COASTAL ZONE MANAGEMENT PLAN OF KOCHI CORPORATION
ERNAKULAM DISTRICT, KERALA

(As per CRZ Notification 2011 in 1: 25000 scale)

Prepared for

Kerala State Council for Science Technology and Environment
Govt. of Kerala

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES
THIRUVANANTHAPURAM 695011

May, 2014

PROJECT TEAM

Dr. K.V. Thomas	-	Principal Investigator
Dr M. Samsuddin	-	Co Principal Investigator
Dr. D. S. Suresh Babu		
Dr. K. Raju		
B. K. Jayaprasad		
D. Raju		
M.K. Sreeraj		
M.K. Rafeeque		

Project Staff

Dr. K.O. Badarees	-	Project Scientist (till 19.06.2013)
K. C. Vimal	-	Project Scientist/Senior Research Fellow
M. Rameshan	-	Project Scientist
Abhi Aravind	-	Senior Research Fellow
T. Neelima	-	Senior Research Fellow
R. V. Viji	-	Junior Research Fellow
T. J. Arun	-	Junior Research Fellow
C. Anoop	-	Technical Assistant
S. Sooraj	-	Technical Assistant (till 03.03.2014)
R. Swaraj	-	Technical Assistant
Muhammed Asif	-	Technical Assistant
P. T. Arun	-	Technical Assistant
Dileep Roy	-	Technical Assistant
Robert Thampi	-	Technical Assistant
Yedu Balachandran	-	Technical Assistant
Muhammed Sameer	-	Technical Assistant
Jose Mathew Varghese	-	Technical Assistant
R. Rajesh	-	Technical Assistant
K.V. Laju Prasad	-	Technical Assistant
R. Shihabudeen	-	Technical Assistant

CONTENTS

List of Figures and Tables

National Centre for Earth Science Studies, Thiruvananthapuram

Coastal Zone Management Plan (CZMP) of Kochi Corporation in 1:25000 scale

I. Introduction

The preparation of the Coastal Zone Management Plan (CZMP) for Kochi Corporation has been undertaken as part of the CZMP preparation for the coastal zone of Kerala, including urban and rural areas. The approach and methodology followed are the same for all the Corporations, Municipal Councils and rural areas in the State.

The damages to the coastal zone and the impact of coastal hazards to communities and properties, to a certain extent, can be controlled by regulating high impact activities in the coastal zone. It was with this objective the Coastal Regulation Zone (CRZ) Notification (MoEF, 2011; 1991) was introduced in the country.

II. CRZ of Kerala

CRZ (2011) notification (para 7 (V) A(ii)) has approved a special status for Kerala coastal zone as "areas requiring special consideration for the purpose of protecting the critical coastal environment and **difficulties faced by local communities**".

1. To facilitate the above requirement, the CRZ of Kerala has been categorized **under Category V (CRZ V)**.
2. While detailing the 'Norms for regulation of activities permissible under this notification it is mentioned under (para 8 (V) 2) that in view of the unique coastal systems of backwater islands along with space limitations along the coast of Kerala, the following activities are regulated in CRZ:

    (i) all the islands in the backwaters of Kerala shall be covered under the CRZ notification;

    (ii) the islands within the backwaters shall have 50mts width from the High Tide Line on the landward side as the CRZ area;

    (iii)within 50mts from the HTL of these backwater islands existing dwelling units of local communities may be repaired or reconstructed however no new construction shall be permitted;

(iv) beyond 50mts from the HTL on the landward side of backwater islands, dwelling units of local communities may be constructed with the prior permission of the Gram panchayat;

(v) foreshore facilities such as fishing jetty, fish drying yards, net mending yard, fishing processing by traditional methods, boat building yards, ice plant, boat repairs and the like, may be taken up within 50mts width from HTL of these backwater islands.

3. Under 'Guidelines for preparation of Coastal Zone Management Plans in Annexure I(II)12, it has been directed that 'In the CRZ V areas the land-use map shall be superimposed on the Coastal Zone Management Plan and clearly demarcating the CRZ I, II, III, IV.

The fisher people are confined to a very narrow stretch of 50 to 100m from the HTL and belong to 'ecosystem people' who require the coastal zone for their settlement requirements and livelihood related activities. Considering the livelihood requirements of the ecosystem people, the high density of coastal population, unique style of their livelihood activities, the CZMP have to project the various requirements to address the **difficulties faced by local communities.**

III. Coastal Zone Management Plans

The CRZ provides a spatial planning framework for Coastal Zone Management Plans which provide setbacks around sensitive eco-zones restricting development and other activities close to it. Setbacks require specific reference lines and boundaries for its meaningful implementation. The High Tide Line (HTL) forms the cardinal reference line for determining the setbacks for CRZ. The 100, 200 and 500m CRZ lines landward from the HTL are the landward setback lines. The Low Tide Line (LTL) and the Territorial water boundary (12 nm) form the setback lines towards the sea. The Coastal Zone Management Plans are prepared in 2 scales:

1. CZMP consisting of CRZ maps in 1:25000 scale with Survey of toposheets as base maps.
2. CZMP consisting of CRZ maps in 1:4000 scale with cadastral maps as base maps.

The approach followed is:

i. Generation of data in 1:4000 scale on HTL, LTL and eco-morphological systems relevant for CRZ.

ii. Demarcation of HTL, LTL, ecosystems and morphology relevant for CRZ in 1:25,000.

iii. Demarcation of HTL, LTL, ecosystems and morphology relevant for CRZ in 1:4,000 scale.

iv. Preparation of CZMP maps consisting of CRZ maps in 1:25000 scale.

v. Preparation of Local level CZMP maps in 1:4000 cadastral scale.

The CZMP/CRZ maps in 1:25000 scale with Survey of India toposheets as base maps are required for formulating policy decisions. These are to be submitted to MoEF, Govt of India for approval after stakeholder/public consultations. The local level CRZ/CZMP are prepared in 1:4000 with cadastral base maps and based on the approved CZMP.

Local level data in cadastral scale has been generated initially which is being used for preparing the 1;25000 CZMP on toposheet base maps. The same is used for local level CRZ/CZMP maps.

IV. CZMP in 1:25000 scale

The present study and report provide the CZMP in 1:25000 scale.

1. High Tide Line

Different tide levels like Mean High Water Springs, Mean Low Water Springs, Lowest Astronomical Tide, etc are defined and successfully used for navigational purposes and sea surveying. The High Tide Level is dependent on lunar cycles. It is normally taken as the water level at which the high tide intersects with the vertical plane.

The above definition is not in commensurate with the objectives of demarcating the HTL which is to regulate the activities on the land. The experience of Naval Hydrographer while demarcating the HTL in Goa way back in 1992-93 brought out the limitations in assigning the usual definitions for the HTL (Menon, 1993). The HTL demarcated in this case for Goa was found to be in the sea during the next monsoon.

A functional HTL is defined in the CRZ notification with the sole objective of protecting a given stretch of coastal strip from environmental degradation. Hence an approach different from the ones followed for navigational purpose, is necessary for demarcating HTL, in tune with the definition given in the Notification.

The HTL is defined 'for the purpose of the notification' as *"the line on the land upto which the highest waterline reaches during the spring tide"* which is different from the well known and widely accepted definition of High Tide Level. The above definition of HTL takes into consideration not only the level of inundation due to maximum tide (spring tide) but also the wave set up (having a seasonal periodicity). The sea level thus formed due to the combined effect of spring tide and wave set up gives the line of maximum reach of water on the land.

There is a similarity between the HTL thus defined and the High Water Line (HWL) given in Survey of India (SoI) toposheets. Both are lines drawn on the land. But the HWL and HTL are different that the former gives the fair season shoreline (because SoI field mapping is conducted during non-rainy season) during spring tide while the latter accommodates the rough season (monsoon) shoreline oscillations due to monsoon wave set up in addition to spring tide inundation.

2. Low Tide Line

Unlike the HTL the Low Tide Line (LTL) has not been defined for CRZ. The HTL required specific definition since the 100, 200 and 500m setback lines are defined with respect to the HTL. The conventional definition of lowest low water level and the resultant low water line during spring tide may be taken as the LTL.

3. Setback lines

The 100, 200 and 500m setback lines are drawn landward of the HTL. Once the HTL is well defined and demarcated, the above 3 setback lines could be drawn without any ambiguity following planimetric methods.

3.1. Setback line for CRZ II

For urban areas like Kochi Corporation in which developed areas are eligible to be categorized as CRZ II, the setback lines are different. Those prohibited activities listed in the CRZ notification (2011: under para 3) are applicable for the entire CRZ. Other construction

activities are permitted in CRZ II landward of ‘existing’ buildings or ‘existing’ or ‘approved’ roads. The word ‘existing’ and ‘approved’ are specifically defined in the notification.

4. Influence of Tidal action

The distance up to which CRZ is applicable upstream of estuaries, creeks, backwaters and lagoons depends on the extent of tidal influence. The distance up to which tidal influence is experienced is dependent on salinity concentration: if it is 5 ppt or more the water body is considered to be influenced by tidal action (MoEF, 2011). Salinity measurements are carried out to determine the limit. Tidal barrages and bunds constructed are also taken as the limit of tidal influence.

5. Different approaches to demarcate HTL

The highest level horizontal positional and spatial accuracy in mapping and presenting the HTL becomes necessary for field uses by CRZ implementing agencies. The agencies are looking for a planimetric accuracy approaching zero error.

The different approaches now practiced in the country to demarcate the HTL are:

- tide level projection
- using morphological signatures
    - field methods
    - satellite data

The NCESS follows the approach using morphological signatures (CESS, 1995)

5.1. HTL using morphological signatures

Morphological signatures are good indicators of shoreline oscillation and inundation of coastal waters, which could be used for identifying the HTL. The inundation of coastal waters on to the land and seasonal shoreline oscillations are dependent on coastal morphology. Shoreline remains stable and would not retreat significantly along cliffy coasts. The shoreline retreats up to the cliff base along pocket beaches. Artificial morphologies like seawalls confine the oscillation of shoreline along the line of the structure itself. Sandy beaches are prone to seasonal and long term shoreline oscillation. Long term stability of the

beach and the position of the stable part of the beach would be evident from morphological signatures such as berm and berm crest.

This could be done by field methods and using satellite data.

5.2. Field method

The HTL has to be fixed with respect to certain reference points on the land. These reference points at sufficiently close intervals (preferably at least 1km alongshore) have to be marked with respect to latitude-longitude and known points in the base map. Geomorphologic features like berm crest, cliff, headland, line of permanent vegetation, etc are indicators of the reach of sea water into the land. Stable coastal protective structures like seawall also limit the intrusion of seawater. Hence High Tide Line (line of maximum reach of seawater into the land during spring tide) can be fixed in the field, with respect to these features and tied to the reference points, as detailed below.

a. *Landward (monsoonal) berm crest for beach*es

In all the well-formed wide beaches, one or more berms (which are nearly horizontal part of the beach formed by the deposition of sand by wave action) are usually observed. The seaward end of the berm, which shows a sudden downward slope is called the berm crest. When there is only one berm, it normally gets eroded during the monsoon with a berm crest on the landward side. But when there are two berms the landward berm is the monsoonal berm, which normally do not get eroded. Or else we can say that the erosion reaches only to the second berm crest. Since the tidal waters do not reach the coast beyond this landward berm crest, it is taken as the HTL. The distance to this point from the reference point is measured using the beach profile to fix the position of the HTL.

b. Seawall/revetments/embankments

In highly erosion-prone areas, there are no landward second berms. Such locations will be protected mostly by seawalls. During monsoon season majority of these are devoid of beaches. The waves impinge upon the seawall during the monsoon season, especially during the high tide. Thus they are the artificial barriers stopping the waves/tides at the coast. Since the seaward part of the seawall in most cases is defaced due to erosion, the landward toe is taken as the HTL boundary in such locations. There are some locations with two or three

lines of seawall, particularly in the accreting areas. The seaward seawall is considered here for the purpose. On the other extreme, in the case of continuously eroding sites there are lines of sea wall which are now in the sea. In such cases the landward seawall is taken. In order to facilitate the demarcation of HTL at seawall locations, the latter has to be clearly marked in the beach profile during coastal surveys.

c. Permanent Vegetation Line

Permanent vegetation develops on the stable part of the beach. The part of the beach landward of monsoon berm crest is mostly stable. Hence the line of permanent vegetation normally follows the line of monsoon berm crest which is the HTL.

d. Tidal flats and mudflats

Tidal flats and mud flats are formed by fine-grained silts and clays in a medium to large tidal environment. They have a fairly large intertidal zone fringed by vegetation. In such cases the landward limit of HTL can be demarcated as the line of permanent vegetation other than salt marsh vegetation and mangroves of intertidal habitat. Other geomorphic signatures like changes in land forms & sediment characteristics can also be used.

e. Rocks, Headlands, Cliffs

At the rock outcrops, headlands and cliffs the water is quite deep that there is virtually no spatial displacement in the waterline. Hence, the High Water Line available in the topographical maps (transferred to the base map) can be taken as such (Fig.4). However, at the eroding laterite cliffs (e.g. Varkala, Paravoor, Thalassery in Kerala), the latest position of the toe is taken from the cross section measured at the respective sites. This is to be verified against the satellite imagery and transferred to the base map.

6. 100, 200 & 500 m lines

Once the reference points and the HTL are available, it is not difficult to draw 100, 200 and 500m line on the map as required in the Notification.

The distance of 100, 200 and 500m from the HTL is converted to the map scale at each reference point and demarcated. The above lines are drawn parallel to the HTL uniformly all along the coast.

For the use in the field, the distance of LWL, 100, 200 and 500m line from HTL from all the reference points can be given as a table. The location details, including place names, latitude, longitude etc can also be given in these tables.

7. HTL demarcation in the field and CRZ map generation

Since CRZ is applicable to inland water bodies, the influence of tidal action upstream of the water bodies is determined by verifying the salinity of the water body during the driest month of the year. If the salinity is 5 ppt or more, then the water body is considered to be influenced by tidal action. This is assessed from field measurements and indicators like the limit of tidal influence given in the CZMP (1996) and presence of mangroves.

Field studies are undertaken for fixing ground control points for georeferencing and referring the position of the HTL. A hybrid approach of field studies supported through information extracted from satellite imageries and existing maps are relied upon for CRZ mapping to identify the HTL, LTL, eco-geomorphic systems and land use relevant for CRZ. The eco-geomorphic systems include mangroves, intertidal zone, mudflats, saltpans, etc.

7.1. CRZ/CZM map in 1:25000

The CRZ map in 1:25000 is prepared with Survey of India topsheets as base maps. These toposheets being of the coastal area, are restricted and hence have to be procured through proper channel following specified procedures and after giving statutory undertakings to ensure authorized use and safe custody. Toposheets of the area of study are georeferenced and the High Water Line (HWL) in the toposheets have been extracted along with other coastal features like waterbodies, inter tidal zones, mudflats, beaches, mangroves, saltpans, prawn aqua farms, etc. The HWL is updated with current field measurements and satellite imageries to get the present HTL. Field measurements were made in 1:4000 scale for better accuracy and compatibility with large scale local level CZMP.

The variations of present HTL from that of CZMP (1996) is verified and documented. The probable reasons for the variations are looked into and the details are given wherever possible.

7.2. CRZ/CZM map in 1:4000

The base map on which HTL and LTL are demarcated have to be familiar for officials of local bodies and the public. These have to be of sufficiently large scale with sufficient number of reference points identifiable on the ground for facilitating field applications.

7.3 Base maps

Cadastral maps available with Revenue/Survey and Land Records Dept are in 1:4000 or 1:5000 scale. Survey plots and plot boundaries are locatable on the ground. 'Plot boundary junction points' are taken as the reference points. The National Centre for earth Science Studies has successfully used cadastral maps for preparing Panchayat resource maps which are being widely used by local bodies for local level planning (CESS 2000).

8. Field mapping and map generation

Initially cadastral maps of the required area are obtained from the concerned departments (Revenue/ Survey and Land Records Dept). These are checked for its scale accuracy through comparing the distance of 2 known points from the map and from the ground. Toposheets and imageries of the area for which HTL is to be demarcated, are referred to know the features and available morphological signatures. Information derived from toposheets and satellite imageries of different coastal ecosystems in the given area is used as baseline information for planning the field investigations. Cadastral maps are rectified with coordinates of known ground control points (GCP) taken from the field. The datum used is WGS 84 and the projection is UTM.

Ground features that can be clearly identified both on the ground and on the cadastral map are used as ground control points (GCP). With precise planimetry of the identified GCPs, the cadastral maps are geo-referenced with GPS/DGPS measured geo coordinates. GCPs used are survey plot boundary junctions or survey stones established at the time of field survey for the preparation of cadastral maps. These are identified in the field. At least one control point is identified within 1km of alongshore length. The coordinates (Latitude; Longitude) of the identified control points are taken using GPS/DGPS. The signature for the nearest HTL is identified and distance to the HTL from the control point is measured with distometer (usually laser distometer). The GPS/DGPS is moved along the HTL identified through signatures and the readings are recorded. Wherever possible these are linked to the control

points identified earlier and distance to HTL measured with distometer. The data thus collected is transferred to cadastral maps and superimposed in GIS platform. Information from satellite imageries are used to verify the data collected and also to supplement the data wherever the area is not approachable. Cadastral maps and satellite images are rectified in the same geographical coordinate system and projection.

The most difficult part is the transferring of information from imageries to unprojected cadastral maps on which CRZ maps are prepared. This is overcome by using sufficient number of precise reference/control points spread over the entire study area for georeferencing and compartmentalizing the maps. One of the major contributors to errors is those occurring while reproducing the cadastral map from original map through photocopying and scanning. While photocopying the enlargement or reduction produce the scale error; also the shrinkage/folding of paper during the process. Another is the scale error during geo-referencing the map. It may be noted that cadastral maps have no projection while the images are projected. When overlying cadastral map on image by applying a common coordinate system, some distortions do occur at edges and in the shape of features such as road network, plot boundary etc. The errors in reproduction of cadastral maps can be minimized by taking proper precautions. The errors in georeferencing could be controlled by taking precautions through selection of proper field Ground Control Points (GCPs) and identifying the field GCPs in the cadastral as well as satellite images precisely. And by making some finer adjustments, the ecosystem boundaries delineated from satellite images could be matched with real cadastral boundaries on the ground.

The use of satellite imageries in combination with field mapping provides better results in cadastral level mapping. At the same time, various location and spatial errors that could get magnified in large scale maps like cadastral maps require to be contained through appropriate approach.

8.1. Use of Remote sensing data for HTL

With the availability of precision GPS and high resolution satellite data like Quick Bird, IKONOS, Resource Sat (P6) and Cartosat, it is now possible to get a mapping accuracy of less than one meter for the demarcation of HTL/LTL. It requires georeferencing using accurate GPS data at precisely locatable Ground Control Points (GCPs) in satellite images to

have improved accuracy level in the identification and demarcation of HTL/LTL. Accurately identifying the positions for HTL with respect to signatures may become difficult when vegetation like coconuts cover the signatures. For getting multispectral data with high spatial resolution, the Cartosat (PAN) image has been merged with IRS-1C/1D LISS III, IRS P6 LISS IV and has been used wherever required. The IRS-1C/1D LISS III image has a spatial resolution of 23.5m; the IRS P6 LISS IV has a resolution of 5.8 m whereas Cartosat-1 (PAN) has a spatial resolution of 2.5 m.

8.2. LTL delineation

The LTL also depends on lunar cycle. The seaward/waterside limit will depend on the width of tidal flat and beach. An initial assessment of LTL could be made from Hydrographical charts. While mapping HTL the signatures of LTL could be noted and the distance from HTL to LTL may be assessed. This is further verified and corrected with the information from Hydrographical charts and satellite imageries. Information on LTL is derived from satellite imagery by identifying the seaward limit of beach/ tidal flat during fair season when the beaches/ intertidal zone have maximum width.

9. CZMP/CRZ map of Kochi in 1:25000 scale

The Kochi Corporation area is shown in three1:25000 toposheets:

- Sheet No. 58 B8 SW
- Sheet No. 58 C1 NE
- Sheet No. 58 C5 NW

In addition to Kochi Corporation, parts of Maradu Municipality and adjoining panchayats are seen in toposheet 58 C5 NW.

The CRZ field mapping was carried out during March to May 2012. As already discussed High Water Line (HWL) has been extracted from geo-referenced SOI toposheets following standard procedures. Field data was generated in 1:4000 scale from twelve villages that comprises Kochi Corporation.

The HWL has been appropriately modified with the HTL obtained from field observations and satellite imageries for preparing the CZMP as per CRZ 2011.

9.1. Data Sources

In addition to field investigations including GPS/DGPS mapping, data sources such as topographic sheets, hydrographic charts and satellite images have been used. Field mappings were carried out during March to December 2013. An initial assessment of the morphology and ecosystems is obtained from Google imageries which are mostly QuickBird images. Google imageries (QuickBird) of 2010 and 2011, available in the public domain, were down loaded as different scenes with resolution zoomed to the required level. These are then merged in Photoshop and georeferenced.

PAN merged IRS-1C/1D LISS III and IRS P6 LISS IV data were also used wherever required. Cartosat (PAN) has a resolution of 2.5m, whereas LISS III has 23.5 m resolution. The IRS P6 LISS IV has a resolution of 5.8 m.

9.2. Salinity and upstream boundary

Salinity measurements have been carried out to determine the upstream boundary of CRZ along rivers and canals during March to May 2014. It is seen that certain areas upstream of Iron Bridge, Petta Bridge and Champakara Bridge are saline with salinity greater than 5 ppt (Table, 1; Fig. 1). These were not in CRZ in CZMP (1995). As per the present salinity observations the areas upstream of Iron Bridge, Petta Bridge and Champakara Bridge require to be included in CRZ.

Table 1: Salinity in different locations

Sampling Location	LONGITUDE	LATITUDE	Date	Time	Salinity (ppt)
1	76.32385	9.97061	3/7/2013	14:30	9.36
2	76.31997	9.95510	3/7/2013	15:45	8.07
27	76.31988	9.95505	3/7/2013	15:50	14.02
3	76.33442	9.95136	3/23/2013	9:05	16.98
4	76.32698	9.95602	3/23/2013	9:15	17.36
5	76.32064	9.96162	3/23/2013	9:25	13.50
6	76.30870	9.96722	3/23/2013	9:40	13.70
7	76.30496	9.97039	3/23/2013	10:05	5.40
8	76.30656	9.97258	3/23/2013	10:25	7.20
9	76.30642	9.97274	3/23/2013	10:30	8.30
10	76.30529	9.97833	3/23/2013	11:00	4.99
11	76.29884	9.95606	3/23/2013	11:40	6.40
12	76.30509	9.95719	3/23/2013	12:05	17.10
13	76.30413	9.96113	3/23/2013	12:15	6.20
14	76.29010	10.03119	3/23/2013	13:35	4.26
15	76.28853	10.03382	3/23/2013	15:25	5.70
16	76.32488	9.98486	3/23/2013	16:40	10.35
17	76.32876	9.99099	3/23/2013	16:55	10.27
18	76.31853	9.95450	3/30/2014	11.3	14.00
19	76.33442	9.95103	3/30/2014	13.32	14.60
20	76.32511	9.97211	3/30/2014	13.50	14.10
21	76.33308	9.97986	3/30/2014	15.20	14.50
22	76.32828	9.99097	3/30/2014	15.5	7.10
23	76.30069	10.04433	3/30/1014	14.3	0.00
24	76.29331	10.02575	4/1/2014	14.50	12.50
25	76.29525	10.01958	4/1/2014	11.50	0.00
26	76.33067	9.99964	4/1/2014	16.15	4.00

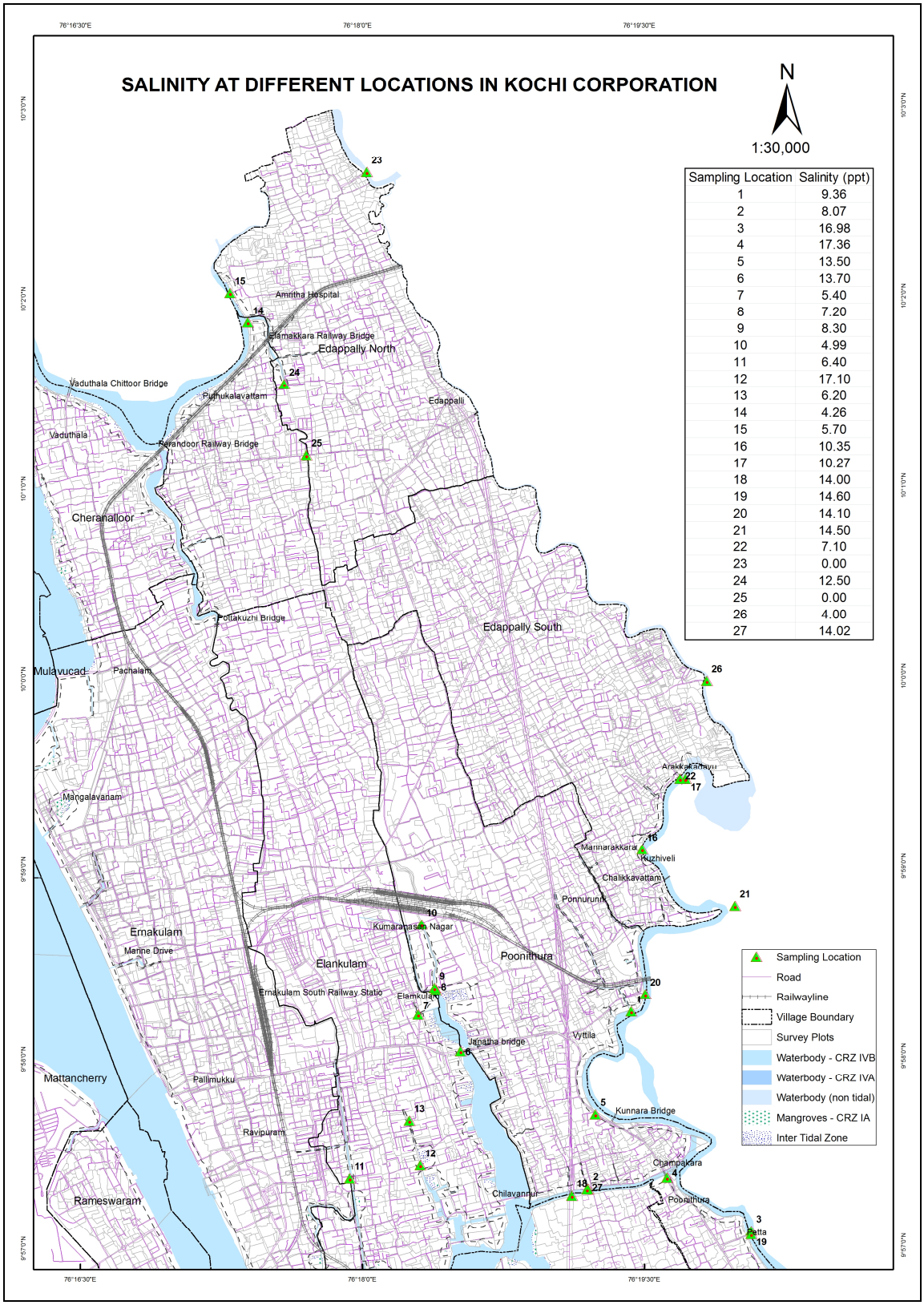


Figure 1. Salinity at different locations

10. CRZ categories

The CRZ of Kochi consists of CRZ I (CRZ IA & CRZ IB), CRZ II, CRZ III and CRZ IV. The CRZ IA are those ecologically sensitive and the geomorphological features which play a role in maintaining the integrity of the coast as listed under para '7(i)A' such as mangroves, corals, sand dunes, etc. The CRZ IB is area between Low Tide Line and High Tide Line. The CRZ II is those developed areas (with more than 50% built up area) in legally designated urban areas. Kochi being a Municipal area, the CRZ in Kochi which have more than 50% built up area, is CRZ II. The CRZ III is undeveloped areas in the CRZ of Kochi Municipal area. The CRZ IV is the nearshore waters, the inland water bodies and the bed. The details are given in the attached CRZ map (Figure 2 and Table 2).

Avicennia officinalis, Rhizophora mucronata, Bruguiera gymnorrhiza, Sonneratia caseolaris, Excoecaria species, Acanthus ilicifolius and *Derris* sp are the dominant variety of mangroves. Tidal influence in some of canals and rivers is regulated by bunds/ sluices to regulate saline incursion. Many of such sluices have become non-functional. Reclamation of mudflats/tidal flats and waterbody has caused significant changes in the morphology and HTL in many places. In that process mangrove also have been damaged (Appendix 1).

Kochi Corporation being highly developed with a very high potential for further development, the Kerala Coastal Zone Management Authority and the Govt of Kerala took the view that the CRZ in Kochi Corporation, other than CRZ I, CRZ IV and open spaces such as parks and play grounds have built up area more than 50% and hence could be considered as CRZ II. Accordingly the CRZ in Kochi Corporation, other than CRZ I, CRZ IV, are shown as CRZ II.

The Corporation has HTL for a length of 225.86 km. The total CRZ area is 9.32 km^2. Mangrove area (CRZ IA) is 0.49 km^2 with a mangrove buffer zone of 1.6 km^2. The intertidal zone (mostly mudflats on the banks of backwater) is spread over 0.60 km^2.

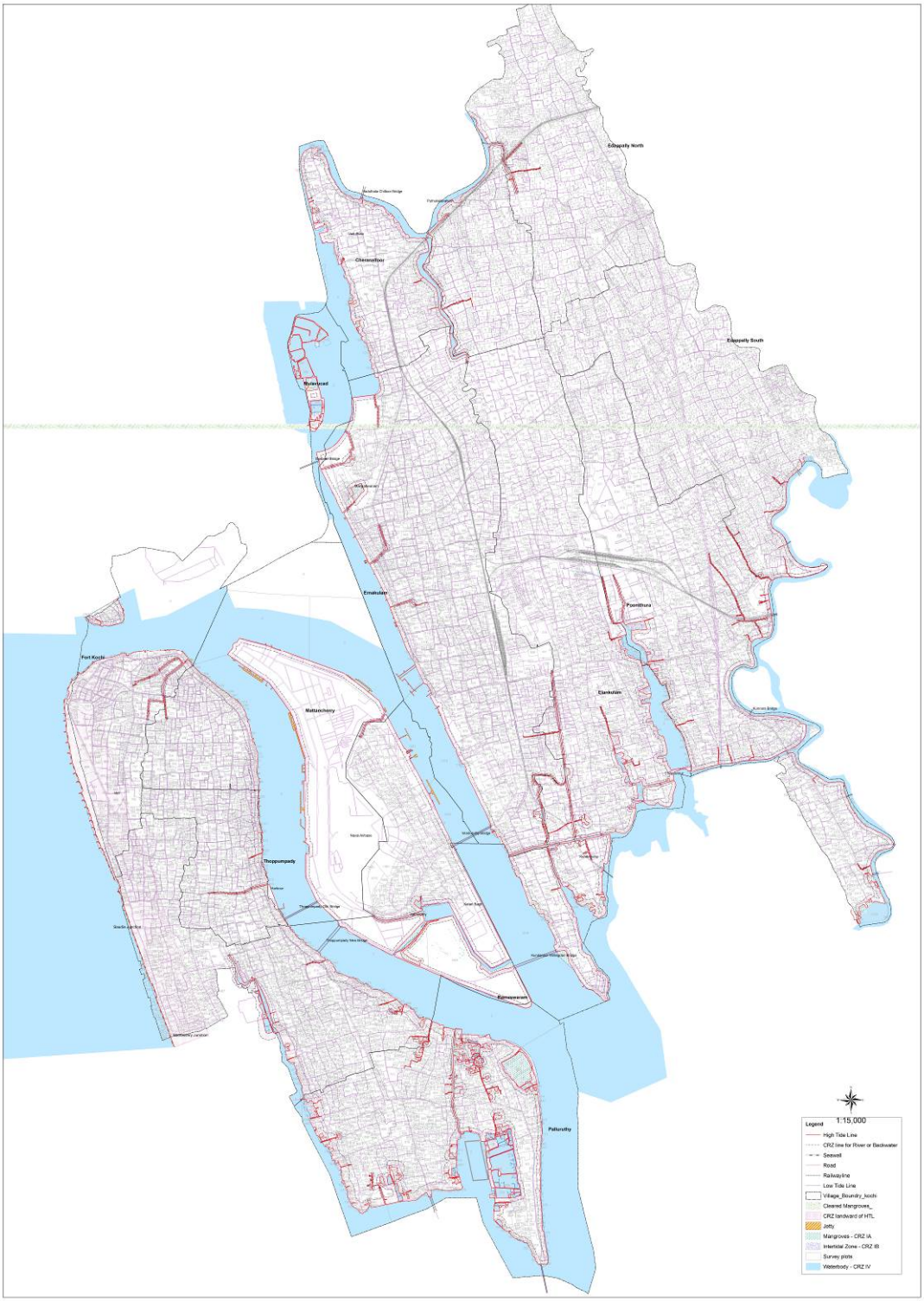


Figure 2. HTL and coastal ecosystems such as mangroves demarcated in cadastral scale for Kochi Corporation

Table 2. CRZ details of Kochi Corporation

HTL Length (km)	Mangroves (CRZ IA) (km^2)	Inter Tidal Zone (CRZ IB) (km^2)	Mangrove buffer zone (CRZ I) (km^2)	CRZ II (km^2)
225.86	**0.49**	**0.60**	**1.6**	**9.32**

11. Summary

- Kochi Corporation is in Ernakulam district. It has Lakshadweep Sea is on its west. Vembanadu backwater and interconnecting canals crisscross the Corporation. The Kochi tidal inlet provides a permanent connection to the sea.
- Kochi Corporation is contained in toposheets No.58 B8 SW, 58 C1 NE and 58 C5 NW. Parts of Maradu Municipality and adjoining parnchayats are also seen in these toposheets.
- The CZMP is prepared in 1:25000 scale based on field information collected in 1:4000 cadastral maps.
- *Avicennia officinalis, Rhizophora mucronata, Bruguiera gymnorrhiza, Sonneratia caseolaris, Excoecaria species, Acanthus ilicifolius* and *Derris* sp are the dominant variety of mangroves
- Flow in many canals is blocked due to reclamations restricting tidal flow. Bunds and sluices have regulated the flow of tidal waters in many canals and rivers.
- Kochi Corporation is highly developed with a very high potential for further development, the CRZ in the Corporation, other than CRZ I, CRZ IV and open spaces such as parks and play grounds is considered to have built up area more than 50% and hence categorized as CRZ II.
- The Kochi Corporation has HTL for a length of 225.86 km.
- The CRZ of the Corporation consists of CRZ I, CRZ II and CRZ IV. Parks, play grounds and similar open spaces (not shown in the present CZMP) are to be categorized as CRZ III.

- The total CRZ area is 9.32 km^2 which includes those areas outside the revenue boundaries in the intertidal zone.
- Mangrove area (CRZ IA) is 0.49 km^2 with a mangrove buffer zone of 1.6 km^2.
- Intertidal zone (which includes mudflats on the banks of backwater/ river) is CRZ IB and is spread over 0.60 km^2. No distinction is made between biologically active and not biologically active mudflats.

Appendix 1

An overview of Reclaimed Lands under CRZ of Kochi Corporation (based on imageries since 2002 and field study)

Sl. No.	Sy No.	Village	Place	Year of reclamation	Land cover at the time of reclamation
1	1	Palluruthi	Edakochi	2005	ITZ/MG
2	3	Palluruthi	Edakochi	2005	MG
3	17	Palluruthi	Edakochi	2005	ITZ/MG
4	24	Palluruthi	Edakochi	2005	ITZ/MG
5	200	Palluruthi	Near Parippu	2005	MG
6	250	Rameswaram	Edakochi	2003	ITZ/MG
7	251	Palluruthi	Near Parippu	2005	ITZ/MG
8	253	Rameswaram	Edakochi	2005	ITZ/MG
9	253	Palluruthi	Santham Colony	2005	MG
10	261	Rameswaram	Santham Colony	2005	ITZ/MG
11	265	Rameswaram	Santham Colony	2005	ITZ/MG
12	266	Rameswaram	Fort Vypin	2005	ITZ/MG
13	281	Fort Kochi	Fort Vypin	2005	MG
14	322	Palluruthi	Fort Vypin	2005	ITZ/MG
15	324	Palluruthi	Fort Vypin	2005	Land Area on the banks of Vembanadu
16	325	Palluruthi	Fort Vypin	2005	Land Area on the banks of Vembanadu
17	326	Palluruthi	Perumpadappu	2005	
18	327	Palluruthi	Perumpadappu	2005	Land Area on the banks of Vembanadu
19	328	Palluruthi	Perumpadappu	2005	
20	330	Palluruthi	Perumpadappu	2005	Land Area on the banks of Vembanadu
21	331	Palluruthi	Perumpadappu	2005	Land Area on the banks of Vembanadu
22	340	Palluruthi	Perumpadappu	2005	ITZ/MG
23	344	Palluruthi	Perumpadappu	2010	Land Area on the banks of Vembanadu
24	349	Palluruthi	Edakochi	2007	Land Area on the banks of Vembanadu

Sl. No.	Sy No.	Village	Place	Year of reclamation	Land cover at the time of reclamation
25	398	Palluruthi	Perumpadappu	2005	MG
26	424	Palluruthi	Santham Colony	2007	Land Area on the banks of Vembanadu
27	473	Rameswaram	Santham Colony	2003	ITZ
28	474	Rameswaram	Santham Colony	2003	ITZ
29	475	Rameswaram	Santham Colony	2003	ITZ
30	484	Rameswaram	Puthanpalam	2005	ITZ
31	514	Elankulam	Puthanpalam	2005	ITZ
32	533	Elankulam	Chilavannur	2005	ITZ
33	554	Elankulam	Chilavannur	2005	ITZ
34	559	Elankulam	Chilavannur	2005	ITZ
35	560	Elankulam	Chilavannur	2005	ITZ
36	561	Elankulam	Vinoba nagar	2005	ITZ
37	562	Elankulam	Chilavannur	2005	ITZ
38	563	Elankulam	Vinoba nagar	2005	ITZ
39	564	Elankulam	Vinoba nagar	2005	ITZ
40	565	Elankulam	Vinoba nagar	2005	ITZ
41	567	Elankulam	Vinoba nagar	2005	ITZ
42	568	Elankulam	Vinoba nagar	2005	ITZ
43	572	Elankulam	Neptune Country	2005	ITZ
44	573	Elankulam	Neptune Country	2005	ITZ
45	574	Elankulam	Vinoba nagar	2005	ITZ
46	581	Elankulam	Vinoba nagar	2005	ITZ
47	585	Elankulam	Vinoba nagar	2005	ITZ
48	632	Elankulam	Vidya nagar	2005	ITZ
49	634	Elankulam	Vidya nagar	2005	ITZ
50	635	Elankulam	Vidya nagar	2005	ITZ
51	636	Elankulam	Chirakkal	2005	ITZ
52	728	Palluruthi	Chirakkal	2005	ITZ/MG
53	729	Palluruthi	Chirakkal	2005	ITZ/MG

Sl. No.	Sy No.	Village	Place	Year of reclamation	Land cover at the time of reclamation
54	730	Palluruthi	Chirakkal	2005	ITZ/MG
55	731	Palluruthi	Chirakkal	2005	ITZ/MG
56	732	Palluruthi	Vidya nagar	2003	ITZ/MG
57	743	Elankulam	Chirakkal	2005	Land Area on the banks of Vembanadu
58	745	Palluruthi	Chirakkal	2005	ITZ/MG
59	753	Palluruthi	Santham Colony	2005	MG
60	762	Rameswaram	Chirakkal	2005	ITZ
61	767	Rameswaram	Chirakkal	2005	ITZ
62	770	Rameswaram	Chirakkal	2005	ITZ
63	837	Palluruthi	Vidya nagar	2005	ITZ/MG
64	874	Elankulam	Puthanpalam	2005	Land Area on the banks of Vembanadu
65	884	Elankulam	Puthanpalam	2005	ITZ
66	885	Elankulam	Puthanpalam	2005	ITZ
67	886	Elankulam	Puthanpalam	2005	ITZ
68	887	Elankulam	Puthanpalam	2005	ITZ
69	888	Elankulam	Vidya nagar	2005	ITZ
70	893	Elankulam	Vidya nagar	2005	ITZ/MG
71	900	Elankulam	Chirakkal	2005	ITZ/MG
72	909	Rameswaram	Chirakkal	2007	ITZ/MG
73	910	Rameswaram	Konthuruthi	2005	MG
74	935	Elankulam	Chirakkal	2005	MG
75	951	Rameswaram	Thevara	2005	MG
76	955	Elankulam	Thevara	2005	ITZ/MG
77	966	Elankulam	Mattummal	2005	ITZ/MG
78	1404	Rameswaram	Southwest of Willingdon Island	2005	ITZ/MG
78	1008	Elankulam	Mattummal	2005	MG
79	1011	Elankulam	Janatha	2005	Land Area on the banks of Vembanadu
80	1017	Poonnithura	Janatha	2004	ITZ

Sl. No.	Sy No.	Village	Place	Year of reclamation	Land cover at the time of reclamation
81	1019	Poonnithura	Janatha	2004	ITZ
82	1029	Poonnithura	Janatha	2003	ITZ
83	1031	Poonnithura	Perumpadappu	2003	ITZ
84	1037	Palluruthi	Perumpadappu	2007	ITZ
85	1041	Palluruthi	Perumpadappu	2008	ITZ
86	1042	Palluruthi	Perumpadappu	2008	ITZ
87	1044	Palluruthi	Perumpadappu	2008	ITZ
88	1046	Palluruthi	Perumpadappu	2010	ITZ
89	1047	Palluruthi	Perumpadappu	2010	ITZ
90	1048	Palluruthi	Perumpadappu	2010	ITZ
91	1064	Palluruthi	Perumpadappu	2010	ITZ
92	1065	Poonnithura	Perumpadappu	2005	Land Area on the banks of Vembanadu
93	1066	Poonnithura	Perumpadappu	2003	Land Area on the banks of Vembanadu
94	1068	Palluruthi	Janatha	2003	ITZ
95	1073	Poonnithura	Janatha	2003	Land Area on the banks of Vembanadu
96	1104	Palluruthi	Perumpadappu	2008	Land Area on the banks of Vembanadu
97	1151	Palluruthi	Perumpadappu	2003	ITZ/MG
98	1157	Palluruthi	Perumpadappu	2002	ITZ
99	1407	Poonnithura	Iron Bridge	2008	ITZ
100	1408	Poonnithura	Iron Bridge	2005	ITZ
101	1430	Poonnithura	Iron Bridge	2005	ITZ
102	1431	Poonnithura	Chirakkal	2005	ITZ
103	1455	Palluruthi	Perumpadappu	2005	MG
104	1458	Palluruthi	Edakochi	2003	Land Area on the banks of Vembanadu
105	1548	Palluruthi	Chirakkal	2003	MG
106	1565	Palluruthi	Perumpadappu	2003	ITZ/MG
107	1601	Palluruthi	Konthuruthi	2005	ITZ

ITZ : Intertidal Zone**; MG :** Mangroves

76°17'30"E

76°20'0"E

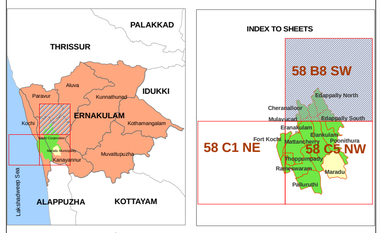
10°4'30"N

10°2'30"N

Continued to sheet no. 58 C5 NW

Index Map

58 B8 SW



± CZMP MAP IN 1:25000

SHEET No.	DISTRICT	CORPORATION/MUNICIPALITY
58 B8 SW	ERNAKULAM	KOCHI (part)

CRZ of Kochi Corporation is given in toposheet No. 58 C1 NE, 58 C5 NW and 58 B8 SW

Legend

- Road
- Railway line
- Seawall
- Municipal/ Corporation Boundary
- Village Boundary
- High Tide Line
- Low Tide Line
- CRZ Line for River or Backwater
- 100m CRZ Line
- 200m CRZ Line
- 500m CRZ Line
- Mangroves - CRZ IA
- Mangrove Buffer Zone - CRZ I
- Inter Tidal Zone - CRZ IB
- CRZ II [Being in Corporation,the developed area (>50% builtup area) in the CRZ is CRZ II]
- CRZ III
- Waterbody (sea) - CRZ IV A
- Waterbody (backwater) - CRZ IV B
- Waterbody (non-tidal)
- 4 Survey Plots

Coastal Zone Management Plan
Kochi Corporation, Ernakulam District
Kerala

Mapped During	Scale
May 2012	0 250 500 1,000 Meters 1:25,000
Checked by	Approved by
DRAFT MAP	
Refer CRZ report for details	

National Centre for Earth Science Studies
Akkulam, Thuruvikkal P.O
Thiruvanathapuram - 11

76°10'0"E

76°12'30"E

9°5'30"N

9°3'0"N

VYPIN

Vembanad Backwater

KOCHI CORPORATION

FORT KOCHI

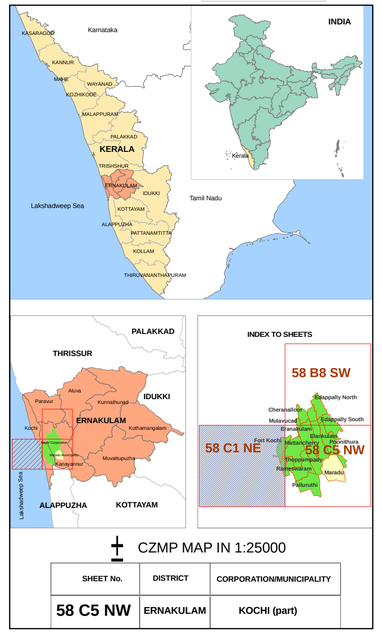
MATTANCHERRY

Lakshadweep Sea

Continued to sheet no. 58 C5 NW

Index Map

58 C1 NE



± CZMP MAP IN 1:25000

SHEET No.	DISTRICT	CORPORATION/MUNICIPALITY
58 C5 NW	ERNAKULAM	KOCHI (part)

CRZ of Kochi Corporation is given in toposheet No. 58 C1 NE, 58 C5 NW and 58 B8 SW

Legend

- Road
- Railway line
- Seawall
- Municipal/ Corporation Boundary
- Village Boundary
- High Tide Line
- Low Tide Line
- CRZ Line for River or Backwater
- 100m CRZ Line
- 200m CRZ Line
- 500m CRZ Line
- Mangroves - CRZ IA
- Mangrove Buffer Zone - CRZ I
- Inter Tidal Zone - CRZ IB
- CRZ II [Being in Corporation,the developed area (>50% builtup area) in the CRZ is CRZ II]
- CRZ III
- Waterbody (sea) - CRZ IV A
- Waterbody (backwater) - CRZ IV B
- Waterbody (non-tidal)
- 202 Survey Plots

Coastal Zone Management Plan
Kochi Corporation, Ernakulam District, Kerala

Mapped During	Scale
May 2012	0 250 500 1,000 Meters 1:25,000
Checked by	Approved by

DRAFT MAP

Refer CRZ report for details

National Centre for Earth Science Studies
Akkulam, Thuruvikkal P.O
Thiruvanathapuram - 11

Continued to sheet no. 58 B8 SW

Continued to sheet no. 58 C1 NE

76°17'30"E

76°20'0"E

9°57'30"N

9°55'0"N

KOCHI CORPORATION

EDAPPALLY SOUTH

ERNAKULAM

Vembanad Backwater

MATTANCHERRY

POONITHURA

ELANKULAM

THOPPUMPADY

WILLINGDON ISLAND

MARADU MUNICIPALITY

MARADU

RAMESWARAM

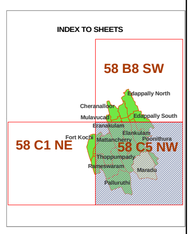
PALLURUTHY

Lakshadweep sea

Vembanad Backwater

Index Map

58 C5 NW



± CZMP MAP IN 1:25000

SHEET No.	DISTRICT	CORPORATION/MUNICIPALITY
58 C5 NW	ERNAKULAM	KOCHI (part), Maradu

CRZ of Kochi Corporation is given in toposheet No. 58 C1 NE, 58 C5 NW and 58 B8 SW

Legend

- Road
- Railway line
- Seawall
- Municipal/ Corporation Boundary
- Village Boundary
- High Tide Line
- Low Tide Line
- CRZ Line for River or Backwater
- 100m CRZ Line
- 200m CRZ Line
- 500m CRZ Line
- Mangroves - CRZ IA
- Mangrove Buffer Zone - CRZ I
- Inter Tidal Zone - CRZ IB
- CRZ II [Being in Corporation,the developed area (>50% builtup area) in the CRZ is CRZ II]
- CRZ III
- Waterbody (sea) - CRZ IV A
- Waterbody (backwater) - CRZ IV B
- Waterbody (non-tidal)
- 13 Survey Plots

Coastal Zone Management Plan
Kochi Corporation, Ernakulam District, Kerala

Mapped During	Scale
March - May 2012	0 250 500 1,000 Meters 1:25,000
Checked by	Approved by

DRAFT MAP

Refer CRZ report for details

National Centre for Earth Science Studies
Akkulam, Thuruvikkal P.O
Thiruvanathapuram - 11