DRAFT REPORT ON

COASTAL ZONE MANAGEMENT PLAN (CZMP) FOR ALAPPUZHA 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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CONTENTS

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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 Alappuzha District

The Alappuzha district, also known as Alleppey was carved out of the erstwhile Kottayam and Quilon (Kollam) districts, on the 17th August 1957, consisting of six Taluks namely, Sherthalai (Cherthala), Ambalappuzha, Kuttanad, Chengannur, Karthikappally and Mavelikkara. It is assumed that the geographical position and physical features of the place, the land between the sea and the network of rivers flowing into it, had earned her the name Alappuzha. The district is bounded on the north by Kochi and Kanayannur taluks of Ernakulam district, on the east by Vaikom, Kottayam and Changanassery taluks of Kottayam district and Thiruvalla as well as Kozhencherry taluks of Pathanamthitta district, on the South by Kunnathur and Karunagappally taluks of Kollam district and on the west by Lakshadweep Sea. The district has a sea coast of about 82 kms long and also has the presence of vast stretch of lakes and backwaters. Alappuzha district lies between latitudes 09° 05' 00" N and 09° 54' 00" N and longitudes 76° 17' 30" E and 76° 40' 00" E. Total area of Alappuzha district is 1414 km^2. In terms of area, Alappuzha is the smallest district in the State. The location map of Alappuzha 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.

Alappuzha district is one of the districts in the Travancore area of the State, which is having two Revenue Divisions namely Alappuzha division comprising of Cherthala, Ambalappuzha and Kuttanad Taluks covering 49 Villages and Chengannur Division, comprising of Karthikappally, Chengannur and Mavelikkara Taluks covering 44 Villages. Under the Local Self-Government System, the district is divided into 6 Municipal Councils (Cherthala, Alappuzha, Kayamkulam,

Harippad, Chengannur, Mavelikkara), 12 Development Blocks (Ambalapuzha, Aryad, Bharanickavu, Chambakkulam, Chengannur, Kanjikuzhy, Haripad, Mavelikara, Muthukulam, Pattanakkad, Thycattussery and Veliyanad) and 72 Panchayats. The area encompassing the Alappuzha city and surroundings forms the headquarters of the district.

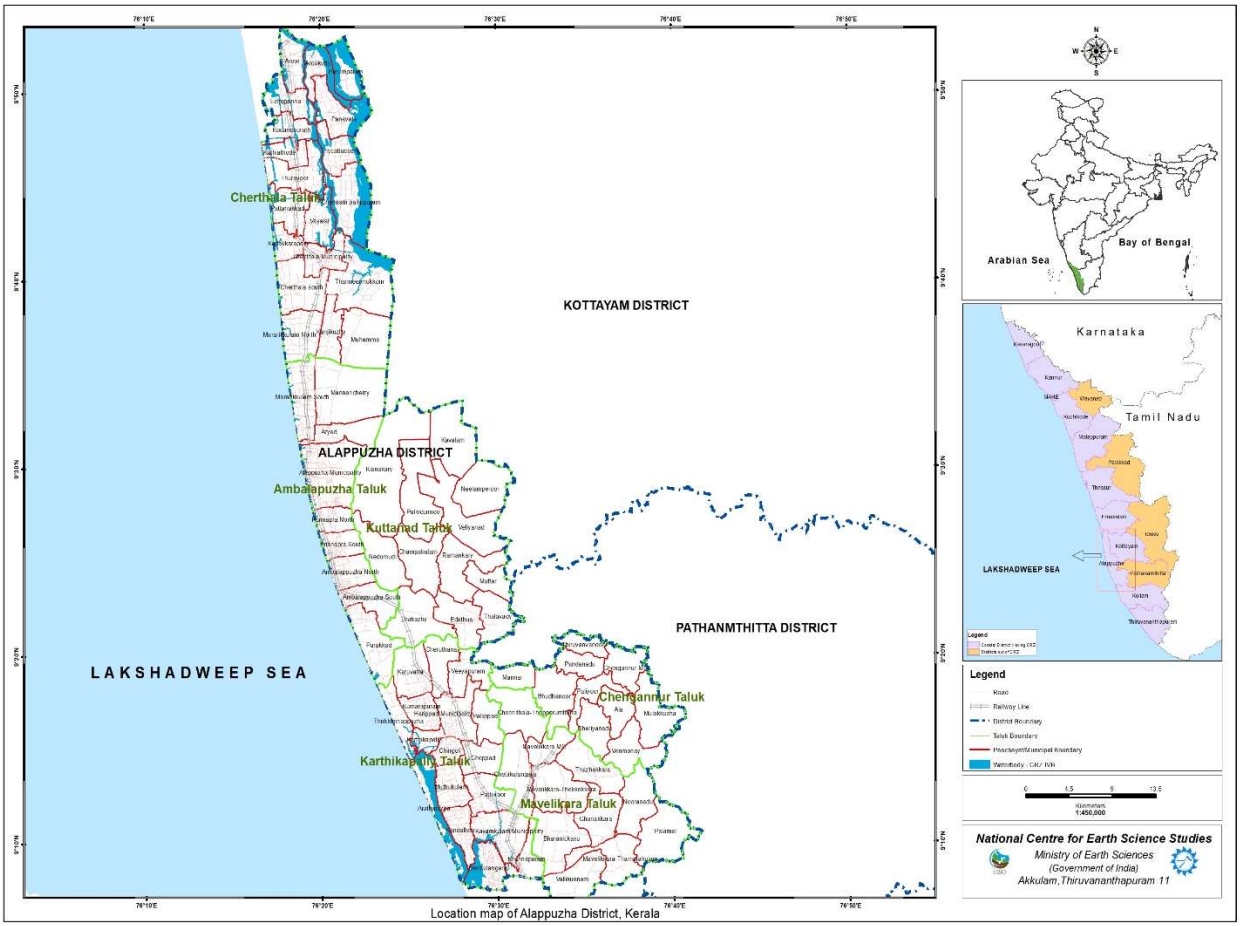

Figure 1: Location map of Alappuzha District

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 Alappuzha district comprises of three sub-micro regions viz., (i) Aleppey coast, (ii) Kuttanad low lying plain and (iii) Chengannur rolling plain.

(i) Alleppey coast region falls all along the coast of the district comprising the whole of Cherthala taluk and part of Ambalappuzha, Karthikappally and Mavelikkara taluks. It is a low-lying land having marshy areas in some places. Regarding the relief feature of this region, the height of the land is very low even below the sea level in some areas, besides some portion being marshy lands maximum height is recorded at Vallikkunnam village of Mavelikkara taluk (18m). Vegetation also covers this area.

(ii) Kuttanad low lying plain is a special striking feature of Kerala. This region comprises of the whole of Kuttanad taluk and parts of Ambalappuzha, Chengannur, Mavelikkara and Karthikappally taluks. This region is a basin between the coast and its eastern plain. In many places the height is lower than the sea level. Here maximum height (6m) is recorded at Kunnamangalam village of Mavelikkara taluk. It is the typical example of kole lands, and it is highly influenced by the Vembanad lake. Paddy and coconut are the important crops of this region. The main mode of transportation is inland water transport.

(iii) Chengannur rolling plain region falls in the eastern portion of Alappuzha district comprising parts of Thiruvalla, Mavelikkara and Chengannur taluks. This region is also a plain region having the average height between 80 and 90m. The maximum height of this region (157m) falls in Thottappuzhassery village of Thiruvalla taluk, and the minimum height (50m) falls in Kulanada village of Kozhancherry taluk. This region slopes gently towards the west. Coconut is widely cultivated in this region besides sugarcane on the banks of rivers.

Alappuzha district is unique for its wide and lengthy coastal plain. The total area of the district is 1414 sq.km out of which more than 60% constitute the coastal low land and backwater bodies. District can broadly be divided into two provinces. (1) The coastal plain with Quaternary sediments towards the west. (2) The midland terrain with Precambrian basement rocks and Neogene sediments towards the eastern part. The general elevation of the area is less than 6 m above mean sea level with some parts of the area below mean sea level in the range of 1-2 m. Typical coastal geomorphic features such as beaches, shore platforms, spit and bars, beach ridges etc., are seen. The beach ridges are suggestive of successive marine regression. A small part of the district in the southeast forms part of mid land hard rocks.

The area east and southeast of Alappuzha town is known as 'Kuttanad region'. It represents a low-lying deltaic region characterized by wetlands. The beach ridges are suggestive of marine regression. Beach is very narrow and straight. The absence of extensive tidal plain and the intensive coastal erosion may be indicative of neo-tectonic activity. The beach between Purakkad and Thrikkunnappuzha is undergoing active erosion. The widest part of the coastal plain of Kerala is seen in this district, in the stretch between Ambalappuzha-Thiruvalla, Haripad-Chengannur sections where its width is as much as 35 km. The prominent landforms of this area are the palaeo beach ridges, inter tidal flats, delta and flood plain. The low land region along the mouth of Pamba and Achankovil rivers has helped to develop a well-marked distributary system in the form of a delta. Eastern part of the district is characterized by small laterite capped hillocks and narrow valleys representing the midland region.

2.1(c) Rivers and drainage characteristics

The district is blessed with a network of rivers, backwaters and canals which are included in the west coast canal system used as navigation. The important rivers draining mainly in the district are the Pamba River and its tributaries viz., Achankovil and Manimala Rivers.

Pamba River, which is the third longest river in Kerala State is formed by several streams originating from Peerumade Plateau and nearby region. The main tributaries of the rivers are Pambayar, Kakkiar, Arudaiar, Kakkadar and Kallar. The river enters the district at Chengannur and flows through Pandanad, Veeyapuram, Thakazhy and Champakulam. At Pandanad, it flows in a South Westerly direction up to Muttar where Manimala River joins it. The other branch flows around Parumala and a branch of the Achankovil river joins it. It empties into the Vembanad lake through several branches such as Pallathuruthi Ar, Nedumudi Ar and Muttar. The Pamba River drains an area of 804 sq.km of the district and form a deltaic region skirting the southeastern, southern and southwestern fringes of Vembanad Lake.

Manimala River originates from Mothavana hills in Kottayam district and enters the district at Thalavadi village in Kuttanad taluk while it passes through Edathwa and Champakulam villages and joins the Pamba river at Muttar. Manimala River enters the Kuttanad area at Thondara and confluences with Pamba River at Neerettupuram.

Achankovil River originates from Pasukidamettu, Ramakkaltheri and Rishimalai of Kollam district and enters the district at Venmoni. This river is often known as Kulakkada river. It passes through Cheriyanad, Puliyoor and Chengannur villages and enters Mavelikkara taluk at Chennithala. Achancovil Ar enters Kuttanad at Pandalam and joins Pamba River at Veeyapuram. Vembanad Lake, the largest back water in the State lies in the northeastern part of the district separating Alappuzha from Kottayam district.

2.1(d) Coastal Wetlands

Apart from the estuarine part of the rivers joining the Lakshadweep Sea, other important backwaters in the form of lagoons (Kayals), canals and distributary systems of the rivers occupy a considerable part of the coastal plain of Alappuzha district. Vembanad Kayal, Karthikappally Kayal, Vayalar Kayal and Vatta Kayal are some of the prominent back water bodies. In addition to this, there is a conspicuous low-lying area which is below the sea level (0.5 to 1m below msl) and is always under waterlogged condition. This is the Kuttanad area south of Vembanad lake. All these water bodies are brackish during summer. The Thanneermukkom barrage across Vembanad lake and the Thottappally spillway help to a certain extent the incursion of sea water during the high tide. Furthermore, the district is an area of impounded water, area in extent and often with a regulated flow of water. It includes manmade reservoirs/lakes/tanks/canals, besides natural lakes, rivers/streams and creeks. The water bodies mapped occupy an area of 17550 Ha accounting for 12.40 percent of the total area.

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.

As per the Census 2011, with 2127789 persons, Alappuzha district ranks 9th among the districts of the state in population. The district has the fourth highest effective literacy rate (95.72 per cent) and with regard to female literacy rate, it also stands at the 4th in the State. Alappuzha is the second densest district (1504) in the state in terms of population per sq. km. Kuttanad Taluk, known as the rice bowl of the state, has a predominant position in the production of rice. In work participation rate (37.81 per cent), the district has the 4th position among the districts. Alappuzha district ranks the 3rd in female work participation rate (24.02 per cent). In the district 74.13 percent of workers are main workers and 25.87 percent are marginal workers. The district stands in the 2nd position in the percentage of workers in household industry (4.46 per cent).

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.

Physiographically, the 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 area is mainly covered by the low land coastal plain and part of lateritic mid land. The coastal plain forms a narrow belt of palaeo-coastal/alluvial depositional landforms which running parallel to the coast with a maximum width of about 35 km. A major part of the district represents coastal plain characterized by landforms of marine, fluvial and fluvio marine origin. 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 landforms are conspicuous in the coastal plain region, consisting of sand and alluvium. The widest part of the coastal plain of Kerala is seen in this district, in the stretch between Ambalappuzha-Thiruvalla, Haripad-Chengannur sections where its width is as much as 35 km. Other major geomorphological features identified from the area are barrier islands, beach ridges, mudflats and tidal flats, flood plains and mangrove swamps. The ground elevation ranges from 0.3–98 m

above MSL. The data shows a smooth gradient in the coastal plain part (0–8 m) compared to the eastern side adjoining midlands. The maximum ground elevation of 98 m above MSL is noticed in the eastern part. The lowland area that forms the western part comprises of backwaters, lagoons and artificial channel networks. The midland areas lying east of the low land coastal plain have natural drainages. As a whole, the area has a slope downwards from east to west.

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 Alappuzha 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. The activities covered in this sector are (i) fishing in ocean, coastal, offshore and inland waters for commercial purposes ii) Subsistence fishing in inland waters (iii) Gathering of sea weeds, seashells and other ocean and coastal water products (iv) Fish curing. Kayamkulam and Thottappally are the two existing fishing harbours in Alappuzha district, with Chethi and Arthunkal under construction. This is one of the well-developed coastal districts in southern part of Kerala State which extends 82 km consisting of 54 fishing villages. This stretched between Pallithode in the north and Valiazheekkal in the south. Vembanad and Kayamkulam backwaters and the network of rivers and canals enrich inland fish farming. Both brackish water fish farming and freshwater fish farming are done in this district. There are 30 marine and 24 inland fishing villages. Based on 2018-19 report, annual fish production was 45500 MT from marine and 51207 MT from inland sector totaling 96707 MT. Fisher folk population was 194252 with a breakup of 131077 from marine and 63175 from inland as per the estimate for 2019-20. In the district, no hatcheries and aquafarms exist in the public sector. 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 Alappuzha district

Alappuzha, which hitherto famous as the Venice of the East, boasts of a network of waterways having rich biodiversity. Alappuzha is the only district in Kerala having no area under forest cover. However, the ecology of the region is under a huge threat. Kuttanad, is the landscape

in Alleppey with the lowest altitude in India, a major part being below mean sea level. Part of India's largest wetland systems, Vembanad Kole, Kuttanad region occupies large expanse. Kuttanad was reclaimed from Alappuzha and Kottayam districts and is highly fertile. Kuttanad has an average elevation of one metre above mean sea level and has a dense population too. Known as "the rice bowl of Kerala," Kuttanad is one of two places in the world where agriculture is practiced below sea level. Bio-bunds made of mud, coir, banana waste and bamboo check seawater intrusion and provide an indigenous de-watering and pumping mechanism; pettium parayum is a local mechanism which channels water to the fields. Goose rearing, poultry, coir making, fisheries and horticulture are the common sources of livelihood which also help conserve biodiversity**.** With almost 20,000 waterfowls, including the endangered spot billed pelican, oriental darter, water cock and black billed tern, the wetland is remarkable for its migratory bird population. Due to a mix of saline and fresh water, the wetland has a rich diversity of clam, shrimps and live and sub-fossil deposits, several species of fin fish, shellfish, the endangered golden catfish, the Pearl spot, perchlets and freshwater giant prawns. The region is also known for its rich flora diversity. It has several species of algae (green, blue, yellow brown), desmids, agiosperm and rare mangroves.

The aquatic habitats are common in the lowlands of the district with extensive lakes, canals and river systems occupying substantial geographical area. While the partly submerged areas of the district are utilized for cultivation of paddy, the banks and inland areas adjoining the water bodies harbor agri-biodivesity and native elements of fauna and flora. Strand flora is quite rich in the district, with hundreds of native species. Woody climbers, shrubs and herbs are also seen in such areas as exemplified by presence of several species.

Alappuzha 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 Kayamkulam Kayal have good expanse of mangroves. 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 Corportaion. 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 (Kayals); 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. 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.

Unlike in the past, in Alappuzha, small patches available are confined in Kayamkulam and Pathiramanal Vembanad backwater areas.

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 Alleppey 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 Alappuzha 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 Alappuzha District

Sl. no	Name of Waterbody	Latitude	Longitude
1	Vembanad Backwater	9°40'27.26" N	76°23'59.31" E
2	Pampa (Tributary)	9°19'2.28" N	76°23'11.78" E

3	Pullikil River	9°16'20.69" N	76°24'30.52" E
4	Trikkunnapuzha River	9°15'32.30" N	76°24'44.26" E
5	Karipuzha Thodu	9°12'42.67" N	76°29'50.38" 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, an estimate in 1992 gave an aerial extent of 90 sq.km of

mangroves in Alappuzha district, mostly distributed along the estuarine banks of Vembanad and Kayamkulam lakes. 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 met with in such disturbed formations. In the ecotones and more degraded sites harbouring the vegetation type, several mangroves associate also flourish.

The total extent of mangroves in Alappuzha district is 1.28942 Km^2, which is a moderate presence among the coastal districts in Kerala. Among the local bodies, Arattupuzha Panchayat (0.216485 Km^2) followed by Punnapra North (0.18934 Km^2) have moderate growth of mangroves. In the case of Panchayats such as Kadakkarapally, Karthikapally, Kodamthuruth, Mararikkulam North, Mararikkulam South, Muthukulam, Panavally, Perumbalam, Punnapra South, Thanneermukkam and Vayalar are devoid of mangroves. Among the urban local bodies, Alappuzha Municipality (0.282794 Km^2) followed by Cherthala Municipality (0.005633 Km^2) have some meager presence of mangroves and is being threatened in the face of rapid urbanization process. Harippad and Kayamkulam Municipalities do not have any traces of mangroves. (Detailed table is annexed in Annexure 2).

5.2. Coral Reefs

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

5.3. Reserve Forests

Reserve Forests have not been reported from the Alappuzha coast.

5.4. Sand Dunes

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

5.5. Salt marsh

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

5.6. Nesting Ground of Birds

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

No archeological or heritage site falls in the CRZ area of the Alappuzha district.

5.8. Seagrass

Seagrass locations have not been reported from the Alappuzha coast.

5.9. Mud flats

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

5.10. Turtle Nesting Grounds

Only one stretch near Purakkad beach has been identified as turtle nesting site along the Alappuzha district. Local information gathered confirms that turtles do not appear regularly during nesting period of November and December every year. Area of turtle nesting for the location is around 0.006258 Km^2. (Detailed table is annexed in Annexure 2).

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 Alappuzha 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 7.027416 Km^2. Apart from this, vast expanse of pokkali fields is available in the Alappuzha district accounting for an area of 12.76014 Km^2 (provided in the Table in the Annexure-2), where alternating seasonal practices of aquaculture and paddy cultivation is being done. Arattupuzha Panchayat tops the list with 1.417221 Km^2 spread of intertidal area, followed by Pattanakkad Panchayat with 0.356355 Km^2. Except Krishnapuram as well as Pathiyur panchayats and Cherthala and Harippad Municipalities, all other local bodies have varying spread intertidal areas. In the case of Pokkali category of CRZ IB, Chennam-Pallippuram panchayat (4.609205 Km^2) followed by Aroor (2.140857 Km^2) have widespread. (Detailed table is annexed in Annexure 2).

5.12. Salt pan / Aquaculture ponds

Though aquaculture ponds are available in Alappuzha 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 Alappuzha District which are spread along certain parts around Vembanad Lake.

Integrated Island Management Plan (IIMP)

The islands demarcated in Alappuzha 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 two forty seven number of backwater islands are present in Alappuzha 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 0.000039 km^2 (Pattanakkad) to 23.669522 km^2 (Chennam Pallippuram, Thycattussery). All together the area of islands accounts for 106.154267 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 ALAPPUZHA DISTRICT

The CRZ of the Alappuzha district consist of CRZ-IA, CRZ-IB/CRZ-IB Pokkali, CRZ-II, CRZ-IIIA, CRZ-IIIB, CRZ-IVA and CRZ-IVB. Altogether 36 local bodies are covered under the CRZ area of which 32 are Grama Panchayaths and 4 are Municipal Council areas. Altogether 39 villages are under the purview of CRZ in Alappuzha District. 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, a part of Cherthala Vadaku and Cherthala Thekku has been merged with Arthunkal village (15.096607 Km^2), a part of Kayamkulam is merged with Krishnapuram (18.024011 Km^2) and a part of Karumadi village merged with Ambalapuzha North (8.65409 Km^2) and Ambalapuzha (5.83389 Km^2). Similarly, as per new panchayat boundary, a part of Cherthala south and Thannermukkom is merged with Cherthala Municipality (20.946096 Km^2), a part of Aryad merged with Alappuzha Municipality (45.184224 Km^2), a part of Thannermukkom merged with Kanjikuzhi (17.007971 Km^2), a part of Chingoli, Muthukulam, Kandalloor and Thrikkunapuzha merged with Arattupuzha (20.946104 Km^2).

CRZ categories and ESAs (Panchayat/Village-wise) in Alappuzha 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 Alappuzha District is summarized below:	
Total length of HTL along the Seacoast	77.97 Km
Total length of HTL along the inland water bodies	880.79 Km
Total Area under the Archeological/Historical sites	NIL
Total Area under the Turtle Nesting Sites	0.006258 Km^2
Total area under mangrove extent	1.28942 Km^2
Total area under mangrove buffer	0.653025Km^2
Total area under intertidal zone (CRZ-IB)	7.027416 Km^2
Total area under intertidal zone (CRZ-IB) Pokkali	12.76014 Km^2
Total area under CRZ-II along the Seacoast	4.536367 Km^2
Total area under CRZ-II along the inland water bodies	1.612452 Km^2
Total area in No Development Zone in CRZ-III along Seacoast	9.530732 Km^2
Total area in No Development Zone in CRZ-III along water bodes	21.73162 Km^2

Total area in CRZ-IIIA along the coast between 50-500 meters	7.912799 Km^2
Total area in CRZ-IIIB along the coast between 200-500 meters	9.974702 Km^2
Total area under the CRZ-IVB category	68.15379 Km^2