per energy conservation board which is proposed to mandatorily for all air conditioned spaces while it is aspiration for non- air conditioned spaces by use of appropriate thermal insulation material to fulfil requirement.

af. The buildings should have adequate distance between them to allow movement of fresh air and passage of natural light, air and ventilation.

ag. Regular supervision of the above and other measures for monitoring should be in place all through the construction phase, so as to avoid disturbance to the surroundings.

ah. Under the provisions of Environment Protection Act 1986, legal action shall be initiated against the PP if it was found that construction of the project has been started without obtaining EC.

ai. Six monthly compliance reports should be submitted to the MoEF&CC with copy to the Goa-SEIAA and GSPCB.

6. Further, the Authority decided to direct the PP to comply with the following

"General Conditions" during post-construction phase:-

a. PP shall ensure completion of STP, MSW disposal facility, green belt development prior to occupation of the buildings. The PP to explore possibility of utilising excess treated water in the adjacent area for gardening before discharging into sewer line. No physical occupation of allotment will be given unless all above said environmental infra structure is installed and made functional including water requirement prior certification from appropriate authority shall be obtained.

b. Wet garbage should be treated by organic waste convertor and treated waste (manure) should be utilised in the existing premises for gardening. No wet garbage will be disposed outside the premises. Local authority should ensure compliance to this.

c. A complete set of all the documents submitted to Goa-SEIAA should be forwarded to local authority, GSPCB and Planning authority.

d. In case of any change(s) in the scope of the project, the project would require a fresh appraisal by the Goa-SEIAA.

e. Separate funds shall be allocated for implementation of environmental protection measures /EMP along with item wise break-up. The funds earmarked for the environment protection measures shall not be diverted for other purposes.

f. A copy of the environmental clearance letter shall be sent by PP to the concerned Village Panchayat and planning authority as applicable, from which suggestions / representation, if any, were received while processing the proposal. The EC letter shall also be put on the company's website by PP within one week time period from the date of issue of environmental clearance.

g. The PP shall upload the status of the compliance of the stipulated EC conditions, including results of monitoring data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of the MoEF & CC, the respective Zonal office, CPCB and the GSPCB.

h. The environmental statement for each financial year ending 31st March in Form-V is to be submitted to the GSPCB as prescribed under the Environment (*Protection*) Rules 1986 (as amended) and subsequently shall also be put on the company's website along with the status of the compliance of the EC conditions and shall also be sent to the respective Regional Office of the MoEF & CC.

i. Consent to Operate shall be obtained from GSPCB before operation, failing which the Environmental Clearance herein shall be deemed to be withdrawn.

j. Sewage Treatment Plant (STP) shall be installed at site. The STP should be certified by an independent expert and adequacy report in this regard should be

submitted to GSPCB before the project is commissioned for operation. Necessary measures should be made to mitigate the odour problem from STP. There shall also be a comprehensive AMC of 5years from the commissioning of the STP by the agency installing the STP.

k. The solid waste (dry as well as wet garbage) generated should be properly collected and segregated. Organic Waste Converter shall be installed by RWA for the treatment of biodegradable (wet) garbage generated within the complex. Non-Biodegradable waste should be outsourced properly after recovery of recyclable material. Adequate measures should be taken to prevent odour problem.

l. Noise should be controlled to ensure that it does not exceed the prescribed standards both during day & night time.

m. The ground water drawal from existing/proposed bore wells if any should be done only with the prior permission of Ground Water Board. The ground water level and its quality should also be monitored regularly both during construction and operation phase in consultation with Ground Water Board.

n. Traffic congestion near the entry and exit points from the roads adjoining the project site must be avoided. Parking should be fully internalized and no public space should be utilized.

o. Energy Conservation measures such as solar lighting for common area, solar water heating system, CFLs/TFLs for lighting of areas, LED lights for signage, solar inverters on the etc should be adopted.

p. Used CFLs/TFLs should be properly collected and disposed off/ sent for recycling as per the prevailing guidelines/rules of the regulatory authority to avoid mercury contamination.

q. A Report on energy conservation measures conforming to energy conservation norms finalized by Bureau of energy Efficiency should be prepared incorporating details about building materials and technology, R & U factors etc and submit to the State Expert Appraisal Committee and a copy to GSPCB in three months time.

3. Proposed residential project Alcon Construction (Goa) Pvt. Ltd. Located at Survey No. 112/1 and 112/2, Tonca, Taleigao, Tiswadi North Goa.This application dated 17th September 2021 received on Parivesh (website of MoEF).

Sr. No.	Description	Details
1	Name of the project Proponent	Mr. Aakash Khaunte
2	Address for Communication	Sukerkar Mansion, First Floor, M.G.Road Panaji ,Goa (India) 0832-2224451/52

	Name & location of the project	Proposed expansion in Residential development (Phase II) at Survey No 112/1 and 112/2 (part) Taleigao Village, Taluka Tiswadi , District - North Goa Village Taleigao, Goa
4	Plot Area	Plot Area Phase II- 5393.67sq.m
5	Net plot Area	Net plot area Phase II 4074.67 sq mtr
6	FSI Area Non-FSI Area Total construction Area Building configuration & Height of the building	Phase II-10724.96 8453.59 19,178.55 sq.m Basement+Stilt+ 8 floors Height of Building -24 M
7	No. of shops	Number Of Flats-112
8	Total water requirement(Construction/operation phase)	Construction Phase-9 cmd Operation Phase -90cmd
9	Sewage generation	64 cmd
10	STP Capacity / Proposed Technology	STP capacity-70 cmd Proposed Technology -MBBR Technology
11	Total Solid Waste Quantities	Solid waste-136 kg/day
13	Energy Efficiency	19.46 %
14	Parking 4 W and 2W	Four Wheeler:-159 Nos Two Wheeler:-15 Nos
15	Power requirement	Connected Load: -10940 KVA Transformers: -2 x 63 0 KVA
16	D.G set Capacity	Power back up for : - 100 KVA
17	RWH tank capacity	Proposed Phase II RWHT OF 55 KLD
18	EMP cost (including DMP cost)	EMP Cost:124 Lakhs DMP Cost:30 Lakhs
19	No. of tress on site	Nil
20	No. of trees to be cut	Nil
21	No. of tress to be planted on site	61 Number of trees to be planted
22	CRZ status	Not Applicable

The Committee had inspected the site on 11th August 2021. The PP made presentation on 22nd September 2021, before the SEAC. The SEAC noted that the said Project is extension of the existing Project which has obtained the Environmental Clearance from the Authority earlier. The existing Project has complied with the condition of the Environmental Clearance and after detailed discussion and deliberation, the Committee decided to recommend the proposal for grant of prior environmental clearance (EC) to the Goa-SEIAA.

Specific Conditions'

a. The approach road leading to the site should be constructed prior to commencement of any construction activity at site as per the regulations of the Town & Country Planning Department.

b. PP has to put crash barrier along the Nallah/St. Inez Creek.

c. PP should take a note that rainwater discharge should be allowed towards the downstream of the nallah.

d. The PP should adhere to the Commitment on access road to be maintained during construction phase be prepared and submitted at the time of post-EC compliance.

e. PP should take enough precaution for Disaster management Plan in case of urban flooding /Nallah flooding during monsoon.

f. PP has to dispose of current dumped waste.

g. PP should prioritize the issues related to health and hygiene in complying with the matters related to waste disposal and treatment / air and water pollution / waste-water management.

h. PP needs to ensure that no treated water or any waste sewage shall be discharged into any water body. E-waste shall be disposed through Authorised vendor as per E-waste (*Management and Handling*) Rules, 2011.

i. Project Proponent (PP) should necessarily make appropriate provision while constructing the roof-tops at the time of construction stage only to enable installation of solar panels towards south facing walls as and when made applicable in future.

j. The Project Proponent shall utilise fly ash bricks in masonry works.

k. The PP shall use construction debris for land filling wherever applicable.

l. At least 20% of the open spaces as required by the local building bye-laws shall be previous. Use of Grass pavers, paver blocks with at least 50% opening, landscape etc. would be considered as previous surface.

m. Compliance with the Energy Conservation Building Code (ECBC) of Bureau of Energy Efficiency shall be ensured. Buildings in the States which have notified their own ECBC, shall comply with the State ECBC. Outdoor and common area lighting shall be LED. Concept of passive solar design that minimize energy consumption in buildings by using design elements, such as building orientation, landscaping, efficient building envelope, appropriate fenestration, increased day lighting design and thermal mass etc. shall be incorporated in the building design. Wall, window, and roof u-values shall be as per ECBC specifications.

n. Use of water saving devices/ fixtures (viz. low flow flushing systems; use of low flow faucets tap aerators etc) for water conservation shall be incorporated in the building plan.

o. Installation of dual pipe plumbing for supplying fresh water for drinking, cooking and bathing etc and other for supply of recycled water for flushing, landscape irrigation, car washing, thermal cooling, conditioning, etc. shall be done.

p. Separation of grey and black water should be done by the use of dual plumbing system. In case of single stack system separate recirculation lines for flushing by giving dual plumbing system be done.

q. Solar based electric power shall be provided to each unit for at least two bulbs/light and one fan. As proposed, central lighting and street lighting shall also be based on solar power.

r. The project proponent will provide landscape bed of 600mm wide X 600mm deep along the periphery of the plot to carry out plantation of trees. The treated water from the sewage treatment plant will be pumped through high flow drips on these beds to prevent outflow of treated sewage water outside the premises.

s. Areas which are marked as **No Development Zone (NDZ)** should be year marked on site and no construction shall be carried out in the said NDZ. Land Profile of NDZ shall not be altered.

t. No construction shall be carried out in the property which is identified as private forest, if any.

u. PP should obtain all the requisite permissions/NOCs/Licenses etc from all the competent authorities before commencement of any activity at site.

Further, progress will be reviewed after six months *(minimum 3 times in a year) depending upon progress of the work.* Further, the compliance to these conditions as and when submitted by PP will be verified /ascertained by the authority to propose additional conditions if any.

2. Further, the Authority has decided that PP needs to comply to the following **"General Conditions"**:-

a. The PP should use Ready-Mixed Concrete (RMC) to minimize air / water / land pollution and water usage during the construction phase.

b. ***Solar power generation*** - Every major consumer of conventional power will have to generate and opt for certain percentage of power generation from the non-conventional sources. In this context, Project Proponent (PP) should necessarily make appropriate provision while constructing the roof-tops at the time of construction stage only to enable installation of solar panels as and when made applicable in future. In addition, south-facing walls to be utilized to install solar panels to harness optimum solar energy. Use of solar panels may be done to the extent possible like installing solar street lights, common solar water heater system. PP should install, after checking feasibility, solar-plus-hybrid non-conventional source as source of energy.

c. PP should adopt roof-top rainwater harvesting / conservation measures to optimally utilize the water availability by constructing sumps for collection of rainwater as per the site-specific location details provided.

d. PP should prioritize the issues related to health and hygiene in complying with the matters related to waste disposal and treatment / air and water pollution / waste-water management.

e. PP should not disturb the natural drainage and as far as possible and maintain the original topography while designing for landscape development by planting local plant species and which are not alien to the prevailing environment.

f. PP should clarify any issue related to public objections, if any, and should not conceal the scientific facts in light of the proposed developmental activity vis-à-vis its landuse categorization / zoning.

g. PP should submit half-yearly compliance report(s) in hard as well as soft copy format to the Authority for the period upto project completion.

h. This environmental clearance is issued subject to land use verification. Local authority / planning authority should ensure this with respect to Rules, Regulations, Notifications, Government Resolutions, Circulars, etc. issued if any, from time to time. Judgements / Orders issued by Hon'ble High Court, NGT, Supreme Court regarding DCR provisions, environmental issues applicable in this matter should be verified by the competent authorities.

i. PP should ensure and ascertain that '**civil plans**' which were submitted to the Committee/ Authority during the process of project appraisal be submitted to other line Departments / agencies concerned while seeking NOC / Consents/ Permissions, as applicable. If any discrepancy is found in the plans submitted or details provided may be reported to this Authority. This environmental clearance is issued with respect to the environmental considerations and it does not mean that Goa-SEIAA approved the proposed land.

j. PP needs to ensure that no treated water or any waste sewage shall be discharged into any water body. STP of suitable capacity shall be installed considering the quantity / quality of waste water generation.

k. E-waste if any shall be disposed through Authorised vendor as per E-waste (*Management & Transboundary Movement*) Rules, 2016.

l. This environmental clearance is issued subject to obtaining NOC from the Forestry & Wildlife angle including clearance from the Standing Committee of the National Board for wildlife, if applicable. The grant of environmental clearance does not necessarily imply that Forestry & Wildlife clearance has been granted to the project, which has to be dealt separately by the competent authorities in accordance with law.

m. The height, construction gross built up area of proposed construction **is 19,178.55 Sq.mts** shall be in accordance with the existing FSI/ FAR norms of the local body and planning authorities and it should ensure the same along with survey number before approving layout plan and before according commencement certificate to proposed work, Plan approving authority should also ensure the zoning permissibility for the proposed project as per the approved development plan of the area.

n. All required sanitary and hygienic measures should be in place before starting construction activities and to be maintained throughout the construction phase.

3. Further, the PP is required to comply with the following **"General Conditions" during construction phase:-**

a. 'Consent to Establish' shall be obtained from the Goa State Pollution Control Board (GSPCB) under Air Act and Water Act, as applicable and a copy shall be submitted to the Authority within 30 days of starting construction work at site.

b. Permission to draw groundwater, as applicable, shall be obtained from the Groundwater Cell of the Water Resources Department (WRD) government of Goa.

c. Project proponent shall not make any change in the Surface Layout Plan / Civil Plan submitted to the Authority without its prior permission. **In case of any change(s) in the scope of the project and/or otherwise, the project proponent need to inform this Authority.**

d. Project proponent shall make suitable provisions for sewage / wastewater disposal and storm water release independently.

e. CNG powered generating sets to be used during construction.

f. The installation of the Sewage Treatment Plant (STP) if any should be certified by the GSPCB and a report in this regard should be submitted to the Authority before the STP is commissioned.

g. Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche and first aid room etc.

h. Adequate drinking water and sanitary facilities should be provided for construction workers at the site. Provision should be made for mobile toilets. The safe disposal of waste water and solid waste generated during the construction phase should be ensured.

i. The solid waste generated should be properly segregated. Dry /inert solid waste should be disposed off to the approved sites for land filling after recovering recyclable material.

j. Disposal of muck during construction phase should not create any adverse effect on the neighbouring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved site with the approval of competent authority.

k. Arrangements shall be made that waste water and storm water do not get mixed.

l. All the top soil excavated during construction activities should be stored if or use in horticulture/landscape development witnin the project site.

m. Additional soil for levelling of the proposed site shall be generated within the sites (to the extent possible) so that natural drainage system of the area is protected and improved.

n. Green-belt development shall be carried out considering CPCB guidelines including selection of plant species and in consultation with the State Forest / Agriculture Department.

o. Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contaminants.

p. Construction spoils, including bituminous material and other hazardous materials must not be allowed to contaminate water courses and the dump sites for such materials must be secured so that they should not leach into ground water.

q. Any hazardous waste generated during construction phase should be disposed off as per applicable rules and norms with necessary authorisation of the GSPCB.

r. Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emission standard and should be operated during non-peak hrs.

s. Ambient noise levels should conform to residential standards both during day and night. Incremental pollution load on the ambient air and noise quality should be closely monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level construction phase, so as to conform to the stipulated standard by CPCB/ GSPCB.

t. The approval of competent authority shall be obtained for structural safety of the buildings due to any possible earthquakes, adequacy of fire fighting equipments etc. as per National Building Code (NBC) including measures from lighting.

u. Storm water controlled and its re-use as per Central Ground Water Board (CGWB) and Bureau of Indian Standards (BIS) for various applications.

v. Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred.

w. The groundwater level and its quality should be monitored regularly in consultation with ground water authority of the Water Resources Department (WRD), Government of Goa.

x. The installation of the sewage treatment plant (STP) should be certified by an independent expert and a report in this regard should be submitted to the GSPCB before the project is commissioned for operation. Treated effluent released from STP shall be recycled / refused to the maximum extent possible. Discharge of this unused treated effluent, if any should be discharged in the sewer line. Treatment of 100% grey water through the centralised treatment should be done. Necessary measures should be adopted to mitigate the odour problem from STP.

y. Use of glass may be reduced upto 40% to reduce electricity consumption and load on air-conditioning. If necessary, use high quality double glass with special reflective coating in windows.

z. Roof should meet prescriptive requirement as per energy conservation building code by using appropriate thermal insulation material.

aa. Energy conservation measures like installation of LEDs' for the lighting the areas outside the building should be integral part of the project design and should be in place before project commissioning. Use of CFLs / TFLs, if any, should be properly collected and disposed off / sent for recycling as per the prevailing guidelines / rules of the regulatory authority to avoid mercury contamination.

ab. Noise should be controlled to ensure that it does not exceed the prescribed standards. During night time the noise levels measured at the boundary of the building shall be restricted to the permissible levels to comply with the prevalent regulations.

ac. Traffic congestion near the entry and exit points from the roads adjoining the proposed project site must be avoided. Parking should be fully internalised and no public place should be utilised.

ad. opaque wall should meet prescriptive requirement as per energy conservation board which is proposed to mandatory for all air conditioned spaces while it is aspiration for non- air conditioned spaces by use of appropriate thermal insulation material to fulfil requirement.

ae. The buildings should have adequate distance between them to allow movement of fresh air and passage of natural light, air and ventilation.

af. Regular supervision of the above and other measures for monitoring should be in placed all through the construction phase, so as to avoid disturbance to the surroundings.

ag. Under the provisions of Environment Protection Act 1986, legal action shall be initiated against the PP if it was found that construction of the project has been started without obtaining EC.

ah. Six monthly compliance reports should be submitted to the MOEF with copy to the Goa-SEIAA and GSPCB.

4. Further, the Authority decided to direct the PP to comply with the following

<u>"General Conditions" during post-construction phase:-</u>

a. PP shall ensure completion of STP, MSW disposal facility, green belt development prior to occupation of the buildings. The PP to explore possibility of utilising excess treated water in the adjacent area for gardening before discharging into sewer line. No physical occupation of allotment will be given unless all above said environmental infra structure is installed and

made functional including water requirement prior certification from appropriate authority shall be obtained.

b. Wet garbage should be treated by organic waste convertor and treated waste (manure) should be utilise in the existing premises foe gardening. And no wet garbage will be disposed outside the premises. Local authority should ensure compliance to this.

c. A complete set of all the documents submitted to Goa-SEIAA should be forwarded local authority, GSPCB and Planning authority.

d. In the case of any change(s) in the scope of the project, the project would require a fresh appraisal by the Goa-SEIAA.

e. Separate funds shall be allocated for implementation of environmental protection measures /EMP along with item wise breaks-up. The funds earmarked for the environment protection measures shall not be diverted for other purposes.

f. A copy of the environmental clearance letter shall be sent by PP to the concerned Village Panchayat and planning authority as applicable, from which suggestions / representation, if any, were received while processing the proposal. The EC letter shall also be put on the company's website by PP within one week time period from date of issue of environmental clearance.

g. The PP shall upload the status of the compliance of the stipulated EC conditions, including results of monitoring data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of the MoEF & CC, the respective Zonal office, CPCB and the GSPCB. The pollutant levels in respect of SPM, RSPM, SO_2 and NO_X (*ambient levels as well as D.G. stack emissions*) shall be monitored.

h. The environmental statement for each financial year ending 31st March in Form-V is to be submitted to the GSPCB as prescribed under the Environment (*Protection*) Rules 1986 (as amended) and subsequently shall also be put on the company's website along with the status of the compliance of the EC conditions and shall also be sent to the respective Regional Office of the MoEF & CC.

i. Consent to Operate shall be obtained from GSPCB before operation, failing which the Environmental Clearance herein shall be deemed to be withdrawn.

j. Sewage Treatment Plant (STP) shall be installed at site. The STP should be certified by an independent expert and adequacy report in this regard should be submitted to GSPCB before the project is commissioned for operation. Necessary measures should be made to mitigate the odour problem from STP.

k. The solid waste (dry as well as wet garbage) generated should be properly collected and segregated. Organic Waste Converter shall be installed by RWA for the treatment of biodegradable (wet) garbage generated within the housing complex. Non-Biodegradable waste should be outsourced properly after recovery of recyclable material. Adequate measures should be taken to prevent odour problem.

l. Noise should be controlled to ensure that it does not exceed the prescribed standards both during day & night time.

m. The ground water drawl from existing/proposed bore wells if any should be done only with the prior permission of Ground Water Board. The ground water level and its quality should also be monitored regularly both during construction and operation phase in consultation with Ground Water Board.

n. Traffic congestion near the entry and exit points from the roads adjoining the project site must be avoided. Parking should be fully internalized and no public space should be utilized.

o. Energy Conservation measures such as solar lighting for common area, solar water heating system, CFLs/TFLs for lighting of areas, LED lights for signage, solar inverters on the etc should be adopted.

p. Used CFLs/TFLs should be properly collected and disposed off/ sent for recycling as per the prevailing guidelines/rules of the regulatory authority to avoid mercury contamination.

q. A Report on energy conservation measures conforming to energy conservation norms finalized by Bureau of energy Efficiency should be prepared incorporating details about building materials and technology, R & U factors etc and submit to the State Expert Appraisal Committee and a copy to GSPCB in three months time.

5. Further this EC is issued without prejudice to the action initiated in the Environment (*Protection*) Act or any court case pending in the court of law. As such, it does not mean that the PP has not violated any environmental laws in the past and whatever decision under the said Act by the Hon'ble Court will be binding on the PP. **Hence, this environmental clearance does not give immunity to the PP in the case complaint is filed against, if any, or action initiated under the said Act.**

6. In case of submission of false document and non-compliance to any of the stipulated conditions, this Authority will revoke or suspend the EC without any intimation and initiate appropriate legal action under the Environment (*Protection*) Act, 1986 (*as amended till date*).

7. E-waste generated in the complex should be managed as per CPCB guidelines on E-waste management.

8. The Goa-SEIAA reserves their right to add any stringent condition or to revoke the environmental clearance, if conditions stipulated above are not implemented to the satisfaction of the Authority or for that matter, for any other administrative reasons.

9. In addition, the following conditions shall be specifically complied with:

1. Project proponent shall advertise at least in two local newspapers widely circulated in the region around the project, one of which shall be in the

Konkani or Marathi language within **seven days** of receipt of this communication, informing that the proposed project has been accorded prior Environmental Clearance (EC) and the copies of the clearance letter will be available on the PP website.

2. **Validity of the Environmental Clearance (EC) accorded shall be for a period of 07 (seven) years from the date of its issue.**

3. These stipulations would be enforced among others under the provisions of Water *(Prevention and Control of Pollution)* Act, 1974, the Air *(Prevention and Control of Pollution)* Act 1981, the Environment (Protection) Act, 1986, the Public Liability (Insurance) Act, 1991 and EIA Notification, 2006.

4. In the case of any change(s) in the scope of the project, the project would require a fresh appraisal by State Environment Impact Assessment Authority.

5. Status of compliance to the various stipulated environmental conditions and environmental safeguards will be uploaded by the project proponent in its website.

6. Any appeal against this prior environmental clearance shall lie with the National Green Tribunal (NGT), if preferred, within 30 days as prescribed under Section 16 of the National Green Tribunal Act, 2010 (*Central Act 19 of 2010*).

The meeting ended with a vote of thanks to the chair.

Dr. Benjamin Braganca

Dr. Chandrashekher U. Rivonker

Dr. Dipak C. S. Gaitonde

Shri . Sanjay Amonkar

Dr. Subhash H. Bhosale

22-09-2021

Shri. Sanjeev Joglekar
(Secretary Goa-SEAC)

Shri. Gautam Vikas Desai
(Chairman Goa-SEAC)

Place: Patto-Panaji

Date: 22nd September 2021

Annexure F

MINUTES OF THE 64th GOA STATE ENVIRONMENT IMPACT ASSESSMENT AUTHORITY (GOA–SEIAA) MEETING HELD ON 05/10/2021 AT 04.00 PM. IN THE CONFERENCE ROOM OF THE 4th FLOOR, DEMPO TOWER, PATTO, PANAJI-GOA.

The sixty-fourth meeting of the Goa-SEIAA (*hereinafter referred as 'Authority'*) was held on 05th October 2021 at 04.00 pm. in the conference room, 4th floor, Dempo Tower, Patto, Panaji. The list of members present during the meeting is annexed (*refer Annexure – 1*).

At the outset, Chairman welcomed Authority members and briefed about the agenda items (*refer Annexure – 2*) to be taken up for discussion / deliberations and suitable decisions. Accordingly, the same were considered as detailed below –

1. **To decide on project proposal received from Goa Cricket Association, for "Construction of Cricket Stadium" Dhargalim, Pernem – Goa.**

Project specific details submitted by the Project Proponent are as follows:

Sr. No.	Description	Details
1	Name of the project Proponent	Mr.Vipul Vinod Phadke Hon Secretary Goa Cricket Association
2	Address for Communication	Goa Cricket Academy, Alto Porvorim, Bardez, Goa Tel: 091-832-2416844
	Name & location of the project	Proposed New Construction of Cricket Stadium at Dhargalim Village, Pernem Taluka, North Goa District
4	Plot Area	Plot Area-1,89,930 sq. m
5	Net plot Area	
6	FSI Area Non-FSI Area Total construction Area Building configuration & Height of the building	 48,139.46 sq.m Cricket Stadium Height-21.45 M
7	No. of shops	Seating capacity- 32490 Numbers
8	Total water requirement (Construction/operation phase)	Construction Phase -30 cmd Operation Phase-672 Cmd
9	Sewage generation	364 cmd
10	STP Capacity / Proposed Technology	STP Capacity : 2 STPs of 100 cmd Fluidized Aerobic Bioreactor- FAB Technology):
11	Total Solid Waste Quantities	7,310 kg/day
13	Energy Efficiency	Energy Efficient Lighting, Fans, Air conditioners with Controls (a) Use of LED lights (indoor and outdoor) (b) Use of all energy efficient fans and unitary ACs with minimum coefficient of performance (COP). Energy efficient Pumps, Lifts and other Equipment: (a) Providing energy efficient pumps and DG set. (b) Providing energy efficient/ regenerative lifts. Integration of controls with IBMS and sensors for lighting fixtures

<table>
<tr><td></td><td></td><td>(a) Providing timer for lighting fixtures
Generation of Renewable Energy
(a) Utilization of solar energy through provision of solar PV panels.
(b) Preliminary analysis of the site suggests that a total of 1,060 Solar Modules can be placed on the site.
This site will be capable of generating 596.7 MWh annual</td></tr>
<tr><td>14</td><td>Parking 4 W and 2W</td><td><table><tr><th>Description</th><th>Number of cars</th><th>Number of TW</th><th>Number of Bus</th></tr><tr><td>Open Parking</td><td>1849</td><td>1401</td><td>19</td></tr><tr><td>Total</td><td>1852</td><td>1401</td><td>19</td></tr></table></td></tr>
<tr><td>15</td><td>Power requirement</td><td>Connected Load: 4000 KVA</td></tr>
<tr><td>16</td><td>D.G set Capacity</td><td>Power back up for Stadium: DG sets: 3 x 1250 KVA (2+1) for various Utilities
Transformers: 3 x 2000 KVA (2+1) with 1 as standby</td></tr>
<tr><td>17</td><td>RWH tank capacity</td><td>Proposed 2 tanks of 2,50,000 each near fire fighting tank</td></tr>
<tr><td>18</td><td>EMP cost (including DMP cost)</td><td>EMP Cost-1817.00 Lakhs
DMP cost-</td></tr>
<tr><td>19</td><td>No. of tress on site</td><td>1,595 nos.</td></tr>
<tr><td>20</td><td>No. of trees to be cut</td><td>840 nos</td></tr>
<tr><td>21</td><td>No. of tress to be planted on site</td><td>2520 nos</td></tr>
<tr><td>22</td><td>CRZ status</td><td>Not applicable</td></tr>
</table>

The representative of Goa Cricket Stadium Shri. Vipul Phadke, Hon'ble Secretary and Shri. Harish Shinde, CEO, Goa Cricket Association, Dr. Shobha Kamath, Environment Consultant, and Architect Shri. Uday Joshi, appeared before the Authority and explained the details of the Goa Cricket Stadium.

Decision: After discussion and considering recommendation by the Goa-SEAC the Authority, members unanimously decided to recommend the said project proposal for grant of Environmental Clearance under provision of EIA Notification 2006 (as ammended) with a condition that Project Proponent should adhere to the commitment of keeping not less than 10,000 sq.m area as a virgin land/undisturbed and also fence it up to protect it. Also Project Proponent to submit revised plan marking reserved area on Parivesh portal.

2. **To decide on proposed residential project Alcon Construction (Goa) Pvt. Ltd. Located at Survey No. 112/1 and 112/2, Tonca, Taleigao, Tiswadi North Goa. Application dated 17th September 2021 received on Parivesh portal (website of MoEF&CC).**

Decision: After scrutinizing the application and documents submitted by the Project Proponent, the Authority decided to inspect the site on 13th October, 2021

at 11:30 A.M onwards to verify site specific conditions and thereafter call the Project Proponent for presentation before the Authority to decide further.

3. **To decide on application for Environmental Clearance for sand extraction in Chapora river (6 zones) received from District Collector, North Goa.**

Decision: After considering the committee's recommendation and scrutinizing the application and documents submitted by Project Proponent, the Authority decided to recommend proposal for extraction of Sand at Chapora river by traditional (manual) method only at zone 1, 2 ,5 and 6 in the first instance with 50% capacity for first 3 years respectively and then to decide further capacity thereafter. Whereas proposals pertaining to zones 3(Part 1 and Part 2) and 4 may be referred back SEAC to conduct further scientific study in the matter.

4. **To decide on application (Auto ToR Granted) for proposed expansion on MS Billet & TMT Bars manufacturing unit of M/s Global Ispaat Pvt. Ltd. at Plot No. L-16, L-17, M-18 & M-19 of Cuncolim Industrial Estate, Cuncolim Village, Salcete Taluka, South-Goa. This application dated 11th August 2021 received on Parivesh portal (website of MoEF&CC).**

Decision: After scrutinizing the application and documents submitted by the Project Proponent the Authority decided to direct GSEAC to visit the site and identify if any specific conditions to be incorporated and also decided to issue show cause notice cum personal hearing before Goa -SEIAA based on 135th and 136th GSEAC minutes of meeting.

5. **To decide on re-validation of the Environmental Clearance of the project Marvel Resorts Private Limited dated 30th March 2021 received on Parivesh portal (website of MoEF&CC).**

Decision: After scrutinizing the application and documents submitted by the Project Proponent for re-validation the Authority decided to inspect the site on 13th October, 2021 at 11:00 A.M onwards to see the site condition and thereafter call the Project Proponent for discussion.

Matters considered under A.O.B.

6. **To decide on application for (ToR) for building and construction project category (8a) received from All India Institute of Ayurveda (AIIA) located at Dhargal, Pernem – Goa.**

Decision: The Authority decided to grant Terms of Reference (ToR's) to M/s All India Institute of Ayurveda (AIIA) subject to imposition of penalty as per Office Memorandum No.F.No.22-21/2020-IA.III dated 07/07/2021 issued by Ministry of Environment Forest and Climate Change (MoEF&CC).

As per the Office Memorandum project proponent has shown the cost of the project Rs.23,00,00,000/- (*Rupees twenty three crores only*). As per SOP fine to be levied is 1% of total project cost which works out to Rs.23,00,000/- (*Rupees twenty three lakhs only*). The project proponent shall deposit the said amount within a period of one month before this Authority on receipt of the letter along with Terms of Reference.

7. **To decide on submission made by Project Proponent regards to personal hearing held on 23/08/2021 by M/s. Marushka Stone Industries, M/s. Dandra Metals and Shri. Satyappa G. Dhangalkar for extension of validity of EC.**

Decision: The Authority after perusing the documents submitted on 22/09/2021 by above mentioned Project Proponents, the Authority decided to seek property documents from the Project Proponents and ask them to apply online on Parivesh portal for extension of validity of EC.

Smt. Reshma Mathew
Member, Goa-SEIAA

Shri. Suhas Godse
Chairman, Goa-SEIAA

(Dasharath M. Redkar)
Member Secretary, Goa-SEIAA

Place: Patto-Panaji
Date: 05th October 2021