# THE SEA LEVEL RISE IN KOCHI –

# SPECIAL REFERENCE KANNAMALY, CHELLANAM, VYPIN

A Project submitted in partial fulfilment of the requirements for the award of a B.A Degree in History

St. Teresa's College (Autonomous)

Affiliated to Mahatma Gandhi University, Kottayam.


HALINE PAULSON - AB20HIS030

GLORIYA - AB20HIS006

ANNJIYANNA V.J - AB20HIS018

NANDANA S.V – AB20HIS034

NITHYA C.B - AB20HIS036

DEPARTMENT OF HISTORY

ST. TERESA'S COLLEGE (AUTONOMOUS), ERNAKULAM

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CERTIFICATE

This is to verify that the project work entitled "THE SEA LEVEL RISE IN KOCHI – SPECIAL REFERENCE TO CHELLANAM, KANNAMALY, VYPIN" being submitted by name in partial Fulfilment of the requirements for the award of B.A Degree in History of St Teresa's College (Autonomous), Affiliated to Mahatma Gandhi University is a bonafide record of the work done by her under my supervision and guidance. No part of this work has been submitted elsewhere for the award of the degree.

| | | |
|---|---|---|
| Dr. Stancy S. | Dr. Vinitha T.Tharakan | Ms Gayathri Varier |
| Asst. Professor, | Asst. Professor, | Guest Lecturer, |
| Head of the Department, | Dept. of History | Dept. Of History |
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# DECLARATION

We hereby declare that this project work entitled a study on "THE SEA LEVEL RISE IN KOCHI – SPECIAL REFERENCE TO CHELLANAM, KANNAMALY, and VYPIN" is an original work done by us under the guidance of Ms Gayathri, Assistant Professor, Department of History, St. Teresa's College (Autonomous). No part of this work has been submitted elsewhere for the award of any degree.

By,

HALINE PAULSON - AB20HIS030

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Place: Ernakulam

Date:

## ACKNOWLEDGEMENT

We wish to acknowledge all those who helped us to complete this project. We thank God almighty for helping us in the right path and made all things possible.

We take this opportunity to express our profound gratitude and deep regard to our guide Ms Gayathri, Assistant Professor, Dept. of History, St Teresa's College Ernakulam for her exemplary guidance, monitoring and constant encouragement throughout the course of the project. She has taken the pain to go through the project and make necessary corrections as and when needed.

We express our gratitude to our Head of the Department Smt. Vinitha T. Tharakan for her constant support and guidance.

We also thank our teacher Dr. Stancy. S for her support and valuable suggestions.We also thank the staff of Kerala History Association, Ernakulam for using us their Library.

We use this occasion to thank all our respondents for the valuable time they spent with us. We thank the staff of the Library of St. Teresa's college for their cooperation.

Lastly, we extend our heartfelt thanks to our family and friends for their constant encouragement throughout the process of creating this project.

Place: Ernakulam
Date:

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# CHAPTER -1

# INTRODUCTION

## INTRODUCTION

Sea level rise (SLR) is an increase in the level of the world's oceans due to the effects of global warming. Burning fossil fuels is one of the causes of global warming because it releases carbon dioxide and other heat-trapping gases into the atmosphere. The oceans then absorb most of this heat. As water becomes warmer, it expands. This results in ocean levels rising worldwide.[1]

Global mean sea level has risen throughout the 20th century, and its continued rise is one of the sure effects of global warming. This has a range of impacts, including increased risk of flooding and inundation, salinization of surface and groundwater, and morphological changes such as erosion and loss of wetlands. The potential impacts on humans and ecosystems in the 21st century is significant but uncertain. The actual impact will depend on the scale of sea-level rise and climate change, as well as a range of human-controlled factors such as coastal land use and management approaches. Importantly, due to the long thermal lag of the ocean system, there is a strong "sea level rise mandate," and thus the sea level rise response to mitigation is slower than other climate factors.[2]

The main benefits of climate change mitigation in terms of sea level rise will therefore be realized well into the 21st century and beyond. This means that the best response to sea-level rise and coastal climate change is the right combination of mitigation and adaptation. Joint assessments of mitigation and adaptation are therefore needed in coastal areas as these policies are intertwined. Such assessments will need to continue beyond 2100 to fully capture the impact of different policy choices. In addition, policy makers should be aware that the outcome of sea-level rise and climate change assessments will depend on the scale of the assessment and the detailed methodologies used. Therefore, there is a significant need to align policy issues and language with the appropriate level of evaluation.

Despite concerns about sea level rise, most countries currently seem to ignore sea level change in their coastal planning. There is a need to develop the adaptive capacity of vulnerable coastal areas, such as small island states.[3]

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[1] *Sea Level Rise*. https://education.nationalgeographic.org/resource/sea-level-rise.

[2] *Case Study on Sea Level Rise Impacts*. University of Enfield, UK, 2002

[3] Idem.

The consequences of global warming have become increasingly apparent over the last few decades. One of the consequences of global warming is the shrivelling up of glaciers and melting of the polar ice sheets. They, together with the thermal expansion of ocean water, are leading to Sea Level Rise across the world[4].Sea level has important bearing on other environmental aspects as well. The effects of an increase in mean sea level on an estuarine ecosystem are many. The mean water level[5] of a river may increase as a result of rise in mean sea level, such an increase extending too many tens of kilometres upstream, depending on local conditions, river gradient, and the magnitude of the rise. As a result of sea level rise, the tide will propagate further inland. If the river bed does not build up, salt intrusion will increase, affecting water used for human consumption, agriculture, and industries. Increased mean sea level[6] will lead to increased mean wave height and wave related effects (e.g., erosion). These effects in the estuary could lead to habitat shifts in estuarine flora and fauna.[7]

The estimates of global mean sea level change during the last hundred years, based on tide gauge records, indicate a rate of rise of about 1.0-2.0 mm/yr. Factors contributing to the trends include:

1. Vertical land motions[8] (a) natural and (b) anthropogenic (for instance, dam-building and ground water, gas, and/or oil withdrawal)
2. Coupled atmospheric and oceanographic effects (winds, waves, currents, ocean temperature, and salinity).

An important anthropogenic effect which could be included in this category is related to temperature. The global air and sea water temperatures have increased because of the increased use of fossil fuels, industrialization, deforestation, etc. Because of the global warming due to greenhouse effect, thermal expansion of sea water is taking place causing sea level to rise. This, combined with the melting of polar ice caps (also related to global warming) has also increased the sea level. These factors (1 and

[4] Effect of Sea Level Changes on the Ground Water Quality along the Coast of Ernakulam District, Kerala. Jawaharlal Nehru University, New Delhi, 2018.

[5]Mean water level -The average of all hourly water levels over the available period of record.

[6] Mean sea level- the height of the sea surface averaged over all stages of the tide over a long period of time.

[7] Seasonal and Interannual Variability of Sea Level and Associated Surface Meteorological Parameters at Cochin. Cochin University of Science and Technology, 1999.

[8] Vertical land motion- the average long-term rate of change, over multiple years or decades, of the land surface.

2) vary widely in their effects on recorded relative sea levels. Atmospheric and oceanographic processes, however, produce a large fraction of the seasonal and inter-annual variability in sea level records[9].

SEA- LEVEL RISE (SLR) IN INDIA

India is a sub continental nation with 5,700 kilometres of coastline and two million kilometres square of exclusive economic zone. The Indian coast stretches from the Arabian Sea in the southwest of the country to the Gulf of Kutch in the far westernmost point. Across Mumbai's Salsette Islands and the Gulf of Khambhat. Then through Kanara, along the Konkan, and southward through the Raigad district region before continuing to Mangalore. Later it stretches across the Coromandal Coast, also known as Cholamandalam, and along the Malabar via Cape Comorin, in the southernmost section of South India. The coastline on the South Eastern part of the Indian Subcontinent along the Bay of Bengal through the Utkala Kalinga region extends until the easternmost corner of shoreline near the Sunderbans in Coastal East India. There are many beaches and springs here, as well as beautiful sea and oceans like the Arabian Sea.[10]

The World Meteorological Organization (WMO) has warned that sea level rise poses a serious threat to Bangladesh, the Netherlands, India, and China as well as other nations with large coastal populations. The report, Global Sea-Level Rise and Implications Key Facts and Figures, also noted the significant effects on Mumbai, Chennai, Kolkata, and other coastal cities in the country. This has increased by 4.5 mm/yr between 2013 and 2022, and the paper stated that "human impact was most likely the dominant cause of these increases since at least 1971.[11]

According to the WMO, there will be a significant rise in sea level even if global warming is miraculously kept to 1.5 degrees Celsius over pre-industrial levels. Yet, every tenth of a degree matters. The rise in sea level might double if temperatures rise by two degrees, and future temperature increases will cause exponential sea level rises.

[9] Idem

[10] 'Coastal India'. *Wikipedia*, 3 Feb. 2023, https://en.wikipedia.org/w/index.php?title=Coastal_India&oldid=1137192231.

[11] 'Sea-Level Rise a Major Threat to India, Other Nations: WMO'. *Hindustan Times*, 15 Feb. 2023, https://www.hindustantimes.com/india-news/sealevel-rise-a-major-threat-to-india-other-nations-wmo-.html.

In the short to long-term, sea-level rise will have cascading and compounding effects that will threaten livelihoods, settlements, health, well-being, food, water security, and cultural values through the loss of coastal ecosystems and ecosystem services, groundwater salinization, flooding, and damage to coastal infrastructure.

According to experts, India is most at risk from the cumulative effects of sea level rise. "The expansion of water caused by the ocean's fast warming accounts for fifty percentage of sea level rise in the Indian Ocean. Glacier melt does not contribute as much. In terms of ocean surface warming, the Indian Ocean is the fastest-warming ocean. The effects that India is seeing are brought on by a combination of extraordinary occurrences that are already taking place throughout our coastline. Cyclones are increasing quickly as a result of more moisture and heat from warming oceans. Flooding occurs more frequently as a result of storm surges, which accelerate sea level rise decade after decade.[12]

SEA LEVEL RISE IN KERALA

Kerala is a long and narrow land with an average width of sixty seven kilometres. It is a small state, making up about one percent of the nation's total land area. Kerala runs along the Malabar Coast for around five hundred and eighty kilometres, with widths ranging from about thirty to one hundred and twenty kilometres. It is surrounded by Mahe, a portion of the state of Puducherry on the north-western coast, as well as by the states of Karnataka to the north, Tamil Nadu to the east, and the Arabian Sea to the south and west. Thiruvananthapuram is the city's capital.[13]

The susceptibility of Kerala's coast to flooding is shown by the Intergovernmental Panel on Climate Change (IPCC) assessment, which has issued a stark sea level rise warning for the next century. By 2030, the sea level may increase by 0.11 meters, based on the indications supplied by the IPCC and the NASA sea level forecast tool. By 2100, it will have risen 0.71 meters, and by 2150, it will have climbed 1.24 meters. Scientists predict that a 1-meter increase in sea level will result in the loss of three

[12] Idem

[1313] *Kerala | History, Map, Capital, & Facts | Britannica*. https://www.britannica.com/place/Kerala.

hundred and seventy foursquare kilometres of coastal land for the state, including Kuttanad in Alappuzha.[14]

The estimate states that by the year 2130, twenty square kilometres of the Ernakulam district, eighty-eight square kilometres of Kottayam, one hundred and sixteen square kilometres of Alappuzha, and one hundred and fifty square kilometres land in Thrissur will have drowned. The severity and frequency of severe weather events, including heat waves, droughts, floods, and storms, are said to be influenced by climate change, according to the IPCC study. [15]

Over the 21st century, coastal regions will see a constant rise in sea level, which will contribute to coastal erosion as well as more frequent and severe coastal flooding in low-lying places. By the end of the century, extreme sea-level occurrences, which had occurred only once every hundred years, may occur annually. The IPCC report highlights Kerala's primary danger. Kerala is particularly vulnerable because it is a coastal state, with a high density of people who are at risk from the effects of climate change, severe coastal erosion, frequent floods, severe droughts, coastal waters with high salinity ingress, health risks, threat to agriculture, and endangered biodiversity, according to K.K Ramachandran, a scientist at the National Centre for Earth Science Studies.[16]

SEA LEVEL RISE IN KOCHI

Kochi, formerly Cochin, is a city and major port on the Malabar Coast of the Arabian Sea, west-central Kerala state, south-western India. Also, the name of a former princely state, "Kochi" is sometimes used to refer to a cluster of islands and towns, including Ernakulam, Mattancheri, Fort Cochin, Willington Island, Vypin Island, and Gundu Island. The urban agglomeration includes the localities of Trikkakara, Eloor, Kalamassery, and Trippunithura[17]. The city is situated at the northern end of a peninsula, about nineteen kilometres long and less than 1.6 kilometres wide. To the west lies the Arabian Sea, and to the east are estuaries drained by perennial rivers originating in the Western Ghats. Much of Kochi lies at sea

[14]'374 Sq. Kilometres of Kerala's Coastal Land May Submerge by 2130: IPCC'. *The New Indian Express*, Manoj Viswanathan, https://www.newindianexpress.com/states/kerala/2021/aug/11/374-sq-km-of-keralas-coastal-land-may-submerge-by-2130ipcc-2343018.html.

[15] Idem

[16] Idem

[17]Kochi | India | Britannica. 27 Jan. 2023, https://www.britannica.com/place/Kochi-India.

level, with a coastline of forty eight kilometres[18].It is the biggest city along the west coast of India after Bombay and functions as a nerve centre for distribution of goods due to its proximity to Cochin port. The port facilities are located at the mouth of Cochin backwaters, which forms part of a bar built estuary[19]. Six rivers discharge into the estuarine system, the more important ones being the Periyar and Muvattupuzha[20].

As per a study by Risk Management Services, Inc. (RMSI), a Noida-based IT consulting firm, the IPCC reports for key coastal cities, due to the rising sea levels by 2050, a significant number of the population, property, and infrastructure in Kochi will be under water. The IPCC assessment report indicates that India's sea level will rise significantly by 2050. Sea-level rise in the North Indian Ocean (NIO) occurred at a rate of 1.06–1.75 mm per year from 1874 to 2004 and has accelerated to 3.3 mm per year in the past two-and-a-half decades (1993–2017)[21].

## OBJECTIVES

- To analyze the social and economic lives of the coastal residents of the area of study.
- To examine the social and economic consequences of sea level rising in Kochi.
- To understand the environmental consequences of the rise in sea levels.
- To determine the causes for sea level rise.
- To examine government actions, if any, to regulate the rising sea levels and alleviating the issues of the local people.

[18]Kochi, Kerala - Citizendium. https://en.citizendium.org/wiki/Kochi,_Kerala.

[19] Bar build estuary- sandbars or barrier islands are built up by ocean waves and currents

[20] Atmospheric Forcing on the Seasonal Variability of Sea Level at Cochin, South West Coast of India. National institute of oceanography, regional centre, 2005.

[21] "Coastline of Kochi, Thiruvananthapuram May Be Under Water by 2050." The Hindu, Dhinesh Kallungal22 Apr. 2022,

## REVIEW OF LITERATURE

It is incredibly challenging to comprehend how the sea level changes and much more challenging to research and generalize about the perspectives of coastal communities, which are made up of countless numbers of people. Nonetheless, every attempt has been made to gather and analyze data that is accurate and valid as feasible.

For this assignment, C.P. Achuthamenon's The Cochin State Manual was a very helpful source. This book was used to gather information regarding the development of Vypin Island as well as other sea erosion-related facts.

For the study on sea level rise, reports based on those of the World Meteorological Organization and the Intergovernmental Panel on Climate Change was also used.

## METHODOLOGY

The research used books, official documents like gazetteers, newspaper articles, journals, and personal interviews. This project contains data which mainly focuses on the primary sources like personal interviews, surveys, Gazetteers, case studies etc, which makes it qualitative research. This project is analytical, objective, and descriptive in nature.

Primary data used in this research include Interviews with the local people of Chellanam, Kannamaly, Nayarambalam and newspaper reports. A survey was conducted to know about the general public perception regarding the topic. Due to time limit, only a few respondents were selected as sample for the study. Some of them were reluctant to reveal their personal information. A questionnaire was created; however it was necessary to modify the questions in perspective of the respondents' knowledge of the information and data. Official records such as Gazetteers are used. Field visits to the affected areas were also helpful in conducting the project.

Secondary data used in this project are minimal as there is lack of written evidences regarding the topic. However, some of the newspaper articles were helpful. Many of the journals, reports and links related to the topic were available in the online platform which also acted as a helpful resource.

## AREA OF STUDY

The study has been carried out in the lowland areas of the Ernakulam district of Kerala, India

Chellanam: Chellanam is a 17.5 km long coastal Panchayath of Ernakulam that connects the districts of Ernakulam and Alappuzha. It is situated on the southwest edge of the district. There are almost 16000 people living in the Panchayath, most of them are from the working class and the agricultural community and are engaged in everyday labour activities like as fishing, agriculture, aquaculture, etc. It is a fishermen village; majority of people relies on fishing for livelihood.

Kannamaly: In the Ernakulam district of Kerala, India, next to Chellanam is the seaside neighbourhood of Kochi called Kannamaly. It is included in the Kochi Taluk. The town of Kannamaly is located on the Arabian Sea coast with a population 5704. The male and female populations are 2817 and 2887 respectively. The size of the area is about 3.2 square kilometres. The village's borders with the Arabian Sea, KannamaliKayal, Kandakadavu, and Cheriyakadavu are shared in the west, east, south, and north, respectively.[22] Most of the people here are fishermen and daily wage labourers.

Vypin: One of the groups of islands that are a part of Kerala's Kochi city is Vypin. Between the Arabian Sea in the west and the Cochin backwaters, which are made up of the many distributaries of the Periyar River in the east, is the barrier island of Vypin. The island's southernmost point is at the entrance of the Cochin Backwaters at Kalamukku, close to Fort Vypin, while its northernmost point is on the estuary of the Periyar River in Muziris. The Goshree bridges, which begin at Kalamukku in Vypin, touch two additional islands, and end at Marine Drive, span a distance of roughly three kilometres and connect the island to mainland Kochi. The island is around 27 kilometres long. The island of Vypin ranks 58th in terms of population density worldwide. One of the parts in Vypin with the highest population density is Njarakkal.

[22]Kannamaly'. *Wikipedia*, 28 July 2022, https://en.wikipedia.org/w/index.php?title=Kannamaly&oldid=1100897916.

## CHAPTERS

There are four chapters in this project. In addition to providing an overview of the issue of sea level rise on a global scale, the first chapter also discusses the objectives of the study, a review of the sources used for the study, the methodology used, and a brief description of the subject matter before explaining about the Indian coastal region and Kerala coastal line.

The second chapter consist of the history of each places and the beginning of sea level rise and its impacts on people. It also contains secondary data obtained from publications regarding the early situations in Kochi's coastline region. The study area is established. Also, it contrasts and analyses current and past conditions in coastal areas.

The third chapter examines and interprets the gathered databases. Residents of Chellanam, Kannamaly, and Vypin were confronted with the appropriately prepared questions. It is divided into two sections. In the first, people of chellanam, kannamaly, and vypin discuss their experiences concerning coastal flooding. The second section covers the effects of sea level rise on social, economic, and ecological aspects as well as government attempts to lower the threat of sea level rise.

The last and final chapter includes the conclusion and the summary of the study.

# CHAPTER-02

# HISTORICAL BACKGROUND

Kerala's coastline stretches for a total of five hundred and ninety kilometres. The brackish waterways in Kerala cover about 6,250 square kilometres of land, and they include marshes, backwaters, mangroves, intertidal, and intertidal zones. For a variety of fish, shrimp, crabs, and other marine creatures that are significant for commerce, it serves as a good feeding and breeding site. About 3.33 million people make up the state's population, as of the most recent census (2011). Since most people reside in coastal regions and economic and subsistence activities have an impact on the area's environmental quality, there are even greater demands on the population. Both at sea and in the backwaters, Kerala's coastline is in grave danger. The state's coast is five hundred and ninety kilometres long, with hundred kilometres of backwaters made of lagoons, estuaries, barrier islands, and other coastal features. It makes up roughly 10-15% of the state's total land area. In locations with very high population densities of more than 2500 people per square kilometre, almost forty percentile of people reside in or close to coastal areas. In total, there are thirty four lakes and forty four main rivers spread across around 362,000 hectares of land. With 2,262 people living along the coastline, there are eight hundred and fifty nine people per square kilometre on average. The majority of the state's economic activity is concentrated in this area because 40 percentage of the population lives less than twenty five kilometres from the ocean.[23]

There are only few reliable records of Kochi's early history. After the port at Kodungallur collapsed in 1341 AD, Kochi became more important as a trade port. Most of the people in coastal region were fishermen folk. Some of them were traders, they also practiced agriculture. In 1102 AD, with the dissolution of the Kulasekhara Empire, the PerumpadappuSwaroopam was established. In the early middle ages, when the Zamorin of Calicut acquired the Ponnani territory during the Tirunavaya conflict, the king of Perumpadappu (near Ponnani) escaped to Kodungallur. They eventually relocated to Kochi, where they founded the Kingdom of Cochin. The capital of the ancient princely state, Kochi, was located there for many centuries up until and throughout the British Raj.

From ancient times, Jews, Arabs, Yavanas (Greeks, Romans), and Chinese have known about Muziris, a hub of international commerce north of Kochi (now recognised as Kodungallur in the Thrissur district). Muziris was formerly the centre of the Indian spice trade for hundreds of years. Once the port

[23]An Analysis of Various Coastal Issues in Kerala. Cochin University of Science and Technology, 2014.

at Kodungallur (Cranganore) was wrecked by extensive flooding of the river Periyar in 1341, Kochi gained prominence on the Malabar Coast.

The oldest known references to Kochi are found in the travelogues of the Chinese explorer Ma Huan, who visited Kochi in the 15th century as a member of Admiral Zheng He's treasure fleet. The Italian traveller Niccol Da Conti, who visited Cochin in 1440, also made mention of Kochi in his writings. Currently, Kochi serves as the state's commercial centre and is one of India's second-tier metropolises with the quickest rate of growth.[24]

## CHELLANAM

The pre-colonial Kingdom of Cochin's southern border was defined by Chellanam. Alfonso Albuquerque, a Portuguese commander, overthrew the Adil Shah dynasty of Bijapur in 1510 and established Portuguese sovereignty over Goa. The Gouda Saraswat Brahmins and the Kudumbis. In order to protect their religious and cultural identity, the Daivajnas and VaishyaVanis moved from Goa to India's west coast, mostly by water.[25]

Some of the Goan émigré groups arrived in the Uttara Kannada, Dakshina Kannada, and Udupi districts of the state of Karnataka, while other groups continued on to Kerala. One of these initial migration parties arrived on the Kerala Island of Cherai. From Ernakulam, they gradually moved south and settled in coastal regions.

They were pioneers in the cultivation of the well-known "Chettiverippu" variety of paddy rice, introduced from Konkan, and were experts in paddy farming, particularly in the low-lying fields of the Kerala backwaters. It's possible that a Maharaja invited a group of Kudumbis to relocate to Chellanam where they were welcomed with (free of tax) a coconut garden and rice-growing land. In exchange, they had to provide Avil free of charge to the temple and palace.

[24]'Kannamaly'. *Wikipedia*, 28 July 2022, https://en.wikipedia.org/w/index.php?title=Kannamaly&oldid=1100897916.

[25]'Chellanam'.*Wikipedia*, 20 May 2022,

Castes belonging to the Pulaya and Kudumbi have historically made up the majority of Chellanam's agricultural workers. Additionally, many people are seen to have converted to Christianity throughout the Portuguese era. Residents of Maruvakad, who were residing close to Thiruhridaya Chapel and within 100 metres of the Velankanni Matha Pilgrim Centre on May 24, 2010, unearthed a historic well that was said to have been constructed and utilised by the Dutch Army some 200 years prior.

The most valuable resource for the residents of Chellanam is water. Chellavanam is currently referred to as Chellanam.

Pokkaly fields make up the majority of Chellanam village. The fields used to be prepared for paddy cultivation starting on Vishu Day, which falls in April each year, according to custom. The ground needed to be dried off in the blazing sun for over a month before the first rain of the monsoon season could wash the salt residue from the prawn farming off. South of South Chellanam is where you'll find Chellanam Harbour, one of Kochi's most scenic harbours. One of Kochi's primary fishing hubs is Chellanam Harbor. The Kerala government has suggested funding for the harbour's upcoming phase of development. Agriculture and fishing are the two main sources of income for the population. The most recent technology is used by fishermen as they engage in freshwater and deepwater fishing. The vast majority of people work in Kochi City. A growing neighbourhood in Kochi's south west is called Chellanam. [26]

The majority of Chellanam residents claim that the sea used to be much farther away from where they currently live. They had to go quite a distance to see the water. It took a full day to go there. Around five kilometres separated it from their current home. The water has, however, gotten considerably closer to their homes as a result of the rise in sea level.

There used to be rows of residences, but today many of the lanes have been wrecked by sea waves, forcing residents to relocate to other locations. Even though the homes are far from the sea, they might still find water if they dug twice in their yard. They basically live above water as a result of sea level rise. Water tends to expand under the earth.

[26]Idem

KANNAMALY

Kannamaly is coastal suburb of Kochi situated near Chellanam in the Ernakulam district of Kerala, India. It comes under the Kochi taluk. The town of Kannamaly is located on the Arabian Sea coast. The village's borders with the Arabian Sea, Kannamali Kayal, Kandakadavu, and Cheriyakadavu are shared in the west, east, south, and north, respectively. Combining the terms Kannu and Maly creates the word Kannamaly. Kannu means "eye," while maly means "seaport." [27]

Most of the households were fishermen families. Some people did agriculture as their livelihood. Most males went fishing at sea. The sea and water were absolutely essential to their way of life. In those days, there were a lot of fish in the water. And some remained on land to engage in other maritime-related economic activities including constructing boats, drying fish, and weaving fishing nets. Several people carried fish to the marketplace to be sold.

Several Kannamaly inhabitants believe that, contrary to Chellanam, the sea was already close to the seawall. Some claim that the sea was far from their homes and when they were kids, they went to a beach to play and engage in other activities. Earlier only the Chellanam area experienced issues with coastal flooding. But now the entire coastal region is affected by coastal flooding and erosion.

The water level extends and rises by one centimetre, according to official studies and reports. The tsunami in 2004 marked the beginning of the issues with sea level rise. Following that, the sea wall was damaged, and during specific months, sea water began to enter households. However the coastal flooding increased in intensity and destructiveness following two cyclones. The residents say that sea was calmer before and now it is more aggressive. The weather in sea gets changed easily which makes it unsuitable for fishing.

[27]'Kannamaly'. *Wikipedia*, 28 July 2022, https://en.wikipedia.org/w/index.php?title=Kannamaly&oldid=1100897916.

VYPIN

The Vaipin Island is bounded by the Arabian Sea on the west, the Cranganore and Cochin bars on the north, and the backwaters on the east. Formerly cut off from the mainland for decades, it is now joined to Parur by the Cherai Bridge, which opened in September 1960. Azhikal, Ochanthuruthu, Malippuram, Elangunnapuzha, Njarakkal, Nayarambalam, Edavanakkad, Kuzhippilli, Ayyampilli, Cherai, and Pallippuram are among the locations on this island The island is 25 square miles in size and is well known for its extensive coconut farming.

The Vaipin Island was created by the sediment that rivers deposited as they flowed into the ocean and backwaters. The beginning of the Puduvaippu (literally, New Deposit) Era and the date of its existence, or more likely, the population of the area, are related (A.D. 1341). According to legend, the backwaters at Cochin broke through the little sand barriers separating them from the sea in 1341 A.D. and created a new exit.

The island of Vaipin is thought to have emerged about this period. Civil engineers and administrative authorities have long struggled with how to ensure the security of this vast expanse of sandy soil, which is vulnerable to recurring accretions and erosions and their ensuing continuous changes. This natural backwater had been losing dirt during the monsoon season for many years. The terrified villagers watch as their plots of land and coconut groves are undermined and dragged away by the surging sea every year. It was rumoured that a church had been lost to the approaching water and lay buried several hundred yards from shore. A mile and a half north of the Harbour entrance, at a site named Cruz Milagre; the sea had really crossed the gap in 1875.[28]

[28]The Cochin State Manual. By C. Achyuta Menon. 1911.

# CHAPTER-3

# ANALYSIS AND INTERPRETATION

## 3.1. SEA SURGE IN COASTAL AREAS OF KOCHI

The collected data must be processed so that eligible conclusions are made. The interviews were of valuable help in this regard. The purpose of analysis is to summarize the completed observation in such a manner that they yield answers to the research questions. The purpose of interpretation is to search for broader meaning of the answers by linking them to other available knowledge. The field survey was the approach used in this case. Residents in coastal areas were questioned using a series of prepared questions. We concentrated on areas with more severe coastal floods, such as Velankanni in Chellanam, Kannamaly, and Veliyathanparambu in Nayarambalam (Vypin).

### CHELLANAM

When the situation is properly analysed, cyclones and tsunamis are not the main problems. Of course, they are dreadful nightmares, but when we consider a true threat that has a lasting impact, it directs us towards the problem of rising sea levels in Kochi. Nearly all of the locals we spoke with in person said that there used to be more space between their homes and the coast when they were children. We gathered from their childhood memories that there were more residences and a wider beach area, with an estimated eight to ten houses stacked vertically along the shore. We may conclude from this that the sea has taken land from Chellanam alone by a distance of at least three to four kilometres. Studies show that sea levels are continually increasing, and it's frightening to learn that by 2050, practically the whole Kochi coastline region would be submerged.

Earlier, Chellanam was a stunning and vibrant beach area. The problems began after the tsunami of 2004, when things were just about to return to normal when they were once more struck by a series of storms, which eventually caused the area to become low pressured. It mostly had a negative impact on the citizens of Chellanam's financial situation. The majority of the locals were either fishermen or persons who made their living via sea-related activities. As a result, their means of subsistence were disrupted by the regular appearance of low pressure and cyclones. They were restricted from the sea for a very long time.

The 45-year-old villager in Chellanam, Mrs. Sindhu claims that a large proportion of the beach's coast has been consumed by the seawater, which has alarmingly risen. Sindhu was born and raised in the village. The beach appears to have vanished in the majority of the region, as can be seen, as a result of the rising water level. The "Ockhi" and "Tauktae" had quite a massive impact on every person in the chellanam region as a consequence. The lack of a sea wall, or *pulimood* in the local language, is the primary reason for the difficulties that occurred after the hurricane, said Mrs. Sindhu. This sea wall, which was constructed using cement and rock, often serves as protection from the powerful ocean waves that accompany storms. Failure of government to repair the sea wall caused damage to spread to both sides of the wall.

Before 2017, over 1.5 kilometres of the wall had been destroyed. On November 29, 2017, the cyclone "Ochki" made landfall in India and lasted until December 6.The government set up relief camps in Chellanam on July 15th, bringing 1400 inhabitants under its protection. Since the tsunami of 2004, Mrs. Sindhu said they have never gone through anything like this. According to her, they had to see their house in a pitiful state, covered in a mound of muck and grime, as they were returning home. They had to burn their clothing that had been destroyed by the salt water and muck, along with their cooking equipment. Some people's homes were also severely damaged, such as having rifts form in the house walls.

The previous respondent's neighbour and another resident, Mrs. Smitha, a 41-year-old working woman who has lived there for the past 17 years, claims that the area's increased sea level is frequently causing damage during monsoon seasons. She claimed that everything was regular up until the 2017 Ockhi Cyclone, at which point things started to alter. In her mind, the eastern part of the beach was larger, and there were several residences there as well. Now, however, we can see that the dwellings are now submerged as a result of sea level rise, and the residents have relocated.

The issue, according to 68-year-old resident and mason Mr. Anthony, is severely affecting the community of fishermen in Chellanam. His ancestors were all employed in this traditional occupation, but he was forced to give it up for the first time in his family because of the frequent and dangerous waves and unfavourable weather. Moreover, he notes that ninety percentages of Chellanam's inhabitants are composed of fishermen, and that the regular disruption of the sea is seriously harming their

livelihood. The bulk of them do not want to move because fishing or professions surrounding the sea are their primary source of income. They are also not as eager to adapt to new cultures and ways of life. He adds that the lack of accountability on the part of the government is to blame for the situation having reached this point. The impact of both cyclones would have been significantly lessened if the sea wall had been promptly repaired, and there would have been no damage to the homes and possessions of the coastal population.

Another inhabitant, Mrs. Philomina, who moved from Fort Kochi to Chellanam a few years ago, explains her pitiful state. The terrible catastrophe occurred a few weeks after her new house had its housewarming. Mud, salt water, and dirt had coated her new residence. She claims that it took over a week to clean up their house. She also lost all of the modern electronic gadgets, including the mixer and refrigerator. Their newly purchased wooden furnishings, cupboards, and wooden windows also suffered damage from contact with saline water. The new wooden door was damaged by the powerful cyclonic wind and enormous sea waves. With the constant travel between habitation camps and home, their family also became fatigued. The time it took to get back to normal was almost a year. She attributes the primary cause of sea level rise in Chellanam and the cyclone strike at this level to the new harbor built on the city's eastern side.

Another person, who is roughly 74 years old, said that his family relocated to another place in Chellanam when he was seven years old after his family's previous home was destroyed by the sea. Also, the area where their former home was located might now have a six-feet-deeper sea. This implies that the sea level rise has already begun from that earlier period.

The Chellanam region is a 17.5 km long, thin strip of land, with the majority of the region being low lying. To preserve their vehicles and other belongings from the recent flood and its toute, people endured great suffering. It has been discovered that the sea wall overtops saltwater by roughly one metre, which then circulates throughout the whole region. Those living nearby had severe consequences, including significant losses to their household goods and vehicles due to a lack of drainage facilities.

The population growth in the area was also impacted by the sea level rise problem. Most individuals are not very interested in migration. To individuals who leave a certain location and go to another, the government has provided ten lakhs. But for a number of explanations, many are reluctant to accept the government's offer. First of all, Rs. Ten lakhs are not even close to being enough to purchase and construct a new home somewhere. They would not receive at least three cents of land at a different location, and they would be responsible for covering the expense of building on their own. Even if they were able to establish a new home somewhere, they would still need to find a new employment and source of income. As a result, the majority of individuals are unwilling to move. The old generation people find it difficult to move from Chellanam to a new place. Even if the sea destroys their house, they find another house near the coastal region itself. Nonetheless, some of the young people do not wish to stay in the seaside area. They relocate to cities and towns in search of new employment. They believe that they should be able to live peacefully without worrying that the sea would demolish their home.

Since the 2017 event, the region's economic situation has completely changed. As mentioned, the bulk of the population works in sea-related industries, particularly fishing. The area was included to the list of low pressured places since the problem of sea level rise has plainly shown its symptoms. The inhabitants were thus prohibited from engaging in any activity involving the sea, including fishing. As a result, the local economy started to deteriorate dramatically. Also, the younger generation in the area started to lose interest in continuing their ancestors' habit of fishing, which was their primary source of income. A significant section of the younger generation there, according to this research studies, is not interested in continuing the traditional sea-related profession and is shifting their interests to other sectors since they do not feel the job to be lucrative or safe. Hence, there has also been a cultural deviation.

By examining the surroundings of the area and the attitudes of the inhabitants during the field visit and interview sessions, it was determined that they had not shown a great deal of interest in replacing the destroyed compound walls or purchasing new furnishings. As they are unsure about the direction of the water and coastal flooding, it is claimed that the locals are severely disappointed. They mentally prepare to evacuate the region the next instant if something unexpected occurs and are always expecting a rapid change in the weather. In a nutshell, the residents of Chellanam have a miserable life

that excludes even restful sleep and mental tranquilly. Their already extremely poor state is being made worse by the delay in seawall building. The natives themselves create the bund along shoreline by filling cement in jute bags to avoid waves attacking their homes.

Over the period of 40 to 50 years, significant portions of local community and revenue land have destroyed in this area. The peculiar nature of seawater movements occurring in the Cochin area of the Arabian Sea is thought to be the cause of the phenomena of coastal damage. According to a few studies, the dredging by the Cochin Port Trust, which included the deepening of the outer channel, caused the Chellanam shoreline to begin to erode. The dredged material's offshore disposal doesn't contribute to the replenishing of sand along the Chellanam coast. It is thought that Chellanam's coastal erosion is being made worse by Cochin Port Trust's dumping of dredged debris from the ship channel into the ocean.

All these not only have economic, environmental and social consequences, it physically affects the individuals. It causes so much mental traumas, distress and fear in people. Many claim that it is rather terrifying to see big waves hitting their homes. The dwellings would be destroyed as the waves carried enormous stones from the sea wall with them. At least three hours would pass during the duration of the coastal flooding, and occasionally the flooding would resume long after the waves had backed up.

## KANNAMALY

Kannamaly, another coastline village in Kochi, has been severely impacted by coastal flooding brought on by sea level rise. The coastal flooding in Kannamaly got worse following the tsunami in 2004 and hurricanes like ockhi and tauktae in 2017 and 2021. We came to certain findings after conducting interviews with the locals in this area using well-crafted questions. Before, coastal flooding was just a concern in Chelanam. however, it now poses a serious danger to all of kochi's coastal areas, including Kannamaly, Kandakadavu, and Nayarambalam, Fort Kochi. Most the people here are either be fishermen or daily labourers.

Mrs. Gracy, a native of 50 years old, claims to have been born and raised in Kannamaly. She comes from a fishermen family. After the 2004 tsunami, the issue of sea level rise became increasingly severe. Cyclone Ochki also caused catastrophic coastal flooding. She claims that they were isolated to the house and unable to leave. The residence was covered with marine muck. Once the coastal flooding subsided, they cleaned their homes and re-occupied them. As their livelihood is so closely tied to the ocean, they were unable to even get to work during the coastal floods. They are severely impacted by the increasing sea level. A few residents in their area relocated to relief camps. In the early 2000s, problems with sea level rise were less serious. Yet as of late, it has grown.

Local resident Mrs. Reny, 49 years old , and states she settled here following her marriage, which occurred in 1992. The ocean was quite a distance away from the region where they presently reside during this same time. To see the beach, they had to go a considerable distance. The issue of sea level rising wasn't a concern in those years. She asserts that even after the tsunami, the issues were not as serious. Yet coastal flooding has been terrible over the past three years. They are losing a lot of money as a result. They had to cleanse the home of all the sea scum left behind from the coastal floods. They had to replace all the furniture, dishes, and other items.

Joseph, a 68-year-old Kannamaly inhabitant, just resides 10 metres from the ocean. And he never experienced sleeplessness for more than 30 years. He was familiar to waves crashing against his house's wall and surging over the barrier. Yet, he has only been able to get two to four hours of sleep every night for the prior years. He worries about losing his house to the big waves that crash through the broken seawall. Due to tidal erosion, several homes close to his home are inundated. "How am I supposed to sleep in such a place? In order to shield his home from the seas, Joseph explains, "The water may swallow our dwellings at any moment.

Not just Joseph, but several residents of the Chellanam panchayat's Chalakkadavu, Cheriyakadavu, Kandakkadavu, Kannamaly, and Manassery are concerned. They simply ask that the Tetrapod Project be extended to Saudi Junction, which they claim is the only way to protect the shore from surging waves.

"More than 25 years ago, the seawall in the Kannamaly-Manassery region was strengthened. Nothing was done to reinforce or fix it after that. Tetrapod project, which was started at Chellanam, has to be expanded up to Saude Junction inside Kochi corporate limits. If not, everything will be swept away in a few years, adds Joseph.

According to some of the inhabitants, there were no concerns with coastal flooding on past years. However, with time, the sea drew closer to the dwellings. The government regularly provides weather warnings. Yet, there had not been any alerts regarding serious coastal flooding. The waves would hit homes at any moment, whether it was in the middle of the night, the early morning, or the middle of the day. The locals weren't prepared for these large waves during Ockhi. They believed the waves would arrive and depart as usual. But unfortunately, the waves stormed their residences destroyed practically all the appliances, furnishers, certificates etc. Their vehicles, two-wheelers, and auto rickshaws were all damaged as well.

Families with young children and elderly individuals suffered most. They were really unsure of what to do at first. Several families would visit relief camps, but they were not a practical idea owing to the terrible situation of covid. Several of them then relocated to relatives' homes.

The sea level rise had a minor effect on the local people. Those whose homes had been damaged by the sea were compelled to relocate. Others have no desire to leave Kannamaly. because the sea is the backbone of their livelihood. The majority of them are fisherman or daily wage labourers; if there are no jobs at sea, they will seek for other temporary jobs. It would be challenging to locate new occupations if you moved. But, much like in Chellanam, the youths have no desire to stay. Hrithi Joseph, a 22-year-old native, claimed she wanted to relocate somewhere else where she would not have to worry about sea level rise. The cyclone of 2021 completely damaged her house. Her clothing, funds, and certificates were all destroyed by salt water and mud. They afterwards relocated far from Kannamaly.

Each of these not only has physical effects on people but also have economic, environmental, and societal impacts. It leaves them with a lot of psychological traumas, anguish, and dread. Several people assert that watching large waves strike their homes could be quite scary. As huge stones from

the sea wall were carried by the waves, the homes would be wrecked. The coastal flooding would last for at least three hours, and occasionally it would continue long after the waves had backed up.

The people claim that the government's assistance was inadequate. Those who wanted to leave would receive 10 lakhs from them. Following the disaster, government officials would arrive, investigate, and compile a report. Based on that, the government would provide compensation to the affected people. It would be a little form of compensation. Later, as a result of massive protests, the government began building seawalls, pulimuttu, and tetrapods along the beach. Because of all these changes, there was no coastal flooding this year.

**VYPIN**

Vypin is one of the groups of islands that form part of the city of Kochi, in Kerala state of Ernakulam district with around twenty-seven kilometres. This island was formed in 1341 followed by heavy flood and now it is one of the famous tourist places in the state. Edavanakkad, Elamkunnappuzha, Kuzhuppilly, Nayarambalam, Njarakkal and Pallippuram are the panchayaths in Vypin and all the panchayaths are having a part in them which connected to see. The condition of the seawalls in all the regions within Vypin is different. Problems with seawall are directly affecting the lives of people in seaside. They are not able to live other than seaside due to their job that is fishing. So, they are forced to live nearby the sea and their life being risky due to lack of maintenance and in some places, there is no seawall at all. This paper could bring some attention to authority and may use for any further detailed study and action plans.

The natural hazards, including the increasing problems of coastal erosion, high power tides, cyclones, the climate change induced risks, especially, floods, tsunami, sea-wave formations, etc, seriously impact the livelihoods of the coastal communities . Recently, the coastal region especially in the Velliyathamparambu region , have experienced the major problems caused by the devastating cyclone called Okchi during 2 to 4 December 2017, which had resulted in the loss of life of a large number of fishermen, destabilising their families and livelihoods.

By direct observation, we can find the condition of the seawall in each area and also it is important that the area which is famous or considered as a tourist spot the walls are well maintained but still the people nearby that area is facing problems with pollution. In other parts the walls are in very pathetic condition and some there are no walls which is a serious issue. By interacting with the people who are suffering can give a clear picture of what they facing.

Most of the people in Vypin are fisherman and they have to live nearby the sea for their income. By broadly classifying the regions there are areas with seawall which is well maintained and areas without a seawall or not maintained well. The study compares the life of people in these two regions. This study is relevant for any policy-making to prevent problems due to sea-level rising.

There are so many works that related to the Vypin because of the geographical speciality of this island. Studies directly related to seawall are very less but the lack of maintenance of seawall still creating many issues such as damages in the coastal area by swell waves. Seawall is a structure that separates land from water. Its purpose is to discourage coastal erosion as well as other types of damage caused by wave action and storm surge, such as flooding.

Seawalls are typically huge structures that are built to withstand the full force of waves and storms. The roads are damaged and probably there will be soil in the roads and very hard to travel in some regions which will affect the life of seaside people. When the high waves push seawater into houses the people are helpless. They are forces to live nearby the sea because they depend on the sea, most of them are fisherman.

The condition of people who lives in seaside with well-maintained seawall is also facing issues. The areas which can be considered as tourist spots like Cherai and Kuzhippilly are having seawall which is very well maintained. But as these areas are tourist spots people lives there are facing pollution issues due to lack of waste management.

During our data collection in that area  Ajtha Vinod of 45 age  a housewife said that , the sea took away a lifetime of their hard work. Eight years ago, a “sea attack” partially destroyed their home. The house’s foundation washed away by the enormous waves that arrived with her eyes riveted on the

debris, he says, it simply caved in. It hurts to see their home and condition like this. She has a daughter who is completing her degree in nearby college. She also shared experience about how it affected her and her studies. Her study materials, textbooks, certificates were completely destroyed. Also, someday she could not even go to college due to floods and rain. Whenever there is sea turbulence or a surge in water level, their heart skips a beat. This house might also be destroyed at any time if powerful waves broke through the seawall." There is nowhere else we can go", they said.

The government intervened before Cyclone Tauktae hit Veliyathamparambu, which is noteworthy. "The irrigation department spent nearly '10 lakh to fortify some areas of the seawall under the direction of MLA S Sarma. The building only lasted for about a month before collapsing, according to Neethu Binod, president of the Nayarambalam panchayat. She said about the Kerala government has drawn up a comprehensive scheme of 10 lakh rupees for the rehabilitation of fishermen across the region.

The Rs 10 lakh assistance (under the Punergeham project) is not going to benefit anyone here. With that amount, we would be able to buy hardly two cents of land. This is our kadalamma (the Mother Sea), we are not going to leave this place. The government needs to do better," says Kunjappan. But no one is accepting that scheme and not ready to move away from this region. Fear of Wave is not exclusive to Veliyethamparambu. Nearly every community along Vypin, kilometers of coastline experiences recurring high tide concerns. Five people lost their lives in the 2004 tsunami, which also wreaked havoc on this island. The seawall, which was constructed decades ago, has not, in the opinion of the locals, been properly reinforced or rebuilt.

The inhabitants complain that the state government has paid Rs 10 lakh for families to establish residences elsewhere rather than taking scientific steps to soothe their anxieties of being wiped out by the water. The deal has been available for some time, says Devassy, age of 56 a Fisherman. He said that the authorities want to move us. Our reliance on the sea, during the July-August period, when sea erosion is severe. They cannot even go for fishing or any other activities. During that time government will provide them food and shelter. They cannot even sleep properly fearing that our houses might collapse if flood water enters the rooms. They don't have a shield against sea erosion. Every year, three of four houses get damaged in sea erosion," he said. Homes and a groin were constructed with money set aside for tsunami recovery. Yet some of the seawall was demolished following the Tauktae typhoon.

Panchayat president adds that the government shouldn't disregard the fishermen who helped us during the floods.

The house of Suhara, age of 66, is located close to the sea, Suhara and her husband were alone in that house. During the rainy days and sea erosion their house were covered with mud and slob. With the help of some people they removed it. "If sea erosion continues, the temporary wall will be washed away. The people who live near the region will have to bear the brunt of the flooding. Authorities are least concerned over our lives or properties. Spending a day in a relief camp is a miserable experience for victims of natural disasters. Lack of facilities, including toilets, at many camps is the main cause for concern for many, especially women and the bedridden. However, for residents of Veliyathamparamabu has no choice.

"Velliyathamparambu is a hotspot, and tetra pod-laying work is under way there." Said by C.C Siji Ward member of velliyathamparambu. The sea wall erected at velliyathamparambu is in a bad state. "The geo bags and sea walls have been lying in a damaged condition for several years. We approached all departments concerned seeking the implementation of a project to prevent sea erosion. We had also sent letters to the irrigation department many times, but no steps were taken. Though the panchayat erects sand wall every year, it is only a temporary solution," she said. The authorities are only concerned about the coastal belt of Kannamali and the Chellanam stretch. "The people along the coastal belt in our panchayat are also living with hardships during monsoon. It is unfair that authorities are showing scant regard to our lives," she said. She shared some of the pictures of the house that were destroyed during previous times and mention above the 10 lakh plain that were granted by government to the peoples in that region.

Based on a design approved by the Central Water and Power Research Station, Pune, a proposal for seawall construction for the whole of Vypin coastline – costing ninety two crores – has been sent to the higher-ups. "But we have not got financial sanction," he says. The official believes Vypin would need a "more advanced" seawall design. "For that, bathymetry survey needs to be done first. A proposal of I36 lakh for that, too, has been submitted," she said. For emergency work ahead of the monsoon, yet another proposal worth 1.5 crore was also submitted. "We are yet to get a response from the top".

## 3.2 CONSEQUENCES OF SEA LEVEL RISE AND GOVERNMENT ASSISTANCE IN IMPACTED AREAS

### 3.2. (1) Consequences of Sea Level Rise

Coastal farmlands and water sources are also at danger due to rising sea levels. Storm surge and tidal variability intensify the effects of average sea level rise. Both the rise in sea level and the exposed vulnerabilities to the effects have been significantly influenced by human factors. Kannamaly, Chellanam and Nayarambalam are also affected by these global impacts.

Groundwater salinization, floods, and damage to coastal infrastructure are just a few of the negative effects of sea-level rise that will have cascading and compounding effects. In the short to long term, it poses hazards to cultures, economies, livelihoods, communities, health, and well-being as well as to the security of food and water. Due to the sluggish onset changes, increased frequency, and escalating size of catastrophic sea level occurrences brought on by sea level rise, it presents a distinct and significant adaptation challenge.[29]

- Loss of ecosystem : The consequences of sea level rise and the resulting changes to coastal ecosystems are significantly crucial. Both the biodiversity and the people living in the various ecological areas are severely harmed by these effects. A coastal environment offers a diverse species assemblage as well as resources for human needs. The coastal ecosystems contain a variety of dimensions and structures of human need-resources. Coastal areas are highly diverse, ecologically rich, regions of key socio-economic activity, and are particularly sensitive to sea-level change. It is already reported that many coral reefs exist at or near to temperature tolerance thresholds. Several of the tropical oceans have seen rising sea-surface temperatures during the last few decades. Increasing sea surface temperatures have had a negative impact on coral reefs. A variety of fresh water wetlands in low-lying areas might be impacted by sea level rise. Low-

[29]*Global Sea-Level Rise and Implications Facts and Figures*. 14 Feb. 2023, https://public.wmo.int/en/global-sea-level-rise-and-implications-facts-and-figures.

lying floodplains and the accompanying wetlands may be replaced by saltwater ecosystems in tropical areas.[30]

- Groundwater Salinization : Sea Level Rise is considered as one of the effects of climate change that leads to Salt Water Intrusion into the coastal areas around the world, the salt water combines with the clean subsurface water when the sea level rises. thereby contaminating the groundwater and making it unusable for household and irrigation purposes along the coastal areas. Seawater intrusion is the movement of saline water into freshwater aquifers as a result of groundwater development. Any salinity or brackishness along the coastal formations seems to be an indicator of seawater intrusion. Many factors can contribute to salinity, but the main one is the leaching of salts from aquifer material.[31]

- Intensified Flooding: Sea-level rise clearly poses a threat to large coastal urban regions situated in low-lying coastal regions prone to flooding, such as salt marshes, deltaic plains, and estuary and lagoon shorelines. The coast may experience occasional flooding at first, but if there isn't enough sediment to support vertical accretion, this flooding may eventually become permanent. A considerable amount of land will likely be lost as a result of the high and low tide lines moving in a landward direction, permanently submerging a portion of the current intertidal zone(the area where the ocean meets the land between high and low tides). Due to the submergence of their coasts, estuaries and coastal lagoons will often become bigger. Seawater intrusion into coastal lowlands may result in the formation of new lagoons. This unfavourable scenario results from a decrease in sediment supply after the construction of sea barriers that impound silt in basins. Urbanized regions that resemble old salt marshes are under danger of drowning. Here, the natural compaction of peat under the weight of buildings prevents vertical accretion and accelerates sea level rise. Sea-level rise will induce a decrease of the return period of water levels associated with storm surges, even without considering any possible variation in storminess.[32]

[30]Lal, HimanshuSudhee. 'Sea Level Rise and Coastal Dangerous Zone Its Effect a Geographical Study of West Bengal Coastal Region'. *University*, June 2015, https://shodhganga.inflibnet.ac.in:8443/jspui/handle/10603/43039.

[31] Effect of Sea Level Changes on the Ground Water Quality along the Coast of Ernakulam District, Kerala.

[32]Paskoff, Roland P. Effects on Sea Level Rise on Coastal Cities and Residential Areas. Lumiere University, France, 2011.

- Increased Erosion: Lateral erosion may be often the dominant mode of land loss when sea level is rising. Waves begin to break as soon as they get close to the ocean's shoreline. The power of breaking waves striking the shoreline knocked pieces of the existing rock structure away. Water is pushed into rock crevices along the beach by waves, which is another way they degrade the land.[33]

- Tropical cyclones and storm surges: Due to a cyclone called Ockhi in Chellanam, about 220 households were transferred from Kochi's coastal districts as a precaution. Schools were employed as rehabilitation centers in place of over 100 residences, most of which were in Puthenthode and Bazaar. 180 households from Chellanam, 17 from Kannamaly, and 18 from Edavanakad were relocated to these centers, where there was access to food and medical care. Due to another cyclone called Tauktae in Chellanam homes were submerged due to unexpected rain and sea erosion[34]

- Fisheries and Aquaculture: The position of the river estuary would shift due to sea level rise, severely altering the ecology and spawning grounds for fish. Penaid prawns grow and reproduce in brackish water, which is a mixture of fresh and salt water. Sea level rise would reverse this interaction, altering the prawn's habitat. The hatcheries located in Kumbalangi, Kadamakudi, Cheriakadavu etc are located in the coastal zone. Shrimp hatcheries and shrimp farms are vulnerable to the phenomenon since the area is exposed to sea level rise. Yet, by bringing salinity to the coastal area, sea level rise is both beneficial and destructive to shrimp aquaculture. When flooding occurs as a result of another sea level rise phenomenon, such overflowing shrimp ponds, the shrimp end up in the open ocean, which causes significant damage to the industry.

[33]*How Do Waves Cause Erosion and Deposition* https://www.vedantu.com/question-answer/waves-cause-erosion-and-deposition-class-11-social-science-cbse-5ff76a38df870f3650907a02.

[34]'Cyclone Ockhi' 'Cyclone Tauktae'. *Wikipedia*, 26 Oct. 2022, https://en.wikipedia.org/w/index.php?title=Cyclone_Ockhi&oldid=1118320952.

Also,when the sea water level rises, land that is utilized for commercial activities like drying fish, making boats and nets, etc., is lost.[35]

- Agriculture: Salinity intrusion due to sea level rise will decrease agricultural production by unavailability of fresh water and soil degradation. Salinity also decreases the terminative energy and germination rate of some plants. Salinity intrusion degrades soil quality that decrease or inhibit rice production. When the rice fields are converted into shrimp ponds, total rice production decreases because of decreased rice field areas. Sea level rise will increase flood frequency and flooding duration, affecting rice production. Due to sea level rise, salinity of water and soil will increase, and this will damage rice cultivable land. Because of the shortage of fresh water, rice production will be decreased.

- Health: In early April 2008, the World Health Organization (WHO) reported that "climate change is one of the factors causing an increase in the incidence of 2010 diseases like malaria and dengue fever."As one of the effects of climate change, sea-level rise will contribute to the spread of these and other diseases and health problems in several ways. In combination with higher temperatures in many coastal areas, sea-level rise will contribute to the expected resurgence of certain mosquito-borne diseases such as malaria and the introduction of new mosquito-borne diseases, such as dengue fever. As James Titus has noted, "by deepening shallow bodies of water, a sea level rise could cause them to stagnate."Warm, stagnant bodies of brackish water are perfect breeding grounds for disease-bearing mosquitoes. Worldwide, malaria and dengue fever are spreading, both by emerging into new areas and by returning to areas where the diseases had been under control.

According to researchers investigating the link between climate change and cholera, "climate, seasonal weather changes and seasonal changes in ocean currents affect the growth of copepods."Thus, researchers hope that by measuring ocean parameters such as temperature and plankton blooms, they will be able to provide "an early warning system for cholera, enabling an effective deployment of resources to minimize or prevent cholera epidemics. Cholera-carrying

[35]Lal, HimanshuSudhee. 'Sea Level Rise and Coastal Dangerous Zone Its Effect a Geographical Study of West Bengal Coastal Region'. *University*, June 2015, https://shodhganga.inflibnet.ac.in:8443/jspui/handle/10603/43039.

copepods "live in salt or brackish waters, including rivers and ponds, and travel with currents and tides. Evidence indicates that "cholera outbreaks occur shortly after sea-surface temperature and sea-surface height are at their zenith."Thus, sea-level rise, in connection with changes in currents and sea temperatures, could promote the spread of cholera. Moreover, cholera spreads through drinking water and, as has already been discussed, one consequence of sea-level rise is contamination of drinking water supplies.

Contaminated sea water is already the source of increasingly frequent toxic algae blooms. A variety of factors spur marine algae blooms, including temperature, nutrients from agricultural run-off, and other oceanic properties. Some of these algae produce toxic chemicals, and when the algae are present in high concentrations, these toxins can affect humans and other animals.[36]

Table 1. The main effects of relative sea-level rise

| BIOGEOGRAPHICAL EFFECTS | | OTHER RELEVANT FACTORS | |
|---|---|---|---|
| | | CLIMATE | NON- CLIMATE |
| Inundation, flood, and storm damage | Surge | Wave and storm, climate, Morphological changes, Sediment supply | Sediment supply, flood management, morphological changes and land claim |
| | Backwater effect (river) | Run off | Catchment management and land use |
| Wetland loss (and change) | | $CO_2$ Fertilization, sediment supply | Sediment supply, Migration space, direct destruction |
| Erosion | | Sediment supply, Wave and storm, climate | Sediment supply |
| Salt water intrusion | Surface Water | Run off | Catchment management and land use |
| | Ground Water | Rainfall | Land use, aquifer use |

[36]Lal, HimanshuSudhee. 'Sea Level Rise and Coastal Dangerous Zone Its Effect a Geographical Study of West Bengal Coastal Region'. *University*, June 2015, https://shodhganga.inflibnet.ac.in:8443/jspui/handle/10603/43039.

| | | |
|---|---|---|
| Rising water tables/ impeded drainage | Rainfall | Land use, aquifer use[37] |

*Source*: *Case Study on Sea Level Rise Impacts*. University of Enfield, UK, 2002

Notes: Some factors (e.g., sediment supply) appear twice as they may be influenced both by climate and non-climate factors.

The tables demonstrate the biogeographical impacts and the major factors to the increase in global sea levels. These outcomes are also evident in the study's focus area: Chellanam, Kannamaly,Vypin the flooding, storm, and inundation brought on by both climatic and non-climatic factors, including wave and storm activity, sediment supply, carelessness about managing floods, changes to the landscape, etc. Wetland loss is a result of CO2 fertilisation, which restricts plant growth and sediment supply. Wetland is destroyed directly by people through migration and destruction. People move to other locations, especially wetlands, as the sea level rises, causing destruction. People living along the coast are now concerned about coastal erosion and salt water intrusion, which is mostly because of storms, waves, and climate change. It is caused by increased usage of land and aquifiers as well as carelessness in catchment area management.

### 3.2 (2) Government Assistance in SLR impacted Areas

The first attempts to stop coastal erosion in the study area date back to 1910 (Moni, 1973), when a 3 km seawall known as "Campbell's bund" was built to safeguard the coastline to the north of the Cochin outflow. Before building of the seawall, twelve rubble groynes were installed parallel to the shoreline. Before the dredging of the Cochin harbor approach channel, which took place between 1920 and 1929, both the bund and groynes[38] were built. Campbell's bund was built with a sand core and a laterite and granite rubble casing that was mortared with cement. The crest was 3.66 m above mean sea level, and for some time, this has helped to keep this section of the shore from eroding.

A total of 8 km worth of seawalls were built on the south and north sides of the Cochin outflow between 1936 and 1949. This seawall eventually disintegrated because it was unable to resist the constant wave attack. Little stones, steep side slopes, and a lack of an elastic base were blamed for

[37] *Case Study on Sea Level Rise Impacts*. University of Enfield, UK, 2002

[38] A **groyne** is a rigid hydraulic structure built perpendicularly from an ocean shore a river bank, interrupting water flow and limiting the movement of sediment. It is usually made out of wood, concrete, or stone.

the collapse. All of these remarkable developments, nevertheless, had to be experimental. Although though the issue of coastal erosion had been for a very long time, it wasn't until the early 1950s that the need for coastal protection was given the proper attention and on a need basis.[39]

During the most recent rainstorm, it appears that the recently constructed tetra pod-based barrier has provided the people of sea erosion-prone Chellanam with much-needed relief. When the monsoon got stronger, areas that used to get flooded by the destructive waves during the past few years have remained more or less safe. Chellanam's conventional seawall was unable to prevent sea entry, which caused extensive devastation and damage. This led to one of the longest-running protest movements, which has been calling for a long-term fix for well over a thousand days. During Cyclone Tauktae last year, coastal erosion that had become worse following Cyclone Ockhi in 2017 was made more badly, forcing many locals to spend a lot of time in relief camps.

The State government is preparing to expand the initiative to other coastal communities in the State that are equally in danger as a result of the success. Chellanam is now undergoing coastal conservation projects of Rs. 344 crore. Tetra pod barrier construction appears to have aided in protecting the section between Puthanthodu and Chellanam harbor from the risk of sea erosion.

Tetrapod weighing two tonnes and five tonnes are being made. So far, 20, 235 tetra pods have already been produced using 3.50 lakh metric tonne boulders. The project is being supervised by the Anti Sea Erosion Project Management unit under the irrigation department.

The 7.32-kilometre seawall is expected to be finished by April 2023. 40percent of total of the work has already been finished. The building of walkway along the sections where the seawall work has been finished will resume after the monsoon. In the first phase, 6.60 km of the tetra pod barrier will be covered by a three-meter-wide walkway.

With the initial phase of manufacturing, plans are also underway to start the second phase of tetra pod manufacture. The second phase's project estimate is currently being created. Around 10 kilometres of the coastline length will be protected after all stages are finished. In the second phase, tetra pod seawalls will be built in places including Kannamaly.

[39]Kumar, P. K. Dinesh. 'Studies on the Impact of Selected Sea Level Rise Scenarios on the Coast and Coastal Structures around Cochin'. *University*, July 2000, https://shodhganga.inflibnet.ac.in:8443/jspui/handle/10603/131632.

Pinarayi Vijay an, the chief minister, had launched the project on June 11. Yet, before then, construction had already begun. The northern section between Puthanthodu beach and Chellanam fishing harbour will be the subject of the first phase of construction. Moreover, six networks of groynes are being built near Chellanam Bazaar.[40]

For the citizens of the coastal panchayat of Chellanam in Kerala's Ernakulam district, the Punargeham restoration project should have been accepted with a sigh of relief. An effort by the Fisheries Department to assist coastal communities at risk of eviction owing to sea erosion would provide each beneficiary Rs 10 lakh, of which up to Rs 6 lakh may be used to buy a plot of land of their choice, provided that it is at least 200 metres from the high tide line. Any coastal inhabitants who reside 50 metres or less from the high tide line are eligible for benefits.[41]

[40]Correspondent, Special. 'Tetra pod Seawall Brings Relief to Chellanam Residents'. *The Hindu*, 5 Aug. 2022, https://www.thehindu.com/news/cities/Kochi/tetrapod-seawall-construction-against-sea-erosion-success-chellanam-kerala-india/article65730965.ece.

[41] 'Sea Erosion Fears Grip Chellanam, but Residents Refuse Rehabilitation: Here's why'. *The News Minute*, 16 July 2022, https://www.thenewsminute.com/article/sea-erosion-fears-grip-chellanam-residents-refuse-rehabilitation-here-s-why-165912.

# CHAPTER- 04

# CONCLUSION

## CONCLUSION

The study was exclusively focused towards highlighting the causes and consequences of sea level rise in Kochi. The problem has impacted a number of coastal areas, but in this case, the project's main focus has been set on three separate locations. Chellanam, Kannamally, And Nayarambalam are those places. Compared to other areas in Kochi, these 3 locations are particularly impacted by the consequences of sea level rise. Especially after 1993, sea level rose in the research region, but the movement was quite minor. The reliability of the measured sea level rise has increased since 2004. It was determined that the sea level increased at a rate of around 1.8 mm/year over the research period. Among the three, Chellanam has had a greater economic impact than the other two. The area will reportedly be completely submerged by the Arabian Sea by 2050, according to research, and this location has been claimed to be below the minimum sea level. If such a catastrophe were to occur, Chellanam and Kannamaly would be the first areas to collapse.

Kerala is recognized as one of the states with the highest growth rates for marine fisheries over time. Both the threats caused by climate change and the expansion of coastal districts are causing serious environmental problems in the state's coastal regions. Concern has been raised over a 30 to 70 km section of Kerala's coastline owing to varied degrees of coastal erosion. Coastal erosion has gotten worse as a result of human activities including urbanization, dam construction, harbor development, etc. The coastal state has been coping with significant concerns and challenges because of the diminishing fish population and other climate change-related problems that affect the lives of coastal residents.

The threats presented by climate change-related consequences and the general backdrop of decreasing fish supplies are issues that coastal communities are dealing with. The paper makes the case for the significance of protecting marine resources and the environment in order to sustain the economic and social well-being of marine communities, in addition to protecting fishery resources from the standpoint of maintaining intergenerational equity in the access to and use of fishery resources.

Since the 2004 tsunami, this region's circumstance has grown worse. Yet it wasn't until 2017 that the majority of the public started to comprehend what was happening in this area. Tauktae and ockhi were two cyclones that struck in 2021 and 2017 respectively. Over the incidence, the lack of a sea

wall also led to extensive devastation. The purpose of seawalls was to safeguard the inhabitants from strong water waves; when the waves strike the seawalls, their strength will be significantly reduced. The primary cause of the tragedy, according to the locals, was the government authorities' negligence in the restoration of seawalls. Furthermore, they claimed that the government wasn't paying them enough.

Only people who suffered property damage received compensation. Others who experienced flood damage to their vehicles or electronic equipment had to make up the difference on their own. Moreover, they claim that the government has launched a programme that offers ten lakhs to individuals who are prepared to relocate and give up their land to the government. But, they are unsuccessful, which shows that the government has failed to come up with a long-term solution that would allow the villagers to live where they belong.

As we can see, the problem of sea level rise has had a significant impact on the region's economic, political, demographical, and cultural aspects. It has also had a negative impact on the locals' mentality. The economic status of the population of this region has been deteriorated following the tragedy of 2017. The majority of the population is made up of fishermen. As fishing was their primary source of income, being prevented from going to sea while the coastal flooding occurred had a significant impact on their overall economic situation. We realised on the field trip that the people's mindset had changed to one of discouragement and hopelessness. As we spoke with a few of the villages, the majority of them claimed to be leading lives of uncertainty.

The analysis was done to examine the potential impacts and physical responses of the shoreline near Cochin along India's southwest coast as a result of the anticipated rates of change brought on by sea level rise. Studying the, shoreline responses, tropical cyclone development, and impact to coastal protection was accomplished in the background as a contribution to the global research effort focused now in the coastal zones with a mission to obtain detailed pictures of regional impacts (of sea level rise). These studies, which concentrate on site specific characteristics, are likely to provide a lot in the broad generalizations concerning future changes.

Due to the fact that sea level rise is a worldwide phenomenon, its cumulative effects—which include beach erosion, the destruction of coastal ecosystems, and inadequate functioning of

coastal infrastructure—could be enormous. A subset of the potential effects, such as the flooding of land, people, and wetlands, are currently only partially considered in the worldwide evaluation of such consequences. It is inevitable that protective measures against negative effects (such as coastal adaptation) be taken. This requires local effect predictions, which pose a significant challenge to the research community. As an element of coastal adaptation, integrated coastal management is of great importance to ensure the co-existence and well-being of the natural environment and human activities in the coastal zone.

In order to deal with coastal erosion, regulate high tides, restore mangroves, manage solid waste, and other climate change-related problems that are harming Kerala's coastal districts, multiple infrastructure development programmes must be put into place. In light of the declining/depleting fishing resource stock, it is imperative to address the need for alternative livelihood opportunities for vulnerable groups, particularly women, who are most affected by the changing climatic scenario and having a significant impact on the livelihoods of the communities. Each nation on the planet could use the fishing industry as a valuable resource and a long-term source of revenue and sustenance if it were properly protected. If the appropriate laws and regulations are put in place, all threats—aside from those caused by natural disasters connected to the sea—could be eradicated.

APPENDIX NO: 1

## PICTURES

Pic 1: Damaged house in Velankanni, Chellanam

Pic 2: Geobags destroyed by sea water and mud in Chellanam

Pic 3: Another fully destroyed house in Chellanam

Pic 4: Destroyed house at Chellanam

Pic 5: Local library was destroyed and Is filled with dirt and mud in Chellanam

Pic 6: House being destroyed by the stone from seawall coming along the waves. Tetrapod came seen nearby

Pic 7: Construction of seawall in Chellanam

Pic 8: Clearing the water and constructing seawall using large stones

(Picture 1-8 -Source- Haline Paulson on Nov 13, 2022 in Chellanam)

Pic 9: Construction of Seawall using Tetra pods

Pic 10: The inside of a house in ward 8 of Kannamaly. Sand deposits about a foot-high were formed here during the Tauktae cyclone in May 2021

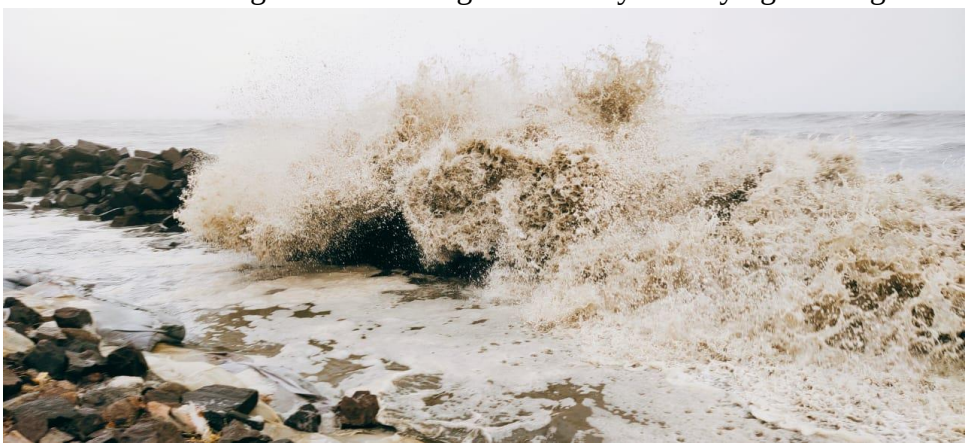
Pic 11: House destroyed due to Coastal flooding in Nayarambalam, Vypin

Pic 12: Houses of Rajamma Das Veliyilparambu and Mollayil Nelson in Cheriyakadavu, destroyed in May 2021

(Picture 9-12 Source- https://www.thenewsminute.com/article/sea-erosion-fears-grip-chellanam-residents-refuse-rehabilitation-here-s-why-165912?amp)

Pic 13: House being destroyed by large waves in Veliyathanparambu, Nayarambalam

Pic 14: Large waves coming into land by destroying existing seawall



(Picture 13-14 collected from the ward member of Veliyathanparambu, Nayarambalam)

## APPENDIX NO- 2

Questionnaire – Analysis on communities in coastal region of Kochi

* Required

1. Name*

2. Age*

3. Gender*

Female

Male

Other

4. Job*
5. Place*
6. Is your area affected by sea level rise?
7. If yes, how does it impact you and your family?
8. How long have you been residing in this place?
9. What impact does it have on your livelihood?
10. How are you adapting to the situation?
11. Have you observed that sea levels have been rising more recently?
12. Was the sea in the same condition as in past years, or has it become rougher or calmer?
13. Which months have the worst coastal flooding?

14. What factors do you believe contribute to coastal flooding and sea level rise in this area?
15. Could you describe a specific incident that occurred during coastal flooding?
16. Do you think that sea level rise will have some impact on the local population?
17. Has the government provided aid to the seriously impacted families from coastal flooding?
18. What steps has the government made to replace the impacted households through resettlement?
19. Are you comfortable leaving this place and relocating elsewhere?
20. What are the necessary measures the government is doing to decrease the threat of coastal flooding?

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