DRAFT REPORT ON

COASTAL ZONE MANAGEMENT PLAN (CZMP) FOR ERNAKULAM DISTRICT – KERALA

(Prepared as per CRZ Notification 2019)

Prepared for

Department of Environment

Government of Kerala

NATIONAL CENTRE FOR EARTH SCIENCE STUDIES

Ministry of Earth Sciences, Government of India

Thiruvananthapuram - 695 011, Kerala

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1. INTRODUCTION

Coastal zone is the transitional zone, where land meets the sea and is influenced by both terrestrial and marine components. Intense interaction characterizes the coastal zone which varies from open sea to semi closed (creeks, lagoons) coastal waters and they exhibit a substantial diversity in environmental and demographic features. Here, land and ocean-dominated global processes converge and interact, characterized by multiple biogeochemical environmental gradients. The balance of these relationships provides a distinct domain of gradient-dependent ecosystems, climate, geomorphology, human habitation and most crucially regimes of highly dynamic physical, chemical and biological processes. Terrestrial processes are primarily governed by hydrological regimes and horizontal flows which provide mechanisms for energy gradients and transfer of materials (nutrients, contaminants, sediments), offering a range of conditions for material transformations and biological sustenance. Oceanic processes are similarly dominated by hydrological and physical factors that regulate the transit of materials and energy regimes, often in contrast with the land-dominated factors. The resultant equilibrium of terrestrial and oceanic processes yields regional and local heterogeneity in physical and ecological structure and supports the dynamics of ecosystem function and biogeochemical cycling in the coastal domain. Thus, mass and energy are constantly exchanging and as a result of these interactions created a unique ecosystem (Shailesh Nayak, 2017).

Coastal zones throughout the world have historically been among the most heavily exploited areas because of their rich resources. Coastal regions provide fish, shellfish, seaweeds and host ports for trading and commerce. In addition, several biota are sources of fertilizer, drugs, cosmetics and household products. Moreover, coastal wetlands also store and cycle nutrients, filter pollutants and help in the protection of the shoreline against erosion and storms. Thus, the richness and diversity of resources found in coastal regions have led to a corresponding concentration of human activities,

and settlement along coasts and estuaries throughout the world. In coastal countries today an estimated half of the total populations live in coastal zones and migration from inland areas to the coast is increasing. Not surprisingly, there is also a sharp conflict between the need for immediate consumption or use of coastal resources and the need to ensure the long-term supply of those resources. In many countries this conflict has already reached a critical stage, with large parts of the coastal zone polluted from local or upland sources, fisheries severely degraded or destroyed, wetlands drained, coral reefs dynamited and beaches long since ruined for human enjoyment. If these coastal resources are to be maintained and restored, effective action is urgently needed. It is also obvious that the coastal zone will be expected to sustain the livelihoods of a very large proportion of the human population and will remain an important asset to people worldwide for the foreseeable future. The sustainability of the coastal environment is continuously impacted by pollution, eutrophication, industrialization, urban development, land reclamation, agricultural production, overfishing and exploitation. Moreover, the poor understanding of the dynamics of land-ocean interactions, coastal processes and the impact of poorly planned and managed human interventions makes the sustainability of human economic and social progress vulnerable to natural and human-induced hazards. Humans are increasingly influencing these regions, which resulting in measurable changes directly within the coastal domain and through feedback, indirectly within the terrestrial, oceanic and atmospheric compartments of the Earth system (Steffen et al., 2004). So, the major challenge that humans face today is how to manage the use of this area so that future generations can also enjoy its visual, cultural and societal resources. We need to ensure robust health of coastal ecosystems through sustainable management, so that they continue to provide various goods and services for future generations, as well.

According to a recent evaluation of the impacts of marine pollution from land-based sources, the degradation of the marine ecosystem is still occurring and, in many places has intensified (GESAMP, 2001). Hence, policies and legislations to reduce conflicts over uses in the coastal zone, protect coastal resources and support livelihood activities of local communities as well as to address the development requirements of the coast to meet economic and societal requirements are essential. Integrating environmental, economic and human activities to ensure pollution-free coastal waters and healthy ecosystems to sustain livelihood and coastal economy necessitates effective integration of science and public policy is very much needed. Due to various development schemes of private

and public, legal and illegal, large-scale modifications and damages to coastal morphology and ecosystems by way of reclamation of tidal flats, destruction of mangroves, leveling of sand dunes, mining of beach sand, construction activities for settlement, establishment of industries, dumping of waste and discharge of pollutants. Rapidly changing landuse due to the immense pressure for development in the coastal zone has adversely affected the coastal ecosystems, coastal morphology and livelihood resources of the coastal areas.

Coastal zone management depends on the information available on various aspects of coastal habitats, coastal processes, natural hazards and their impacts, water quality and living resources. The effective management techniques depend on such information and suitable response by concerned government agencies. Keeping these facts in view, Government of India on the recommendation of Ministry of Environment and forest (MoEF) passed a legislation called Coastal Regulation Zone (CRZ) in the year 1991. Under this legislative act, one of the most cost-effective long - term solutions to control various ecologically destructive activities in the endangered coastal zone, is to invoke spatial buffers around coastal ecosystems. The Coastal Regulation Zone (CRZ) Notifications (MoEF, 2019; 2011; 1991) provides buffer zones in the coastal area is being considered as the pragmatic tool to control, minimize and protect environmental damages to sensitive coastal stretches from unplanned human interference. Management of coastal ecosystems through CRZ requires identification and mapping of the regulation lines and the spatial extent of the ecosystems and morphologies in appropriate scales. Implementation and enforcement of the provisions of CRZ on the ground require extensive coastal mapping and continuous monitoring.

The National Centre for Earth Science Studies (NCESS), Thiruvananthapuram is an agency authorized by Government of India to prepare/update CZMP for the coastal stretches of our Country (OM F. No. J-17011/8/92-IA-III dated 08-08-2019). So, the Government of Kerala entrusted National Centre for Earth Science Studies (NCESS), Thiruvananthapuram for the preparation of Coastal Zone Management Plan (CZMP) for the State of Kerala following the guidelines in CRZ Notification 2019, vide G.O. (Rt) No. 80/2019/ENVT dated 28.08.2019. High Tide Line (HTL), Low Tide Line (LTL), Ecologically Sensitive Areas (ESAs) and Critically Vulnerable Coastal Areas (CVCAs) demarcated by the National Centre for Sustainable Coastal Management (NCSCM), Chennai, and the 'Hazard line' as demarcated by the Survey of India (SoI) have been made use for the preparation of CZMP.

1.1 CZMP Planning Process

The landmark Coastal Regulation Zone (CRZ) Notification, which was first issued on 19th February 1991, has been the most important legislative instrument in the country for coastal governance by considering the livelihood of fisherman and local people residing along the coast. The Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India has issued a revised CRZ Notification on 6th January 2011under Section 3(1) and Section 3(2)(v) of the Environment (Protection) Act, 1986 and Rule5(3)(d) of Environment (Protection) Rules, 1986 in supersession of CRZ 1991 except as respect to things done or omitted to be done before such supersession. Subsequently, in June 2014, the MoEFCC constituted a committee under the chairpersonship of Dr. Shailesh Nayak, the erstwhile Secretary of the Ministry of Earth Sciences, to address the concerns raised by the state governments, eliminating ambiguities and simplifying certain provisions in CRZ Notification 2011. The committee held consultations with the state governments over the following six months and submitted its report to MoEFCC in January 2015. Ultimately, on 18thJanuary 2019, in supersession of the CRZ Notification of 2011, the Government of India brought out the CRZ Notification 2019.

The CRZ is a critical regulation for conservation and livelihood protection on the coast. All developmental activities in the CRZ are regulated through the CRZ Notification. Accordingly, the CRZ has been declared as 'the coastal stretches of the country and the water area up to its territorial water limit'. The Coastal Regulation Zone Notification (MoEF&CC, 2019;2011; 1991) which provides buffer zones in the coastal area is being used as the best tool to control, minimize and protect environmental damages to sensitive coastal stretches from unplanned human interference. Thus, the CRZ Notification promote development in a sustainable manner based on scientific principles considering the dangers of natural hazards in the coastal areas and sea level rise due to global warming.

1.2 Development of a coastal database and information system

In the recent times, the availability of digital spatial data for the world coasts has vastly increased as a result of advancements in data capture and input techniques. The large increase in global data availability has had a significant impact on coastal science. The way in which coastal observations are stored and integrated largely determines the degree to which spatial processes can be understood. Therefore, well-organized and designed data systems are needed to underpin our understanding of the processes taking place over large parts of coasts. The expected accelerated rise in global mean sea levels may cause several physical changes to the world's coasts and hence can endanger coastal populations and infrastructure, as well as threaten many coastal ecosystems. The sensitivity of the coastal zone to sea-level rise, in conjunction with its importance in terms of social, economic and ecological value, highlights the need for consistent national- to global-scale assessments of potential impacts along the coasts. However, the scope of these studies has been limited by the available data in terms of resolution, coverage, parameter availability, and dated sources: this is a generic problem for broad-scale coastal analysis. In addition to these limitations, data quality and integration constitute further problems; even in those cases where data and tools are available to coastal scientists for the analysis and modeling of coastal processes, these usually exist in fragmented forms. This fact compromises the consistency, reliability and versatility of evaluations based on such sources. It has long been recognized that appropriate and reliable information within organized, planned and coherent coastal databases is an essential prerequisite for coastal zone management.

In order to address the preceding issues and provide a consistent source of data for the Indian coast, the data collated digitally onto a GIS platform for the preparation of the CZMP come handy. This database contains physical, ecological and vulnerability parameters and covers the Indian coasts uniformly, probably for the first time on a digital platform permitting retrieval, portability and sharing in a seamless manner. For this reason, the database has been specifically designed to address the data requirements of the project and the needs of researchers in the area of vulnerability assessment of coastal zones. It is also expected to be used for wider assessment of regional and global coastal issues.

1.3 Generation of CZMP maps

Management of coastal ecosystems through CRZ requires identification and mapping of the regulation lines and the spatial extent of the ecosystems and morphologies in appropriate scales. Implementation and enforcement of the provisions of CRZ on the ground require extensive coastal mapping and continuous monitoring. As per the CRZ Notification 2019 issued vide Notification No.G.S.R.37(E), dated the 18th January, 2019, all coastal States and Union territory administrations shall revise or update their respective coastal zone management plan (CZMP) framed under CRZ Notification, 2011 number S.O. 19(E), dated 6th January, 2011, as per provisions of this notification and submit to the Ministry of Environment, Forest and Climate Change for approval at the earliest and all the project activities attracting the provisions of this notification shall be required to be appraised as per the updated CZMP under this notification and until and unless the CZMPs is so revised or updated, provisions of this notification shall not apply and the CZMP as per provisions of CRZ Notification, 2011 shall continue to be followed for appraisal and CRZ clearance to such projects. The Notification also directs the State to prepare or update the CZMP by engaging reputed and experienced scientific institution(s) or the agencies and in consultation with the concerned stakeholders. Consequently, the Government of Kerala entrusted National Centre for Earth Science Studies (NCESS), Ministry of Earth Sciences, Thiruvananthapuram for the preparation of Coastal Zone Management Plan for the State of Kerala following the guidelines in CRZ Notification, 2019.

Accordingly, preparation of the draft CZMP in 1:25,000 scale map identifying and classifying the CRZ areas within the respective territories in accordance with the guidelines given in Annexure-IV to the CRZ Notification 2019 has been taken up by NCESS, which involve public consultation. The subsequent guidelines issued by the MoEF&CC based on Office Memorandum 12-1/2019-1A III dated 26-06-2020 is to facilitate the State Government in updation of the CZMPs. As per the new guidelines, The CZMP database (shapefiles etc.) prepared as per the CRZ Notification, 2011 which have been scrutinized by the Technical Scrutiny Committee, finalized by the National Centre for Sustainable Coastal Management (NCSCM) and approved by the MoEFCC, shall be used as the base for revision or updation of the CZMP, as per the provisions contained in the CRZ Notification, 2019. The guidelines brought out clarity in the case of the Data to be provided,

by the States/UTs to the authorized agencies, CRZ buffers, Processing of Census data, CRZ Classifications, Public consultation of draft CZMP updated or revised based on CRZ Notification 2019, format for CZMP report, approval process of CZMP etc.

2. THE STATE OF KERALA

Kerala, the Gods own Country lies in the southwest corner of Peninsular India and positioned between 8°17'30"N and 12°47'40"N latitudes and 74°27'47"E and 77°37'12"E longitudes. It is bound by the Western Ghats Mountain ranges to the east and the Arabian Sea to the west. The Ghats run parallel to the west coast at a distance ranging from 40-80 km. Kerala is spread over a total area of 38,863 sq.km, having significant stretches of water bodies. Altitudes ranges from below sea level (the Kuttanad area) to 2,695 m and the terrain falls into three well marked divisions: (a) the high ranges of the Western Ghats in the east with undulating hilly tracts, marked by long spurs, extensive ravines and dense forest, (b) the midland occupies with plantations and cultivated plains intersected by numerous rivers and streams, and (c) the coastal belt with dense settlements, coconut plantations and rice fields (Soman, 2002). The total population of Kerala is 33,406,061 (as per 2011 census) with a density of 859 per sq km. The density of coastal urban population is 4,228 per sq. km., as compared to the average urban density of 2,097 in the state. The coastal rural population density is 1700, far above the state average rural population density of 603 (Geevan, 1996). The coastline length of Kerala is about 590 km. Kerala, despite its small land area with long coastline studded with world's best string of beaches. It is bestowed with a vast network of backwaters, lagoons, natural lakes, rivers and canals.

The wetlands of the state are categorized into two primary groups namely inland and coastal wetlands. The total area calculated as wetlands was 127930.07 ha, of which the inland wetlands cover approximately 34199.57 ha and the coastal wetlands estimated 93730.50 ha (MoEF, 1990). According to recent estimates by different agencies on wetland categories such as water spread area, aquatic vegetation and turbidity, it is around 1762 wetlands in the state. Moreover, 2592 wetlands smaller than 2.25 ha had been also identified. As a result, the total wetland area estimated was 160590 ha (Anon, 2010). CED, 2003 had suggested the major wetland classification system for Kerala based on different parameters like location, physical extend, depth, salinity, biodiversity etc

(Kokkal, 2008).

Kerala is rich with 44 rivers (41 west flowing and 3 east flowing) cut across Kerala with their numerous tributaries. The rivers either debouch into the Arabian Sea through inlets directly or drained to the sea through estuaries/lagoons (backwater). There are 48 inlets along the Kerala coast out of which 20 are permanent, whereas the remaining 28 are seasonal (remain open only during the monsoon period of June – September). The seasonal inlets mostly remain closed during the fair season due to the development of spit along the inlets due to deposition from longshore sediment transport. Seasonal inlets are normally cut open during monsoon for discharging storm- water accumulated from rainfall reducing the coastal inland from flooding risk. Reduction in the supply of riverine sediments might have affected the stability of the south-west coast in recent years.

The backwaters as a part of wetlands which running parallel to the coastline is a characteristic feature of the Kerala coast. It can be described as a body of brackish, marine or hypersaline water impounded by a sandy barrier and having an inlet connecting it with the open sea. Backwaters form an attractive and economically valuable and ecologically significant feature of Kerala. During monsoon, the backwaters overflow into the sea, discharging sizeable quantities of sediments, whereas in summer sea water flows into the backwater over considerable distances. The Kerala Public Works Department (Water Resources of Kerala, 1974) has identified 27 backwaters and 7 lagoons in Kerala. Kerala State has fourteen districts of which 9 districts has seacoast on its west.

There are 14 District, 152 Block Panchayats, 941 Grama Panchayats, 87 Municipalities and 6 Municipal Corporations. Apart from this, Kerala has one Cantonment (Kannur). The fourteen districts in the state are distribute over 75 Taluks consisting of a total of 1535 Villages (1664 is including the Group Villages). It is interesting to note that 9 districts (Kasaragod, Kannur, Kozhikode, Malappuram, Thrissur, Ernakulam, Alappuzha, Kollam and Thiruvananthapuram) out of the 14 have Lakshadweep Sea as their western boundaries and therefore come under the purview of CRZ covering considerable parts of coastline. Apart from the 9 districts, some parts of Kottayam district are also under the purview of CRZ since its western boundary is along the banks of tidal influenced Vembanad Lake.

2.1 Ernakulam District

Ernakulam district is situated almost at the middle of Kerala State and on the coast of the Lakshadweep Sea. It has the credit of being the economic nerve centre of the State. It is the most industrially advanced and flourishing district of Kerala compared to the other districts. The district headquarters is at Kochi, which endowed with one of the finest natural harbours in the world. Kochi is the commercial capital and the most cosmopolitan city of Kerala. The harbour is the nucleus around which Kochi and surrounding regions have grown and has become the "Queen of the Arabian Sea". The modern period in the history of Cochin begins with accession to throne in 1790 of Ramavarma, the Sakthan Thampuran, and the treaty concluded by him with the English East India Company. Cochin port is believed to have been formed only by 1341 AD when the ancient harbour of Muziris (also known as Cranganore and Kodungallur) was silted up due to heavy floods in Periyar and became unsuitable for maritime trade. The integration of Travancore and Cochin took place on the 1st of July 1949. The Maharaja of Travancore became the Rajapramukh of the new state and Paravur T.K. Narayana Pillai its first Chief Minister. The regions falling in the present Ernakulam district mostly belonged to Thrissur and Kottayam districts of Travancore-Cochin state. The present district of Ernakulam was formed in 1958 by carving the regions from Thrissur and Kottayam area. The district is bounded by Lakshadweep Sea on the West, Kottayam and Alappuzha districts on the South, Idukki on the East and Thrissur on the North. The district has a seacoast of about 46 kms long and also has the presence of vast stretch of lakes and backwaters. Ernakulam district lies between latitudes 09°47'30"N and 10°18'15"N and longitudes 76°10'05"E and 76°55'05"E. Total area of Ernakulam District is 3068 km2. In terms of area, Ernakulam ranks 4th among the districts in the State. The location map of Ernakulam district is given in Figure 2.

2.1(a) Administration

There are two systems of administrative set up in the State – Revenue and local self-government. Under the revenue system the district is divided into Revenue Division, Taluks and Villages. However, for local administration, the district is divided into Urban local bodies (Municipal Corporation and Municipal Councils) and rural local bodies comes under the hierarchy of District Panchayat consisting of Block Panchayats defined with geographically contiguous cluster of a few Grama Panchayats. For the implementation of development activities, Panchayats are grouped under

Community Development Blocks. Therefore, all these units viz., Taluks, Villages, urban and rural local bodies have their own relevance and importance.

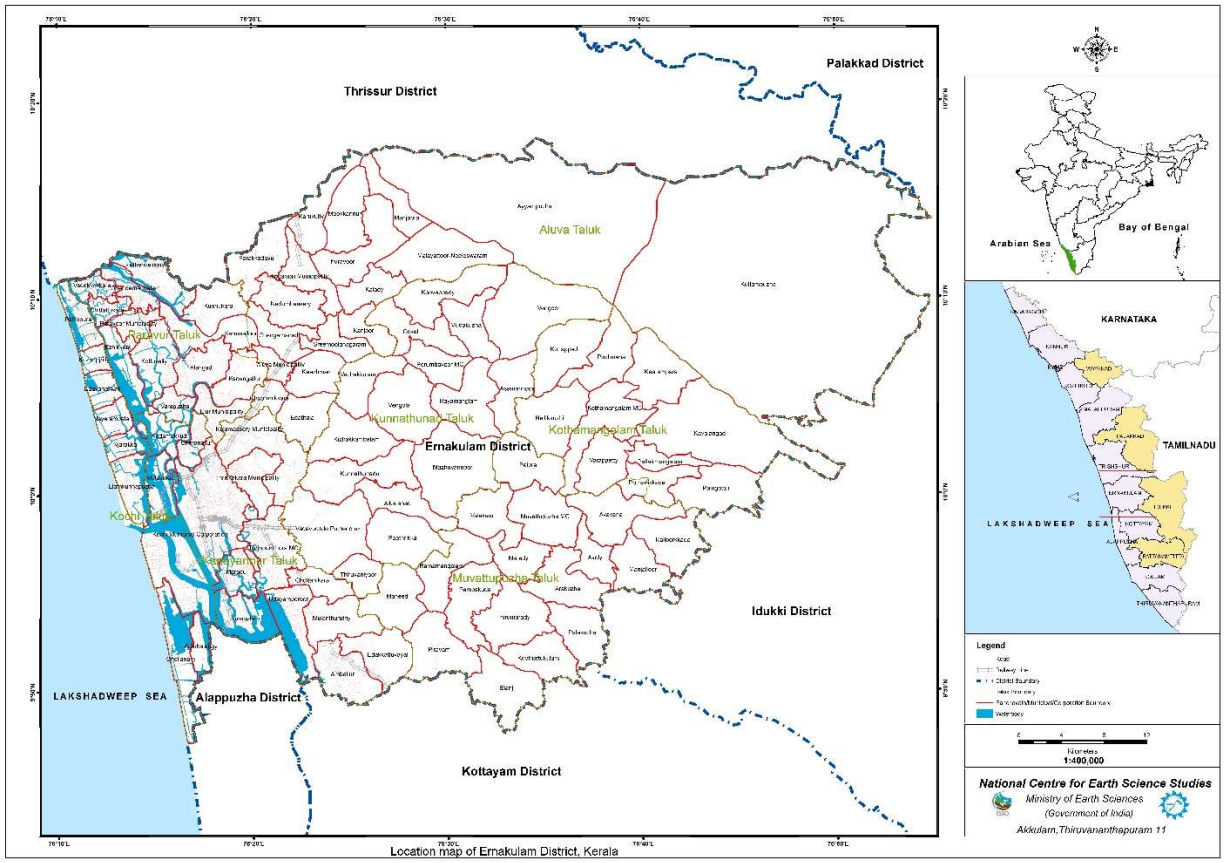

Figure 1: Location map of Ernakulam District

The Ernakulam district is constituted of territories, which formed part of the erstwhile Princely States of Cochin and Travancore and Malabar district of then Madras Presidency. The history of Ernakulam district synchronized with the history of Cochin State. The Ernakulam district comprises of two revenue divisions (Muvattupuzha and Fort Kochi) consisting of 7 taluks (Aluva, Muvattupuzha, Kothamangalam, Kunnathunad, Paravur, Kochi and Kanayannur) and 121 villages. There are 18 Villages under Aluva taluk, 21 under Kanayannur taluk, 18 under Muvattupuzha taluk, 13 under Kothamangalam taluk, 23 under Kunnathunad taluk, 13 under Paravur taluk and 15 under Kochi taluk. There are 14 Development Blocks (Angamaly, Alangad, Edapally, Koovappady, Kothamangalam, Mulanthuruthy, Muvattupuzha, Palluruthy, Pampakuda, Parakkadavu, Paravur, Vadavucode, Vazhakulam and Vypin) and 97 Panchayats. Apart from this, the urban local bodies are the 1 Municipal Corporation (Kochi) and 13 Municipal Councils (Thrikkakara, Kalamassery,

Eloor, Koothattukulam, Piravom, Muvattupuzha, Perumbavoor, North Paravoor, Maradu, Kothamangalam, Aluva, Thrippunithura and Angamaly). The area encompassing the Kochi city and surroundings forms the headquarters of the district.

2.1(b) Physiography

As a continuum of the State, the district too can be divided into three distinct physiographical units such as the coastal plains, the midlands and the eastern highland regions. The coastal plains form the low land areas adjacent to the Lakshadweep Sea.

The Ernakulam district falls in the Central Kerala Coast. Each micro region is further divided into sub-micro regions on the basis of topography, geology, soils, climate and natural vegetation. Thus, Ernakulam district consists of such sub-micro-morphological regions viz., (i) Cochin coast, (ii) Periyar-Muvattupuzha Rolling Plain, (iii) Malayattur Forested hills and (iv) mountainous region.

(i) Cochin Coast is bounded by Thrissur coast in the north, Periyar-Muvattupuzha Rolling Plain in the east, Alappuzha Coast in the south and the Lakshadweep Sea in the west. It is a flat alluvial tract lying all along the coast of this district. The Periyar River and various interlinked backwaters and canals affect the fluvio-estuary deposits in this tract. The maximum height (35 m) is located at Puthenvelikkara village of Paravur taluk. In the southern portions of this region, the influence of seawater is conspicuous. Some areas of this tract also have flood plains. Cochin, the Queen of the Arabian Sea, and Paravur are located in this region.

(ii) Periyar-Muvattupuzha makes its boundaries with Thrissur Plain in the north, Malayattur Forested Hills, Anamalai Forested Hills and Periyar River Basin in the east, Kottayam Rolling Plain in the south and Cochin coast in the west. This region is drained by two major rivers viz., the Periyar and the Muvattupuzha. The south-east portion of this rolling plain has isolated hills with a maximum height of 307m at Pirakunnamkara region of Kuttamangalam village under Kothamangalam taluk. The minimum height is 33 m recorded over the western border at the Thrikkakara. A number of isolated residual hills, between Perumthuruthy and Kuruvil area, are found in the middle and south-eastern portion of this region. Angamali, Alwaye, Perumbavoor, Kothamangalam, Muvattupuzha and Trippunithura towns are located in this region.

(iii) Malayattur Forested Hills falls in a small area in the north-east portion of this district, makes its boundaries with Kodessery Forested Hills in the north, Anamalai Forested Hills in the east and Periyar – Muvattupuzha Rolling Plain in the south and the west. This region is an elevated area with an average height of 600 m. It has dense forests. Steep slopes occur in the western portion of this region. It has foothills of the Western Ghats. The region also falls in the catchment area of the Periyar river. The maximum height is 631m found in the Malayattur reserve forest.

(iv) Mountainous region is the hilly tract along the eastern portions of Aluva, Kunnathunad and Kothamangalam taluks border the Western Ghats. There are a few outlaying small hills in Aluva taluk, some of which are more than 800 feet in height above mean sea-level. There are some hilly areas in Paravur and Kothamangalam taluks also. The terrain of Mulamthuruthy, Amballur, Edakkattuvayal, Kaippattur, Keecherry, Thrikkakara south and Thrikkakara north villages of Kanayannur taluk and the southeastern border of Paravur taluk are hilly with the height ranging between 100 feet to 300 feet above mean sea level.

2.1(c) Rivers and drainage characteristics

The important rivers in the Ernakulam District are the Periyar and the Muvattupuzha of which the former flows through Kothamangalam, Aluva, Kunnathunad and Paravur taluks. The river Thodupuzha, the Kaliyar and the Kothamangalam merge together to form the Muvattupuzha River. The Chalakudy River which flows through the north of Aluva merges with the Periyar at Elamthikara. Chalakudy River is formed by the confluence of five streams, the Parambikulam, the Kuriarkutty, the Sholayar, the Karappara and the Anakkayam, all of them originating from the Anamalai Hills of the Western Ghats. The length of the river is 130km and the total drainage area is 1704sq.km out of which 1404 sq.km lies in Kerala State and the rest 300sq.km in Tamilnadu. The river Thodupuzha, the Kaliyar and the Kothamangalam merge together to form the Muvattupuzha River. During rainy seasons, these rivers are in full spate and low-lying areas on the banks are affected by heavy floods, but in the summer season they generally go dry.

Periyar is the longest river in Kerala with a total length of 244 km and its river basin is the second largest river basin of Kerala and drains parts of Idukki and Ernakulam districts of the state. The river has a total drainage area of 5398 sq. km, out of which 5284 sq.km. lies within the State

and the rest in Tamilnadu. The river is formed by several streams, having their origin in the Sivagiri Group of Hills at an elevation of about +1830m above M.S.L. Major tributaries of the river are Mullayar, Cheruthoni Ar, Muthirapuzha, Perinjankutty Ar and Idamalayar, and most of the upstream tributaries flow through deep gorges and steep valleys. The general drainage pattern of the basin is dendritic in nature. The Periyar is known as the lifeline of Kerala; it is one of the few perennial rivers in the region and provides drinking water for several major towns. The Idukki Dam on the Periyar generates a significant proportion of Kerala's electrical power. It flows north through Periyar National Park into Periyar Lake, a 55 km² artificial reservoir created in 1895 by the construction of a dam across the river. The mainstream of the river bifurcates at Alwaye and both the branches debouch into the Arabian Sea through two different estuaries. The north-trending branch joins the Chalakudy River and joins the Arabian Sea at Munambam through the Kodungallur–Azhikode estuary, whereas the south-trending branch forms numerous rivulets and joins the Vembanad–Kol wetland system and later joins the Arabian Sea through Cochin estuary.

Muvattupuzha River is another important river in Ernakulam district of Kerala. The name is made up of three Malayalam words: 'Moonu', which stands for 'three', 'aaru' - small river, and 'puzha', which also means river. The three rivers in this case are the Kothamangalam river or Kothayaar, Kaliyar and Thodupuzhayaar, which merge to form a single river. Thus, it is called centre point of confluence of three rivers or Thriveni Sangamam in Malayalam. These rivers join together at Muvattupuzha and then flow towards south-west as a single river to the Vaikkom Lake. Finally, it merges with the Lakshadweep Sea. The mainstream length of the river is 121 km with a basin area of 1544 sq.km. During its course it passes through 45 villages of the Thodupuzha, Vaikom, Kunnathunad and Kanayannur Taluks. The famous Thommankuthu Waterfalls is situated in the river Muvattupuzha. It is situated on midland regions with planes and hills scattered all around especially on the Southern and Eastern side. Essentially, this region from Thodupuzha, Muvattupuzha, Kothamangalam were called "Keezhmalanad" of erstwhile Vadakkumkoor Kingdom indicating this as the midlands with Fertile soils deposited by the Thodupuzha River and Muvattupuzha River over a period of time due to floodings of the banks. The old Muvattupuzha bridge built over the Muvattupuzha River was the first concrete bridge in Asia. It was completed in 1914. This serves as the connection between Nehru Park and Kacherithazham. The town consists of two regions separated by the Muvattupuzha bridge.

2.1(d) Coastal Wetlands

Apart from the estuarine part of the rivers joining the Lakshadweep Sea, other important backwater in the district forms a substantial portion. The Backwaters in the forms of lagoons (Kayals), canals and distributary systems of the rivers occupy a considerable part of the coastal plain of Ernakulam district. The low land region has a network of canals and backwaters. Many streams and rivers empty themselves into these backwaters. Vembanad Kayal is the prominent back water body in the district, though location to location it is being known differently. Vembanad estuary, situated in Kerala is the largest tropical wetland ecosystem along the south-west coast of India spread of several districts, but having its large expanse in Ernakulam district. This tropical estuary, fed by ten rivers draining into the Arabian Sea, covers an area of 21,050 ha spread between latitudes 9.59^0 N and 10.61^0 N and longitudes 76.19^0 E and 76.43^0 E. The rich biodiversity of shellfish and other aquatic resources and their socio-economic importance made Vembanad estuary a wetland of international importance and is designated a "Ramsar site". A unique characteristic of the estuary is the Thaneermukkom saltwater barrier which divides the water body into two zones-one with freshwater fed by the rivers on the southern side and the other with brackish water fed both by rivers and Arabian Sea on the northern side. The physical spread of the Vembanad region extends to the low-lying areas surrounding the Vembanad Lake, which form the deltaic plains of Pullot, Periyar, Muvattupuzha, Achencoil, Pamba, Manimala and Meenachil Rivers originating from the Western Ghats. The region lies between 9^0 15' – 9^0 35' N latitude and 76^0 23' – 76^0 35' E longitude. It covers an area of 870 km^2 comprising of about 490 km^2 of paddy fields, 300 km^2 of garden lands. The remaining areas consist of water bodies like lagoons, canals, and rivers. Nearly 60% of the area excluding the lake lie 0.5m to 2m below sea level and this area spread across Kuttanad. The entire region is half submerged in water during the monsoon season from June to January every year. Bunds have been constructed to protect the low-lying areas from floods and tides. During high tide in dry season saltwater incursion is a dominant phenomenon noticed in the Vembanad ecosystem while freshwater inundation occurs during monsoon rains.

Kodungallur Kayal and Varapuzha Kayal are the other two backwaters which adjoining the Vembanad Lake. The Kodungallur Kayal is found at the north of Parur taluk and extends to the Thrissur district. The Varappuzha Kayal is located at the south of the Parur taluk and the Periyar river drains into it.

2.2. Demography and Socio-Economic Activities

Kerala has 33.38 million population as per the Census 2011. It is the 13th most populous State in India with an overall population density of 860 per square kilometer. The State of Kerala accounts for 2.8% of India's population but it contributes nearly 4% of the Indian economy. Kerala is occupied with three times more dense settlement than the rest of the country. The coastal regions are more populated than the mountains and eastern hills of the State with 2.5 times the overall population density. Kerala has a Human Development Index of 0.79, which is "very high" and the highest in India. Kerala also has the highest literacy rates among all Indian states at 98.9% and a life expectancy of 74 years which is among the highest in the country. Kerala has experienced a rapidly dropping rural poverty rate, which fell from 59% in the mid-1970s to 12% by 2010, while the overall poverty rate fell 47% between the 1970s and 2000s, compared to a drop of just 29% in total poverty in the country. As per 2011 census, Kerala is the most literate state in India having literacy rate of 93.91%.

While Kerala has what appears to be rapid growth by the standards of most areas, its 4.9% decadal population growth rate in 2011 was the lowest in India and less than one-third of the India average of 17.64%. Between 1951 and 1991, Kerala's population more than doubled from 15.6 million to 29.1 million, reaching 33.3 million by 2011. Kerala is currently heading for zero growth in its population, as the state has a meager fertility rate and a stabilizing death rate. In 2021, census figures predict Kerala might record negligible population growth, which will be a first in India. The population is advanced with literacy and educational attainment. The various sectors such as agriculture cash crop production, animal husbandry, aquaculture, fisheries, micro enterprises and large-scale industries, tourism etc. plays important role in the economy of Kerala. This state is unique in many respects among the states of India, one of which is its settlement pattern, characterized by a rural-urban continuum. Applying the "continuous method" to study spatial change in the occupational structure across rural, small towns and large urban units (comprising of cities/big/medium towns and agglomerations), it is interesting to note that economic diversification in general and manufacturing in particular, has been fairly rapid in rural areas.

The Ernakulam district ranks the 4th in the State in area and with 3,282,388 persons, Ernakulam district ranks the 3rd in population among districts. Ernakulam district has the 3rd rank in total, the 3rd rank in male and the 7th rank in female work participation rate among the districts.

Ernakulam was the first District in the Country having cent per cent literacy. Its present literacy rank is 3rd in the State. The district has the 12th position in sex-ratio (1027) and 8th position in sex ratio of 0-6 population (961). The district has the 3rd position in urban work participation rate (37.21%) in the State. The district holds the 14th rank in marginal work participation rate (15.04%) and in percentage of non-workers (61.94%). The district has the 1st position in the percentage of main workers (84.96%), literacy rate (95.89%) and urban density (2415). Ernakulam District may well be called the hub of industrialization in Kerala. India's first private Airport at Nedumbassery and the seat of High Court are in the district. Kodanad - one of the largest elephant training centre in South India and Thattekkadu Bird Sanctuary are located in the district. It is one of the Coastal districts of Kerala. Indian Naval Base is located in the district. It is the only district in the State with a Jewish Synagogue. Fort Kochi in Ernakulam District is the oldest settlement area of Jews. The district is famous for Chinese fishing net – Huge cantilevered fishing net. Wonderla, an amusement park for children, is located in the district. The only urban agglomeration i.e., Kochi UA with more than a million population is located in the district.

2.3. Coastal Geomorphology and Ecosystem

The shoreline of Kerala is generally straight, trending NNW-SSE, with minor variations. The various coastal geomorphological units are beaches, beach cliffs, stacks, islands, shore platforms, spits, bars, beach ridges, estuaries, lagoons and tidal flats. The beaches are mostly sandy and dynamic in nature. Throughout the coast exists narrow stretch of beach except in cliff areas. In areas like Kovalam, Vizhinjam, Varkala, Ezhimala, Bekal etc. the headland is directly abetting the sea where the wave break occurs along the foot of lateritic cliff. The height of the cliff may be of 20 m or more. In some coast having cliffs, there are numerous stacks protruding into the sea in nearshore as well as in offshore regions. These stacks are the vestiges left behind after an island or head land portion which has been eroded out or still receding. Around Mahe and Thalassery, these stacks are found aligned nearly parallel to the coast. In lateritic coast offshore islands are observed in certain locations. The Green Island located in the offshore of Thalassery coast is a similar type of island and have continuity with the mainland with a string of stacks. The constant wave attack on the neck portion resulted discontinuity of the stacks and becomes an island. The coastal wetlands, backwaters and estuaries along the coast of Kerala are rich, biologically and ecologically diverse as well as economically significant ecosystems which plays important role in livelihood of people. The major

backwaters in Kerala are Vembanad, Ashtamudi, Kayamkulam, Akkulam, Kadinamkulam, Anchuthengu, Edava, Nadayara, Paravur, Vattakayal, Chettuva, and Valiyaparamba.

Based on physiography, the Ernakulam district can be divided into three distinct geomorphologic units viz., (i) the coastal plains and lowlands in the western part, (ii) the central undulatory terrain comprising the midland region and (iii) eastern highland region. The low land lies between the backwater and sea, while the midland occupies the area in between the low land and the highland. The lowland region falls in Parur and Cochin taluks and western portion of Kanayannur taluk. Coastal plain forms a narrow belt of palaeo-coastal/alluvial depositional landforms running parallel to the coast with a maximum width of about 20 km. The area mainly covered by the low land coastal plain and part of lateritic mid land. It is observed that in most of the places the soil formation is clayey sand to sandy clay. In some places the aquifer is laterite overlain on weathered crystalline basement. Riverine alluvium, sandy soil, clayey soil and fine sand were also found in other locations. The coastal plain is a low-lying area, with a maximum elevation of around 10m, characterized by backwater bodies, marshy lands, sandy flats and alluvial plains, which are liable for flooding during the monsoon. The coastal landforms are conspicuous in the coastal plain region, consists of sand and alluvium. Other major geomorphological features identified from the area are barrier islands, beach ridges, mudflats and tidal flats, flood plains and mangrove swamps.

The midland region has a rolling topography with low hills and narrow valleys. The midland region which constitutes the central belt covers the major portion of Aluva, Kunnathunnad, Kothamangalam and Muvattupuzha taluks and eastern region of Kanayannur taluk. The hills are generally covered with laterite or laterite soils and the valleys are alluvial. Hilly tract is along the eastern portion of Aluva, Kunnathunnad and Kothamangalam taluks which borders the Western Ghats. The region has very gentle to moderate slope from east to west. The eastern most part is a rugged terrain with steep sloped hills and small summits. It actually forms the foothills of the Western Ghats. Elevation of this terrain is generally more than 300m above MSL. There are few outlying small hills in Aluva taluk, some of which are above 800 feet high above MSL. There are some hilly areas in Parur and Kanayannur taluk also. The terrain of Mulanthuruthy, Amballur, Edakkattuvayal, Kaipattur, Keecheri, Trikkakkara South and Trikkakkara North villages of Kanayannur taluk and southeastern border of Parur taluk are hilly, the highest ranging between 100 to 300 feet above MSL. In the eastern portion, the hill near Mullaringad is 1100 feet high. Near

Kondimarton and 8 KM south-west of it, hills of 897 feet and 1008 feet high respectively are noticed. In the northern portion, Kurisumudi (1274 feet), Kattanna (1502 feet) and Karathulimudi hills are seen. As the area is covered by forest soil, thick forest and cultivation of cash crops like rubber and pepper can be seen in the area. The district has less than 90 sq. km. of area under forests, which accounts for 3.53 percent of the total area of the district. The forest of this district falls under Chalakudy, Malayattur and Munnar divisions.

2.4. Marine Fishery Resources

Fisheries sector is recognized as one of the important sectors contributing significantly to the nation's economy. It is not only recognized as a powerful income and employment generator as it stimulates growth of a number of subsidiary industries, but also is a source of cheap and nutritious food earning foreign exchange too. It provides livelihood to approximately 14.49 million people in our country. Kerala is one of the prominent maritime States in India and is blessed with most productive portion of Arabian Sea with a continental shelf area of 39,139 Sq km. Many commercially important finfishes and crustaceans form the high value fish species. The projected value of total fish production from Kerala comes to 706.882 MT by 2019-20. Over exploitation is one of the major threats in marine fishery resources. If the rich underexploited demersal and pelagic resources are utilized effectively, Kerala can brag the top position in total fish production and contribute fruitfully towards the economic development of the State. According to the available estimates of potential fishery resources of the West Coast, particularly in the south-west coasts, Kerala possesses the richest fishing grounds in the region. Marine fish landings for 2014-15 in Kerala was estimated at 524468 MT and that for 2013-14 was 522308 MT. Contribution of various fish resources include, pelagic fin fishes 361956 69 MT, demersal fin fishes 49416 9 MT, crustaceans 65955 12 MT, molluscs 34057 6 MT and miscellaneous 13084 MT.

Kerala holds the second position in terms of fisherfolk population, among the nine maritime states in our country. A great deal of Kerala's economy depends on fishing for subsistence, livelihood and employment. Fish consumption in Kerala is four times the national average and the production share of Kerala is the second largest in the country with 16.6% of India's total marine exports. The total populace of fisherfolk residing in the state of Kerala is estimated to be 11.11 lakh, which includes 8.55 lakh in the marine sector and 2.55 lakh in the inland sector (GOK, 2015). Out

of this, the number of active fishermen is 2.28 lakh (1.90 lakh in marine sector and 0.42 in the inland sector). Currently, there are 222 fishing villages in the marine sector and 113 in the inland sector, where fishing and its allied sectors provide livelihood to a vast majority of population (GOK, 2015). Primarily the fishers depend on fishing as the prime source of income. However, 12% of the fisherfolk generates additional income from allied fishing activities like marketing/repairing nets, fish vending/processing and other fishery related activities. The socio-economic condition of the fisherfolk in the state is sad, when compared to the general section of the population. Most of them are in the grip of subsistence economy and indebtedness due to socio-economic constraints, education and depletion of fishery resources. The density of population in the coastal area is 2168 persons per km^2.

Fisheries in Ernakulam district occupy a very important position in the industrial sector in Kerala. District has the benefit with the immense wealth of marine and inland fishing. It has coastal line of 46 Kms forming 7.8 percent of the total length of coastline in the state along with the backwaters, ports and harbours make it an ideal centre for fishing both marine and inland. Kochi is also an ideal place to provide support to fisheries in its various aspects like education, research and development. Apart from the Cochin Port, Munambam is the major fishing harbour along the coast. Apart from this, Chellanam Fishing Harbour is under construction to facilitate the fishing community in the southern part of the district. This is one of the well-developed coastal districts in central part of Kerala consisting of 24 fish landing centres. There are 21 marine and 15 inland fishing villages in the district. Based on 2018-19 report as per the Statistics from the Kerala Government - fisheries department, the annual fish production in Ernakulam district was 68170 MT from marine and 21589 MT from inland sector totaling 897599 MT. Fisher folk population was 194252 with a breakup of 131077 from marine and 63175 from inland as per the estimate for 2019-20. The district is rich in hatcheries and fish farms established by the public sector of State Government. The fisheries department runs one multi-species eco Hatchery at Bhuthathankettu in Keerampara Panchayath. The Njarakkal Fish Farm and Edakochi Government fish farm are under the ADAK. MATSYAFED established brackish water fish farms at Malippuram and Njarakkal. The seed farm at Kadungalloor established by Kerala Aqua Ventures International Ltd and the Prawn Hatchery by KUFOS at Panangad in Kumbalam Panchayat are the state-of-the-art establishments. Various important institutions are located here to serve this purpose like the Central Marine Fisheries Research institute.

Natural and Engineering Training, Cochin, Base of the Exploratory Fisheries Project, Export Inspection Council of India, Integrated Fisheries Project, the Marine product and Export Development Authority, Naval Physical and Oceanographic Laboratory, Central Institute of Fisheries, Regional Centre of the National Institute of Oceanography (ICAR), Office of the Fisheries Advisor, Office of the Joint Director of Fisheries, Kerala Fisheries Corporation, Regional Shrimp Hatchery, Department of Industrial Fisheries, School of Marine Sciences and School of Industrial Fisheries under CUSAT, Kerala University of Fisheries and Ocean Studies (KUFOS), the Sea Food Exporters Association of India, etc. Fishermen development welfare co-operative societies are functioning in this district extends all basic support and assistants for the development of inland fish farming.

2.5. Biodiversity of Ernakulam district

The ecology of the Ernakulam region is under a huge threat due to the unplanned development. Wetlands and backwaters are the landscape in Ernakulam district encompassing the low land regions. Vembanad Kayal, its network of canals and the surroundings occupy large expanse rich in biodiversity. The aquatic habitats are common in the lowlands of the district with extensive lakes, canals and river systems occupying substantial geographical area. Woody climbers, shrubs and herbs are also seen in such areas as exemplified by presence of several species.

Ernakulam district has considerable aerial extent of mangroves among the coastal districts in Kerala. Especially banks of the tidally influenced part of the Vembanad Kayal and network of canals have good expanse of mangroves though under stress and degradation. Many shore birds were observed abounding the environs of the marsh-mangrove wetland system of these areas. The mangrove fringed coasts and the vast mudflats provided good potential for fisheries. The catches from the coastal estuarine cum backwaters exhibit good diversity and abundance of species. Local fisher folk greatly depend on the fisheries for their subsistence living.

The midland hillocks have its own characteristic floral composition supporting scrub jungles and cashew plantations on the hill slopes and grasslands and associated aquatic and semi-aquatic plants on the hilltops. Even though these hills are exposed directly to the sunlight and wind, they harbour rich species diversity. Recent plant explorations revealed more additions to the known plant

species of the area some of which turned out to be new to science, and endemic to the locality. The vegetation of the hillocks may be classified mainly into grasslands and scrub jungles.

2.6. Pollution and Waste Management issues

Kerala Solid Waste Management Project carried the waste quantification and characterization to represent the bulk waste generators of the State namely Household, Commercial and Institutional. The waste generation rate per capita in municipalities varies from 364 grams/capita to 456 grams/capita. Low waste generation is noticed in urban local bodies of highland areas. Highly urbanized Municipalities generate above 450 grams/capita and the City Corporation generates around 545 grams/capita. Domestic waste contributes 55-65percent of total waste, while commercial establishment and markets are the second-highest generators of waste. The average waste generation rate in Municipalities is 419 gm/capita/day whereas, the Municipal Corporation areas is 545 gm/capita/day. Based on the 3 broad categories of geographical regions (lowland, midland & highland), the waste generation rates are higher in the coastal belts, which is around 545 gm/capita/day in Municipal Corporation areas whereas, the waste generation rate in the midland belt is about 454 gm/capita/day and it is about 383 gm/capita/day in highland areas.

Mainly, the waste management includes the management of biodegradable waste, management of recyclable wastes, management of non-biodegradable and non - recyclable wastes and the management of biomedical wastes. As per the Solid Waste Management Rules, 2016, Centralized Windrow composting systems exists at Brahmapuram, Kochi and at Njaliyan parambu, Kozhikode. However, household level decentralized solid waste management facilities do exist at Kochi and Kozhikode Corporation. More than 70% door to door collection of dry waste is achieved for households in 84 urban local bodies and for establishments in 70 urban local bodies as in May 2022. Haritha Karma Sena is working in 92 urban local bodies and 923 Grama panchayaths for collection of dry waste. For wet wastes disposal decentralized treatment methods such as aero bins, pipe compost, compost pits, kitchen bins, biogas plants etc. are followed. Dry wastes are collected, segregated and disposed through recyclers. In Kerala there are 147 plastic recycling units, 21 Steel mills, and 7 kraft paper units. Non-recyclable plastic waste is shredded in the Resource Recovery Facility and is used for the tarring of Public Works Department and Local Self Government Department roads. During the period 2016-2021, Clean Kerala Company Limited (CKCL) has

produced 2399.13 T of shredded plastics and given to various agencies.

3. PURPOSE AND SCOPE OF CZMPS

The Coastal Zone Management Plans proposes a spatial planning framework for development by providing 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 50, 100, 200 and 500m CRZ lines landward from the HTL are the landward setback lines. In the case of inland Backwater islands and islands along the mainland coast, 20m from the HTL is uniformly demarcated. The Low Tide Line (LTL) and the Territorial water boundary (12 NM) form the setback lines towards the sea. The 50m line or width of the creek from the HTL has been demarcated along the tidal influenced water bodies that are connected to the sea and the distance up to which tidal effects are experienced, determined based on the salinity concentration of 5ppt. The CZMP has to be prepared in two scales (1:25,000 and 1:3960 or the nearest scale) in accordance with the guidelines given in Annexure-IV of CRZ notification 2019. The CZMP in 1:25000 scale with Survey of India Toposheets as base maps is required for formulating policy decisions. These are to be submitted to MoEFCC, Govt of India for approval after stakeholder/public consultations. The local level CZMP are to be prepared in 1:4000 with cadastral base maps and based on the approved CZMP. These local level CZM maps are for the use of local bodies and other agencies to facilitate the implementation of Coastal Zone Management Plans. The CZMP also has to incorporate the Hazard Line as demarcated by Survey of India (SoI) with a view to reduce the vulnerability of the coast. Critically Vulnerable Coastal Areas (CVCAs) demarcated by NCSCM is also incorporated into the CZMP prepared. Shoreline of high, medium and low erosion stretches for such erosion prone areas will be added after receiving the data from NCSCM.

4. COASTAL ZONE MANAGEMENT PLANS

The para 6 of the CRZ Notification 2019, numerates the following instructions for carrying out the CZMP of a State:

(i) All coastal States and Union territory administrations shall revise or update their respective coastal zone management plan (CZMP) framed under CRZ Notification, 2011 number S.O. 19(E), dated 6th January, 2011, as per provisions of this notification and submit to the Ministry of Environment, Forest and Climate Change for approval at the earliest and all the project activities attracting the provisions of this notification shall be required to be appraised as per the updated CZMP under this notification and until and unless the CZMPs is so revised or updated, provisions of this notification shall not apply and the CZMP as per provisions of CRZ Notification, 2011 shall continue to be followed for appraisal and CRZ clearance to such projects.

(ii) The CZMP may be prepared or updated by the coastal State Government or Union territory by engaging reputed and experienced scientific institution(s) or the agencies including the National Centre for Sustainable Coastal Management (hereinafter referred to as the NCSCM) of Ministry of Environment, Forest and Climate Change and in consultation with the concerned stakeholders.

(iii) The coastal States and Union territories shall prepare draft CZMP in 1:25,000 scale map identifying and classifying the CRZ areas within the respective territories in accordance with the guidelines given in **Annexure-IV** to this notification, which involve public consultation. All developmental activities listed in this notification shall be regulated by the State Government, Union territory administration, local authorities or the concerned Coastal Zone Management Authority within the framework of such approved CZMP, as the case maybe, in accordance with provisions of this notification.

(iv) The draft CZMP shall be submitted by the State Government or Union territory to the concerned Coastal Zone Management Authority for appraisal, including appropriate consultations and recommendations in accordance with the procedure(s) laid down in the Environment (Protection) Act, 1986 (29 of 1986).

(v) The Ministry of Environment, Forest and Climate Change shall thereafter consider and approve the respective CZMP of concerned State Governments or Union territory administrations.

(vi) The CZMP shall not normally be revised before a period of five years after which, the concerned State Government or the Union territory may consider undertaking a revision.

4.1. Demarcation of High Tide Line (HTL) and Low Tide Line (LTL)

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 observed in the field as well as from the high-resolution satellite imageries. NCESS follows the approach as per the guidelines mentioned in the Annexure IV of CRZ Notification 2019. As per the Amendment to the CRZ Notification 2019: gazette notification no. S.O. 1422(e) dated 1st may, 2020 & no. S.O. 4886(e) dated 26th November 2021, In case there exists a bund or a sluice gate constructed in the past, prior to the date of notification issued vide S.O. 114(E) dated 19th February 1991, the HTL shall be restricted up to the line long along the bund or the sluice gate and in such a case, area under mangroves arising due to saline water ingress beyond the bund or sluice gate shall be classified as CRZ-IA irrespective of the extent of the area beyond the bund or sluice gate. Such areas under mangroves shall be protected and shall not be diverted for any developmental activities. The coastal morphological signatures are collected by field work as well as from the satellite imageries for the purpose of demarcation of HTL.

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 combination of spatial data sources including satellite data. The HTL must be fixed with respect to certain reference points on the land. These reference points at sufficiently close intervals (preferably at least 1km along shore) 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 beaches***

In all the well-formed wide beaches, one or more berms (which are nearly horizontal part of the beach developed through the deposition of sand by wave action) are usually observed. The seaward end of the berm at which a sudden downward slope is observed is termed a 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, no second berm is observed landward. Such locations will be protected mostly by seawalls. During monsoon season majority of these places 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. There are several locations along Kerala coast, which has only one berm and the beaches undergo severe erosion during the

monsoon, and yet not protected by seawalls. In such cases, permanent vegetation, particularly well grown coconut trees, which are the main vegetation species prevalent all along the coast, is used as an indicator. The part of the beach landward of monsoon berm crest, which is mostly stable, and the line of permanent vegetation normally follows the line of monsoon berm crest which is the HTL.

d) ***Coastal sand dune / paleo-aeolian dune***

Sand dunes are mounts, hills or ridges of sand that lies behind the part of the beach affected by tides. They are formed over many years when windblown sand is trapped by beach vegetation or other stationary objects. Sand dunes are habitat for coastal plants and animals. The size and morphology of coastal dunes is dependent on the complex interaction between controlling winds, sediment supply, and the geomorphology of the nearshore and beach environment. Mostly, dunes can be divided into those that form from the direct supply of sediment from the beach face (primary dunes), and those that form from the subsequent modification of primary dunes (secondary dunes). Sand dunes provides and 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 support an array of organisms by providing nesting habitat for coastal bird species including migratory birds. The main secondary dunes include blowouts, parabolic dunes, and transgressive dune fields.

In Kerala, coastal inland areas have remnants of coast-parallel sand ridges manifesting the Holocene transgressive still stands of sea. North and Central Kerala coasts had such dispositions of strandlines of alternating ridges with swales. However, due to the demand of dense population in the coastal region and development activities, we could rarely see such raised dunes/ridges currently in Kerala except along the Pallikkara-Kanhangad coastal belt in the Kasaragod District. Another interesting feature witnessed is the foredunes bordering the beaches along most part of Kerala coast. They are seen in the backshore of the beaches as shadow dunes continuously being formed due to the sand blown out and trapped around any obstruction such as shrubs or grasses in the backshore.

e) ***Mangroves***

Mangroves are unique plant communities comprising of evergreen trees and shrubs

belonging to several unrelated families observed in tropical to subtropical intertidal regions, where constant tidal water exchange takes place. Mangrove ecosystem ecologically functions as a complex ecotone or interface zone between the terrestrial and marine ecosystems, exemplifying diverse habitats, including microhabitats, characteristic of terrestrial, intertidal and aquatic environs. As an invaluable ecological system and for reasons of its rich biodiversity, economic and social standing for sustenance and survival of community people, sustainability of sea food, and shore-line stability, conservation of mangroves is of paramount importance. They exhibit remarkable adaptation for salt tolerance with a spread of around 1 lakh sq.km world over distributed in about 30 countries. Mangroves in India account for about 5 percent of the world's mangrove vegetation and are spread over an area of about 4,800 sq.km along the coastal States/UTs of the country. The best development of mangroves in India is along the east coast with nearly 57% (~2750 sq.km) of the mangrove ecosystem of the country. Along the west coast of the country occur 23% (~1100sq.km) of the Indian mangroves and the remaining 20% is around the Andaman and Nicobar Islands (India). The east coast, unlike the west coast, is endowed with the largest mangrove wetlands developed on larger river deltas created by the major east flowing rivers of the country.

Kerala once in the 1950's was blessed with a large spread of about 700 sq.km mangroves but has been declined considerably to around 20 sq.km. All along the Kerala coast there are a good number of small mangroves stands, though mostly in isolated patches, fringing the estuaries and backwaters (Kayal); and around islets or along river margins in the coastline stretches. Kerala with its very limited extent of mangroves is in no way free from the current trends of degradation of mangrove systems in the country. Mangrove systems in Kerala exhibited a higher grade of heterogeneity in their environmental settings and ecosystem features. Mangrove systems are one of the most threatened habitats in Kerala, as anywhere else in the country, or in the world. There is confusion about the actual/exact extent of mangrove distribution in Kerala in the absence of a precise estimate of it.

There are 15 true mangrove species and 49 mangrove associates observed in the coastal brackish water areas of Kerala. The 15 true mangrove species belonged to 9 genera spread over 7 families. The family, Rhizophoraceae is the most represented one with 6 species belonging to 3 genera. Mangrove associates are generally observed in the fringe areas where the wetland nature is devoid of any salinity. Species like *Acanthus ilicifolicus*, *Excoecariaagallocha*,

Aegicerascorniculatum, *Rhizophora mucronata*, *Sonneratiaapetalae*and *Acrostichumaureum*are were found in all the districts of Kerala, whereas *Rhizophora apiculata*is widely distributed in Kannur and Kollam districts but not found in Malappuram. *Avicennia officinalis* is one of the common species noticed in all the districts, however, this is not the case with *A. marina* which was not seen in Trivandrum and is one of the threatened mangrove species in Kerala. Out of four species belonging to the genus Bruguiera, B. cylindrica has relatively wide distribution, however, it is not recorded from in Kottayam district. *B. parviflora* has wide distribution in the northern parts of Kerala which is not present in Trivandrum, Kollam, Alappuzha and Kottayam. *Kandeliakandal*is also a rare species which is distributed in all districts except Trivandrum, so also *Sonneratiacaseolaris* which is found in five districts namely Trivandrum, Kollam, Alappuzha, Kannur and Kasargode, whereas *S. alba* is becoming endangered due to its small populations in the districts of Ernakulam, Kozhikode, Kannur and Kasargode. *Lumnitzeraracemosa*is one of the rarest mangrove species in Kerala found in four districts namely, Trivandrum, Kollam, Alappuzha and Kannur.

Sometimes, small creeks or pockets or far inland areas in the upriver vicinities or close to coastal waterways or canal works, harbour mangrove systems, which may apparently remain dry for considerable time, but remain intact-unless it is wantonly degraded by man-since the water table of area or site is generally just below surface (for example mangrove stands at Eranhipalam-Kottooly areas in Kozhikode District). Both the fringe and the riverine mangroves have significant productivity status as they turn out high amount of organic matter. The wetland bays or pockets, of small or large areas, associated with them are affected by freshwater runoff from adjacent upland areas and rivers, as well as sediments and nutrients transported by the river inflows.

Some of the mangrove species reported in the Ernakulam district are *Avicennia officinalis, Bruguiera cylindrical, Bruguiera gymnorrhiza, Bruguiera sexangula, Excoecaria agallocha, Rhizophora apiculata, Rhizophora mucronata, Sonneratia alba, Sonneratia caseolaris, and Acanthus ilicifolius.* The distribution of mangroves in the district varies from moderately dense to sparse degraded types. *Avicennia officinalis* is one of the common species noticed in many colonies of mangroves. Even under severe degradation, *Avicennia marina* species still shows its adaptation capacity under stressful condition with re-sprouting from in and around the destroyed trees. Out of four species belonging to the genus Bruguiera, B. cylindrica has relatively wide distribution in Ernakulam district followed by *Bruguiera sexangula, Bruguiera parviflora* and *Bruguiera*

gymnorrhiz. Kandelia kandal is also reported in the district from locations like Kumbalam which also has been reported from all districts except Trivandrum. Species like *Sonneratia alba* is becoming endangered due to its small populations in the districts of Ernakulam, Kozhikode, Kannur and Kasaragod. *Lumnitzera racemosa* and *Aegiceras corniculatum have become* rare mangrove species in Ernakulam. However, certain studies have reported fair presence of *Lumnitzera racemosa* and *Aegiceras corniculatum* from certain locations in Ernakulam district.

f) *Rocks, Headlands, Cliffs*

The 590km long Kerala coast is dotted in between by rocky promontories, headlands and steeply sloping cliffs. Except the coastal districts of Ernakulam and Alappuzha, all the other 7 districts have distribution of such rocks/headlands/cliffs to varied extent. 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. 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.

The cliffs and rocky promontories are not present along the Ernakulam coast.

g) *Influence of Tidal action*

CRZ shall apply to the land area between HTL to 50 meters or width of the creek, whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea. The tidal influenced water bodies as per the CRZ Notification 2019 means the water bodies influenced by tidal effects from sea in the bays, estuaries, rivers, creeks, backwaters, lagoons, ponds that are connected to the sea. The distance up to which CRZ is applicable shall be governed by the distance up to which the tidal effects are experienced which shall be determined based on salinity concentration of five parts per thousand (ppt) measured during the driest period of the year and distance up to which tidal effects are experienced. As per the Office Memorandum dated 26th June, 2019 of the MoEFCC, guidelines were issued facilitating updation of CZMPs, according to which, the CZMP database prepared as per the CRZ Notification 2011 shall be used as the base for revision or updation of the CZMP, as per the provisions contained in the CRZ Notification, 2019. Therefore,

the tidal effects as marked in the CZMP prepared as per the CRZ Notification 2011 forms the basis for the updation of the CZMP currently being prepared. The tidal limit of various tide influenced waterbodies of the Ernakulam district is given in the table below in terms of location with latitude and longitude.

Table: Salinity/CRZ limit along the inland water bodies in Ernakulam District

Sl. no	Name of Waterbody	Latitude	Longitude
1	Periyar River	10° 8' 40.40" N	76° 16' 55.96" E
2	Periyar River (Tributary)	10° 4' 36.30" N	76° 18' 10.32" E
3	Varapuzha	10° 4' 8.19" N	76° 17' 19.62" E
4	Chithrapuzha	9° 59' 29.61" N	76° 21' 8.86" E
5	Muvattupuzha River (Tributary)	9° 51' 24.89" N	76° 23' 8.08" E

4.2. Demarcation of Ecologically Sensitive Areas

Guidelines for preparation of the CZMP specifies that the CZM maps shall clearly demarcate the land use plan of the area and map out the Ecologically Sensitive Areas (ESAs) or the CRZ-IA areas as per mapping made available by NCSCM to coastal State and Union territories. Coastal ecosystems provide a variety of ecosystem services for humans; however, these systems are susceptible to both terrestrial and marine factors because they are situated in the coastal ecotone. Consequently, coastal marine ecosystems are very sensitive to environmental change and human activities. Constructions for coastal development are still often located in sensitive biological and ecological areas without much consideration of their impact. In this context, the CRZ Notification 2019 provides provisions to achieve coordinated development of the population, economy, and environment in the coastal area. Ecological sensitivity refers to the degree of reflection of ecosystem interference in human activities and changes to the natural environment; that is, the degree to which the ecosystem responds to environmental changes caused by the combination of internal and external factors. Through identifying such sensitive areas, conservation and management strategies could be developed that facilitate the sustainable use of coastal resources.

The different ecologically sensitive areas as listed in the CRZ Notification 2019 have been assimilated from the previously approved CZMP maps as directed through the guidelines and further the changes occurred till recently has been captured using high resolution satellite data. The same has been field verified for accuracy assessment wherever required.

5. ECOLOGICALLY SENSITIVE AREAS/COASTAL LANDUSE

5.1. Mangroves

As per the available literature, about 40% of the mangroves has been depleted during the recent years in Ernakulam District. However, at present, these highly fragmented formation is in a much-degraded state, mainly due to pollution, reclamation and other anthropogenic influences. *Rhizophora apiculata, Bruguiera gymnorrhiza, Bruguiera cylindrical, Carallia brachiata, Avicennia marine, avicennia officinalis, Acrosticum aureum, Aegiceres corniculatum, Acanthus ilicifolius, Derris trifoiata, Derris scandens, Excoecaria agallocha,* etc are some of the species often reported from the area. In the ecotones and more degraded sites harbouring the vegetation type, several mangroves associate also flourish.

Even with the highly degraded nature of mangrove formations, Ernakulam district is ranked 2nd in terms of extent of mangroves followed by Kannur. The total extent of mangroves in Ernakulam district is 5.531498 Km^2, which is a significant presence among the coastal districts in Kerala. Among the local bodies, Elankunnapuzha Panchayat (2.003048 Km^2) followed by Chellanam Panchayat (0.682391 Km^2) have somewhat luxuriant growth of mangroves. Panchayats such as Amballur, Chittatukara, Kalamassery Municipality and Kadungallur are devoid of mangroves. Among the urban local bodies, Kochi Corporation is having the maximum extent of mangroves (0.504842 Km^2) followed by Maradu Municipality (0.463416 Km^2). The adjoining Thrippunithura Municipality also have an extent of mangroves in which 0.253692 Km^2. However, Kalamassery Municipality is totally devoid of mangroves though some traces of mangroves have been noticed in Eloor, Paravoor and Thrikkakara Municipalities.

5.2. Coral Reefs

Coral Reefs locations have not been reported from the Ernakulam coast.

5.3. Reserve Forests

Reserve Forests have not been reported from the Ernakulam coast.

5.4. Sand Dunes

Sand dune locations have not been reported from the Ernakulam coast.

5.5. Salt marsh

Salt marsh locations have not been reported from the Ernakulam coast.

5.6. Nesting Ground of Birds

Nesting ground of bird's have not been reported from the Ernakulam coast.

5.7. Archaeologically important and Heritage Sites

An archaeological site is a place (or group of physical sites) in which evidence of past activity is preserved (either prehistoric or historic or contemporary). Archaeological sites are open museum for living history. Heritage is a broad concept that includes the natural as well as the cultural environment. It encompasses landscapes, historic places, sites and built environments, as well as biodiversity, collections, past and continuing cultural practices, knowledge and living experiences. The prime concern of Conservation, Preservation and Maintenance of ancient monuments and archaeological sites along the coastal region remains one of the objectives of the CRZ Notification.

There are many archeological or heritage sites within the CRZ area of the Ernakulam district. They are Pallippuram Fort, Paravur Jewish Synagogue, Vypeekotta Seminary, Jewish Synagogue at Chendamangalam, Kottayil Kovilakam, Bastion Bunglow, Mattancherry Palace, St. Sebastian's Church, Paliyam Kovilakam, Paliyam Nalukettu, etc. The total area encompassing the listed sites is 0.003275 Km^2.

Pallippuram Fort built in 1503 by the Portuguese is considered as the oldest surviving European monument in India. Also know by the name Ayikotta or Alikotta, the fort is gigantic

hexagonal structure. The architecture of the fort is quite fascinating with a hexagonal outpost and lowest floor raised to a height of five feet. Laterite, mortar and wood are used for the construction. There is a cellar inside the fort, which was used at that time as a magazine. The local people believe that the cellar is a tunnel that leads to the Cheraman Masjid in Kodungallur. The fort fell into the hands of Dutch army in 1663. In 1798, the fort was purchased by the Travancore Maharaja and is now a protected monument of the Kerala State Archaeology Department.

The Jewish communities who came here in different periods settled in and around Kodungallur were involved in trade. Synagogues are Jewish places of worship. One of the oldest such Synagogues is the Paravur Synagogue. The Paravur Synagogue is the most expansive and complete among synagogues in Kerala built in 1615.

The remains of the Vypeekotta Seminary built by the Portuguese are preserved as a historic monument and site. The Vypeekotta Seminary is located in Chendamangalam village in Ernakulam District. This Seminary was established to teach the priests of Malabar, the ceremonies and language to be used in Roman Catholic Churches founded by the Portuguese. There were many buildings on the premises, which were destroyed during the wars in later period. There is a church still functioning in the compound, probably built during the same period, but renovated later. Many stone inscriptions were encountered from the church compound during the exploration done here in 1935. The remains of the Seminary were declared as a protected monument in 1935.

In 1420, the Jews who came from Kodungallur or Palayur to Chennoth (Chendamangalam) built a Synagogue, a place of worship for the Malabari Jews. This synagogue built in the model of Jerusalem Temple was destroyed in a fire, and was rebuilt in 1614, and renovated several times. In the 1960s when the Jews in Kerala returned to Israel the worship here came to a stop. The synagogue is located inside high walls that surround it. The wall in front is as high as the front elevation. This synagogue has been renovated and revived to its former glory by the Government of Kerala, and now houses a small museum of early Jewish life in Kerala.

Kottayil Kovilakam at Chendamangalam, which was the seat of Kshatriya chieftains of Villarvattom is situated near the ancient *Kunnathuthali temple*. Kottayil Kovilakam, the headquarters of the Villarvattom Swarupam, was a local fiefdom in Kochi. Chendamangalam is an

important center of hand loom weaving and coir manufacturing. Near the Krishna temple on one side Tipu Sultans cave and on either side Arabs cemetery. On the riverside a group of huge rocks known as 'ANAPARA' is the main highlight. The Kunnathuthali temples were constructed 400 years ago.

Bastion Bungalow, located near Vasco da Gama square in Fort Kochi, is a sea-facing Dutch heritage structure built in 1667. This elegant bungalow features an Indo-European style of architecture with Kerala tile roofing and a wooden verandah on the first floor. Bastion Bungalow witnessed Kochi's colonial history. From the 16th to the 19th centuries, Kochi was colonised by three European powers in turn—initially the Portuguese, then the Dutch, and finally, the British. In 1503, the Portuguese built Fort Emmanuel featuring seven bastions in Kochi. The Kerala government converted the Bastion Bungalow into a heritage museum, which was open to public since February 2016. The state department of archaeology in Kerala has declared the bungalow a protected monument.

Built around 1555, the Mattancherry Palace, popularly known as the Dutch Palace was originally built by the Portuguese. This was a gift for Raja Veera Kerala Varma, who was then the King of Kochi. Later, when the Dutch took over, they renovated this Palace around 1663. Since then it has been referred to as the Dutch Palace. The Dutch Palace was used as the 'Royal House' by the Royal families of Kochi. It is said that they used this building to conduct many important ceremonies associated with the coronation of the new king. The Palace has typical Kerala style architecture and is a two-storeyed structure. It is a *naalukettu*, which means a central courtyard and four separate wings opening out into this courtyard. The rooms of the women of the Palace is on the ground floor, while there is a huge coronation hall, dining hall, assembly hall, and Royal bed chamber upstairs. It also has a *kovinithalam*or staircase room.

St. Sebastian's Church was built in 1833 at Thoppumpady. It is an active church in Edappally Forane with architectural excellence under the Diocese of Cochin.

Traditional home of the Paliathu Achans (Prime Ministers to the Kings of Kochi), it came to be called 'Kovilakam' or palace after the then Paliath Achan hid the King in his home, when the royal house was threatened by the Portuguese. In appreciation of the Paliath Achan's services, the

Dutch renovated the home in Chendamangalam. He used it as his official residence, where a lot of major decisions were made and put into action. The architectural style of Paliam Kovilakam is a hybrid of Kerala and Dutch styles. 'Paliathachan' is the title given to the Karanavar (Head of the Family) of Paliam Noble Family. During the 17th and 18th centuries, they held the posts of Prime Minister and Chief of Army of the kingdom of Kochi.

Paliam Nalukettu's are the traditional homesteads (tharavads) where several generations of a matrilineal joint family lived together. Nalukettu consists of a main house along with a few satellite houses. Portico, Inner Hall, Kitchen and four blocks - Northern, Southern, Eastern and Western - constitute the different parts of a traditional Nalukettu. The design and construction pattern are closely linked to the life cycle of women in the family, their rituals, beliefs and celebrations. Nalukettu was occupied by the women of Paliam Noble family who followed matrilineal system. This structure is also an epitome of the traditional housing architecture of Kerala.

5.8. Seagrass

Seagrass locations have not been reported from the Ernakulam coast.

5.9. Mud flats

Mud flats locations have not been reported from the Ernakulam coast.

5.10. Turtle Nesting Grounds

Turtle nesting site have not been identified along the Ernakulam district coast.

5.11. Inter-Tidal Zone

Tides play very important role in determining the biodiversity of and fertility of coastal and estuarine ecosystems. Intertidal zone is the area between the high tide (HTL) and low tide lines (LTL) as per the CRZ Notification. Intertidal zone exists wherever the tidal effects are experienced. The intertidal zone is an ecosystem where a multitude of organisms living on the shore/banks survive changes between high and low tides. The tidal ranges are low in the southern side of the west coast of India and as we move northward, its amplitude increases. At Kochi, the ranges are of the order of

1m. The tidal range increases northward and reaches to more than 2m at Marmagao. At Mumbai, maximum ranges in tidal elevations are of about 5 m. Kerala coast being microtidal in nature with tidal amplitude around 1m with slight increase from south to north, the extent of intertidal area by the sea and inland water bodies are limited.

In the case of Ernakulam District, intertidal area within the CRZ-IB category is bifurcated into the intertidal areas by the seacoast as well as the tidal waterbodies which accounts for 35.126676 km^2. Apart from this, vast expanse of pokkali fields is available in the Ernakulam district accounting for an area of 21.99945 km^2 (provided in the Table in the Annexure-2), where alternating seasonal practices of aquaculture and paddy cultivation is being done. Elamkunnapuzha Panchayat tops the list with 2.191021km^2 spread of intertidal area, followed by Chellanam Panchayat with 1.562563km^2. With varying aerial extent, all the local bodies in Ernakulam district have intertidal areas. In the case of Pokkali category of CRZ IB, Chellanam Panchayat (5.062736km^2) followed by Ezhikkara Panchayat (3.420958 km^2) have widespread. (Detailed table is annexed in Annexure 2).

5.12. Salt pan / Aquaculture ponds

Though aquaculture ponds are available in Kozhikkode district, they are mostly classified under the intertidal areas (CRZ IB) or as CRZ IVB due to their alternating use for aquaculture and agriculture. The same sort of categorization adopted in the approved CZMP of 2011 is being followed in the updation process.

6. METHODOLOGY FOR PREPARATION OF CZMP

As outlined in the Annexure-IV, preparation of the CZMP has been undertaken in 1:25000 scale using the base grids of the Survey of India (SOI) topographic sheets. Wherever 1:25000 scaled toposheets are not available, the 1:50000 SOI toposheets were enlarged accordingly to compose the base maps. The base maps were georeferenced as per the datum and projections specified in the guidelines. The cadastral maps of the villages (1:3960 or nearest scales as per availability) likely to be within the purview of CRZ have been appropriately georeferenced to maintain the horizontal accuracy required. To minimize the RMS error during the georeferencing, maximum number of control points were obtained from the field using GPS (combination of methods using long static DGPS, short static DGPS and RTK obtaining acceptable precision resolving ambiguities in the post-

processing techniques) to define the location in terms of latitude and longitude geodetic points in DMS format with second decimal accuracy in seconds (X & Y as cartesian coordinates with submeter accuracy). Wherever, disparity has been noticed in the hardcopy scanned cadastral image, georeferencing has been done by seeding maximum control points adjusting with the physical signatures discernible on the high-resolution satellite image which has been used as a reference image.

6.1. Field mapping and map preparation

The field mapping has been performed with hard copy of the georeferenced cadastral sheets to match the mapping scale with the ground space distance. Hard copy of the satellite images to a matchable scale has also been printed out to refer simultaneously during the field survey which comes handy in matching with the co-locatable ground features. The field surveying becomes confident with the combination of both cadastral and satellite images as well as with tying up the coordinates obtained from the GPS. All the essential features and lines are captured using the GPS by tagging attributes while carrying out the field work so that it becomes easy collate the information into maps without any confusion or missing. The guidelines issued subsequent to the notification specifically clarifies that HTL, LTL, ESAs and Critically Vulnerable Coastal Areas (CVCAs) demarcated by the NCSCM, Chennai, and the Hazard Line as demarcated by the SOI, shall be used in preparation/updation of the CZMPs as required under the provisions of the CRZ Notification, 2019.

Timeline satellite images were verified for any considerable change in the HTL/LTL/ESAs. Significant changes in the terms of the reduction or increase of mangroves have been noticed at several places in the State, which has been verified in the field intensively. Based on the ground condition, the variations in the extent of mangroves as well as the changes in HTL/LTL has been marked using the GPS tracking *in situ*. Apart from digesting the changes in the CZMP, separate table has been created to mark the changes at each location for scrutinizing the same at the vetting stage.

7. CRZ CLASSIFICATION

The CRZ Notification 2019 has classified the CRZ area in the following manner for the purpose of conserving and protecting the coastal areas and marine waters.

7.1. CRZ-1

CRZ-1 areas are environmentally most critical and are further classified as under:

7.1.1. CRZ-1 A

CRZ-1 A shall constitute the following ecologically sensitive areas (ESAs) and the geomorphological features which play a role in maintaining the integrity of the coast viz.:

(i) Mangroves (in case mangrove area is more than 1000 square meters, a buffer of 50 meters along the mangroves shall be provided and such area shall also constitute CRZ–IA).
(ii) Corals and coral reefs.
(iii) Sand dunes.
(iv) Biologically active mudflats.
(v) National parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas under the provisions of Wildlife (Protection) Act, 1972 (53 of 1972), Forest (Conservation) Act, 1980 (69 of 1980) or Environment (Protection) Act, 1986 (29 0f 1986), including Biosphere Reserves.
(vi) Salt marshes.
(vii) Turtle nesting grounds.
(viii) Horseshoe crabs' habitats.
(ix) Sea grass beds.
(x) Nesting grounds of birds.
(xi) Areas or structures of archaeological importance and heritage sites.

7.1.2. CRZ-I B

The intertidal zone i.e., the area between the Low Tide Line and High Tide Line constitutes the CRZ-I B.

7.2. CRZ-II

CRZ-II constitutes the developed land areas up to or close to the shoreline, within the existing municipal limits or in other existing legally designated urban areas, which are substantially built-up with a ratio of built-up plots to that of total plots being more than 50 per cent and have been provided with drainage and approach roads and other infrastructural facilities, such as water supply, sewerage mains, etc.

7.3. CRZ-III

Land areas that are relatively undisturbed (viz. rural areas, etc.) and those which do not fall under CRZ-II, shall constitute CRZ–III and CRZ-III shall be further classified into following categories:

7.3.1. CRZ-III A

Such densely populated CRZ-III areas, where the population density is more than 2161 per square kilometer as per 2011 census base, shall be designated as CRZ–III A and in CRZ-III A, area up to 50 meters from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ)', provided the CZMP as per this notification, framed with due consultative process, have been approved, failing which, a NDZ of 200 meters shall continue to apply.

7.3.2. CRZ-III B

All other CRZ-III areas with population density of less than 2161 per square kilometer, as per 2011census base, shall be designated as CRZ-III B and in CRZ-III B, the area up to 200 meters from the HTL on the landward side shall be earmarked as the 'No Development Zone (NDZ)'.

7.4. CRZ-IV

The CRZ- IV constitutes the water area and shall be further classified as under: -

7.4.1. CRZ- IVA

The water area and the seabed area between the Low Tide Line up to twelve nautical miles on the seaward side shall constitute CRZ-IV A.

7.4.2. CRZ- IVB

CRZ-IV B areas shall include the water area and the bed area between LTL at the bank of the tidal influenced water body to the LTL on the opposite side of the bank, extending from the mouth of the water body at the sea up to the influence of tide, i.e., salinity of five parts per thousand (ppt) during the driest season of the year.

7.5. Regulation limits/lines

The CRZ limits has been revised or updated as per the provisions contained in the CRZ Notification 2019. The 50 meters No Development Zone (NDZ) in the case of CRZ-III areas/ a 50 meters buffer line (CRZ limit) in the case of CRZ-II areas or the width of the creeks that are influenced by tidal from sea in the bays, estuaries, rivers, creeks, backwaters, lagoons, ponds. have been drawn. The landward extent of NDZ/Buffer by the creek is up to the location where the salinity limit of 5 part per thousand is encountered.

By the seacoast, a 500-meter line from HTL is drawn as CRZ limit irrespective of whether the area is under CRZ-III or CRZ-II. As per the CRZ Notification 2019, a new sub-category of CRZ-IIIA by the coast is introduced, where the NDZ is limited to 50 meters and the same has been updated. Similarly, as in the previous CZMP, the 200-meter line of NDZ by the seacoast has been drawn for the CRZ-IIIB areas.

The NDZ of the islands in the coastal backwaters as well as islands along the mainland coast has been limited to 20 meters, the same has been updated in the CZMP being prepared according to the CRZ Notification 2019, but it will be implemented only after the approval of IIMP of the particular Island.

Subject to the information to be provided by the State Government on the details of village-

wise survey numbers pertaining to government land for deciding/enabling ease in demarcation of buffers around mangrove areas, a uniform buffer of 50 meters have been demarcated in case of mangrove area being more than 1000 square meters. The ownership details of Mangroves more than 1000sq.m spread area provided by Govt. of Kerala is provided in the **Annexure 4**.

7.6. CVCA and IIMP

Critically Vulnerable Coastal Areas (CVCA)

Sundarban region of West Bengal and other ecologically sensitive areas identified as under Environment (Protection) Act, 1986 such as Gulf of Khambat and Gulf of Kutchh in Gujarat, Malvan, Achra-Ratnagiri in Maharashtra, Karwar and Coondapur in Karnataka, Vembanad in Kerala, Gulf of Mannar in Tamil Nadu, Bhaitarkanika in Odisha, Coringa, East Godavari and Krishna in Andhra Pradesh shall be treated as Critical Vulnerable Coastal Areas (CVCA) and managed with the involvement of coastal communities including fisher folk who depend on coastal resources for their sustainable livelihood.

CVCA locations as provided by the NCSCM is marked in the Ernakulam district which are spread along certain parts around Vembanad Lake.

Integrated Island Management Plan (IIMP)

The islands demarcated in Ernakulam district as mainland coast islands and inland islands in the coastal backwaters need to have Integrated Island Management Plans (IIMPs), as applicable to smaller islands in Lakshadweep and Andaman & Nicobar, as per Island Protection Zone Notification, 2011 number S.O. 20(E), dated the 6th January, 2011 to be formulated by the Kerala State. This would be carried out with the help of NCSCM, once all such islands marked in this CZMP are approved by the Ministry of Environment, Forest and Climate Change. There are 810 number of backwater islands are present in Ernakulam district. The islands are buffered with 50 m or width of the creek whichever is less and 20m CRZ line landward of HTL is also depicted in the map which will be considered only after IIMP is implemented. The dimensions of backwater islands show wide variation in the district, ranging area from 0.000042 km^2 (Chellanam) to 37.454979 km^2 (Chendamangalam, Karumalloor, Kottuvally, Ezhikara, Alangad, Kadungallur, Varapuzha,

Paravoor, Puthenvelikara, Karumalloor) followed by 10.597276 km^2 (Kottuvally, Ezhikara and Paravoor). The Chendamangalam, Karumalloor, Kottuvally, Ezhikara, Alangad, Kadungallur, Varapuzha, Paravoor, Puthenvelikara, Karumalloor were demarcated as Islands however the eastern part of these villages has non tidal influenced waterbody. All together the area of islands in the district account for 186.661564 km^2 (Detailed table is annexed in Annexure 2).

8. HAZARD LINE

A 'Hazard line' has been demarcated by the Survey of India (SOI) taking into account the extent of the flooding on the land area due to water level fluctuations, sea level rise and shoreline changes (erosion or accretion) occurring over a period of time. The hazard line mapped by SOI has been shared by NCSCM as part of the previous CZMP prepared. The hazard line is to be used as a tool for disaster management plan for the coastal environment, including planning of adaptive and mitigation measures. With a view to reduce the vulnerability of the coastal communities and ensuring sustainable livelihood, while drawing the CZMP, the land use planning for the area between the Hazard line and HTL need to be take into account as such impacts of climate change and shoreline changes.

9. CRZ CATEGORIES OF ERNAKULAM DISTRICT

The CRZ of the Ernakulam District consist of CRZ-IA, CRZ-IB/CRZ-IB Pokkali, CRZ-II, CRZ-IIIA, CRZ-IIIB, CRZ-IVA and CRZ-IVB. Altogether 32 local bodies are covered under the CRZ area. 25 are Grama Panchayaths out of which 10 are other legally designated urban areas, 6 Municipal Council and 1 Municipal corporation. Altogether 48 villages are under the purview of CRZ in Ernakulam District. Other Legally designated urban area as per CRZ Notification 2019 includes Chellanam, Cheranallur, Elamkunnapuzha, Kadamakkudy, Kumbalam, Kumbalangy, Mulavukad, Nayarambalam, Njarackal and Varapuzha. The details are provided in the table annexed (Annexure-2).

The new village and panchayat boundaries provided by KCZMA, obtained from Survey and Land Records does not match with the survey plots and district boundaries in the approved CZMP, 2011. Hence old boundaries (approved CZMP, 2011) are used for this exercise, as per the instruction from DoECC, Govt. of Kerala. However, as per the new village boundary, Palluruthi village

(8.451234 km^2) village is divided into two villages namely Chellanam (5.438202 km^2) and Palluruthy (3.882853 km^2). Kuzhappilly (Block 1 and Block 3) has changed to Kuzhuppilly village. A portion of Rameswaram and Mattanchery villages has been merged with Thoppumpadi village (8.012643 km^2). Similarly, as per the new panchayat boundary, Paravoor Municipality name has changed to north Parvoor Municipality. A portion of Cheranallur panchayat has merged with Kadamakudy panchayat (17.939597 km^2).

CRZ categories and ESAs (Panchayat/Village-wise) in Ernakulam District

A detailed table is annexed (Annexure-2) along with this report separately on the Panchayath/Village-wise statistics of HTL, ESAs, intertidal area, mangrove buffer, area covered under each CRZ category.

10. CONCLUSION

Statistics of the CRZ status of Ernakulam District is summarized below:	
Total length of HTL along the Seacoast	45.62 km
Total length of HTL along the inland water bodies	1703.83 km
Total Area under the Archeological/Historical sites	0.003275 km^2
Total Area under the Turtle Nesting Sites	NIL
Total area under mangrove extent	5.531498 km^2
Total area under mangrove buffer	4.22281 km^2
Total area under intertidal zone (CRZ-IB)	13.127226 km^2
Total area under intertidal zone (CRZ-IB) Pokkali	21.99945 km^2
Total area under CRZ-II along the Seacoast	11.28058 km^2
Total area under CRZ-II along the inland water bodies	26.436028 km^2
Total area in No Development Zone in CRZ-III along Seacoast	0.86721 km^2
Total area in No Development Zone in CRZ-III along water bodes	15.723546 km^2
Total area in CRZ-IIIA along the coast between 50-500 meters	1.364631 km^2
Total area in CRZ-IIIB along the coast between 200-500 meters	0.03401 km^2
Total area under the CRZ-IVB category	96.438268 km^2