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Shields of the Shore

A Scoping Study on the Status, Threats, Resilience, and Conservation Pathways for India's Coastal Blue Vegetated Ecosystems

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About ClimateRISE Alliance
ClimateRISE Alliance is on a mission to build a Resilient, Inclusive, Sustainable, and Equitable India by placing people, nature, and climate at the center of action. The alliance brings together over 100 civil society organizations, think tanks, intermediary groups, and funding organizations. This collaborative platform seeks to shape an India-centric perspective, establish a common vocabulary, and enable multi-stakeholder engagement to advance intersectional climate action for the country's most vulnerable communities.

For more information, visit: *www.climaterise.in*

About SaciWATERs
SaciWATERs, the South Asia Consortium for Interdisciplinary Water Resources Studies, is a nonprofit Think-Act-Tank dedicated to fostering water-secure and climate-resilient ecosystems and communities across South Asia. Established in 2002, SaciWATERs works through interdisciplinary action research, education, capacity building, grassroots implementation, and facilitating collaborative networks for policy advocacy and collective action. With a strong alignment to the UN Sustainable Development Goals (SDGs), it strives to drive meaningful, lasting changes in vulnerable communities.

For more information, visit: *www.saciwaters.org*

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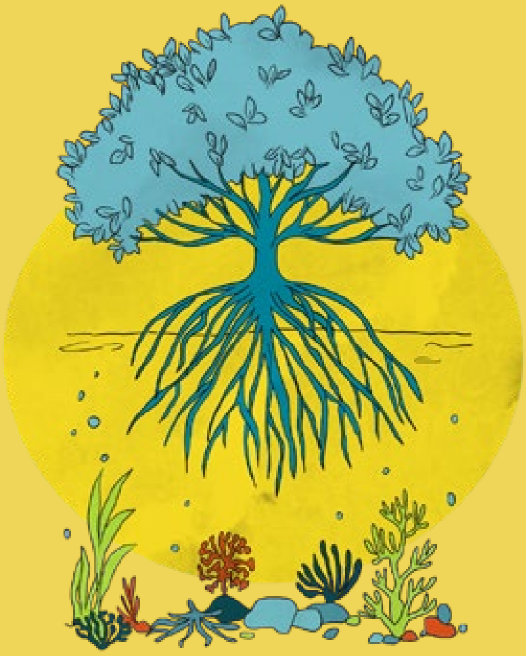


Contents:

Foreword

India's coastline is rich in biodiversity, cultural heritage, and economic opportunity. It is home to crores of people who depend on its resources for their livelihoods. However, these coastal ecosystems, made up of mangroves, seagrasses, and salt marshes—are under unprecedented threat. Anthropogenic pressures, coastal hazards, and climate change are some of the key factors eroding these natural defences.

This study, undertaken by ClimateRISE and SaciWATERs, assesses the current status of India's coastal blue vegetated ecosystems—one of the country's most vital natural assets. Developed in response to a sectoral need for deeper insights, the report compiles key findings on their health, vulnerabilities, and governance. Through a rapid scoping study, SaciWATERs has identified critical challenges and evaluated existing conservation and restoration frameworks. This study aims to bridge information gaps and enhance accessibility to the knowledge needed for effective conservation and restoration. It offers a clear, inclusive synthesis of existing insights while identifying critical gaps in the narrative. These findings the groundwork for urgent action to combat biodiversity loss, environmental degradation, and climate change through informed policy and targeted conservation efforts

At Rainmatter Foundation, we emphasize the critical role of functional ecosystems in mitigating climate change impacts, particularly for the most vulnerable communities. This study outlines actionable pathways to enhance resilience, equity, and sustainability through a targeted agenda of ecosystem restoration, cross-sectoral collaboration, and capacity building. Our goal is to engage policymakers, researchers, funders, and civil society in repositioning coastal blue vegetated ecosystems as fundamental to India's climate resilience and sustainable development. Through collective action, we can safeguard and restore these Shields of the Shore, ensuring their lasting contributions to local livelihoods and global climate resilience.

Siddharth Rao

Director - Conservation and Restoration

Rainmatter Foundation

Acknowledgments

Coastal blue vegetated ecosystems—commonly recognized as blue carbon ecosystems, including tidal salt marshes, mangroves, and seagrass meadows—are essential for climate resilience, biodiversity conservation, and the sustenance of coastal livelihoods. Despite their immense value, these ecosystems face numerous challenges that threaten their long-term survival. This critical state of the ecosystems has motivated us to humbly embark on this study, with the aim of shedding light on the path forward. This scoping study, Shields of the Shore, aims to inform the current status, highlight progress, and identify critical knowledge and action gaps, while serving as an urgent call for a more integrated, science-based, and strategic approach to conservation.

On behalf of the SaciWATERs team, I extend our sincere gratitude to the ClimateRISE Alliance for anchoring and supporting this study. We are grateful for the opportunity to collaborate, which has also provided us with valuable learning experiences. We deeply appreciate the intellectual rigor, dedication, and coordination efforts of the young and dynamic ClimateRISE team, whose insights, review, and logistical support were instrumental in shaping this work.

We are immensely grateful to the sectoral experts who participated in the two rounds of consultations. Their generous contributions of time, expertise, and decades of field experience have enriched this study and provided invaluable perspectives.

A heartfelt thank you to everyone who played a role in shaping this study, and to the design team for their creativity in visually presenting complex ideas in a manner that is both engaging and accessible.

We hope this scoping study serves as a catalyst for further research and concrete action, inspiring policymakers, practitioners, and stakeholders to act with the urgency and commitment that the conservation of these ecosystems demands.

Jayati Chourey, PhD

Executive Director
SaciWATERs

Shields of the Shore

A Scoping Study on the Status, Threats, Resilience, and Conservation Pathways for India's Coastal Blue Vegetated Ecosystems.

Executive Summary:

Coastal blue vegetated ecosystems, or "Blue Carbon ecosystems," are vital to India's environment and communities. Comprising mangroves, seagrasses, and salt marshes, they play a crucial role in maintaining ecological balance, protecting biodiversity, and preserving coastal cultural heritage. These ecosystems are climate heroes—powerful carbon sinks and natural defenses against climate change. They shield coastlines from erosion, support a rich diversity of marine and terrestrial life, while sustaining the livelihoods of millions who depend on them.

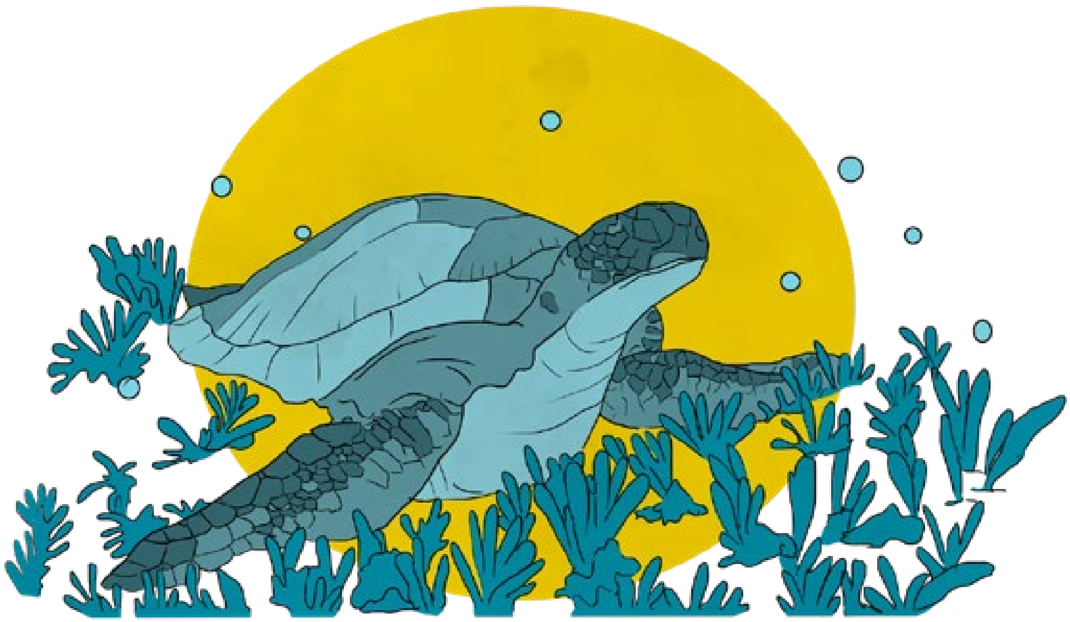
This report on the status of India's Coastal Blue Vegetated Ecosystems highlights the challenges they face, such as urbanization, pollution, and climate change. It also underscores the progress made in understanding, conserving, and managing these invaluable resources, while identifying persisting gaps. The report emphasizes the need for collaborative efforts, innovative management practices, and supportive policies to ensure the long-term resilience and sustainability of these ecosystems.

Chapter 1: Introduction

The Introduction chapter highlights the significance of India's coastal blue vegetated ecosystems, which include mangroves, seagrasses, and salt marshes, as critical components of the country's ecological and cultural landscape. Stretching approximately ***7,517 kilometers***, India's coastline supports a population of ***171 million people*** and plays a vital role in maintaining ***biodiversity***, economic activities, and cultural heritage. This chapter underscores the urgent need for conservation, as these ecosystems face severe threats from ***urbanization, climate change, and pollution***. By outlining the diverse ecosystem services they provide—such as biodiversity support, carbon sequestration, natural protection, and cultural preservation—the introduction sets the stage for understanding the importance of a comprehensive initiative aimed at assessing and safeguarding these invaluable coastal resources.

Chapter 2: Know the Unsung Heroes of India's Coastline: An Introduction to Coastal Blue Vegetated Ecosystems

This chapter introduces India's coastal blue vegetated ecosystems, focusing on mangroves, seagrasses, and salt marshes. It begins by defining these ecosystems, explaining their unique characteristics and ecological importance. The chapter then explores their roles in supporting biodiversity, stabilizing shorelines, and contributing to carbon sequestration. A detailed overview of the species reported within these ecosystems is provided, along with their geographical spread along the Indian coastline. Through this comprehensive introduction, the chapter highlights the vital role these ecosystems play in maintaining coastal health and resilience.



Chapter 3:
Threats and Vulnerabilities Facing Coastal Blue Vegetated Ecosystems

Chapter 3 delves into the critical vulnerabilities facing India's coastal blue ecosystems, particularly under the mounting pressures of climate change, habitat destruction, and pollution. Key ecosystems like mangroves, seagrasses, and salt marshes are increasingly threatened by sea level rise, salinity intrusion, and extreme weather events, which degrade their resilience and ability to provide essential ecological services. The chapter highlights how these ecological stressors not only endanger biodiversity but also intensify socio-economic challenges for dependent coastal communities. Emphasizing the need for comprehensive conservation efforts, this chapter advocates for integrated approaches that address both ecological and socio-economic factors to enhance the sustainability and resilience of India's blue ecosystems.

Chapter 4:
Transforming Conservation: Historical and Emerging Narratives in Coastal Blue Ecosystems

This chapter examines the evolving conservation perspectives on coastal blue vegetated ecosystems—such as mangroves, seagrasses, and salt marshes—emphasizing their roles in carbon sequestration, biodiversity, and cultural heritage. By learning from past narratives, we can develop more effective and inclusive approaches to conservation that respect both ecological integrity and community rights. Initially managed sustainably by indigenous communities, these ecosystems faced degradation during the Age of Exploitation and later industrialization, which disrupted traditional practices. Scientific studies in the 19th century highlighted their ecological importance; however, conservation efforts only gained momentum in the late 20th century with increased awareness of climate change. By 2009, the concept of "blue carbon" formally recognized their climate benefits, though carbon market-driven practices, such as monocultures, now pose new risks. This chapter advocates for a balanced approach to conservation that integrates carbon storage, biodiversity, and community engagement.

Chapter 5:
Governance Frameworks for Sustainable Coastal Blue Ecosystems

This chapter provides an overview of global and Indian governance frameworks for "blue ecosystems," specifically coastal and marine ecosystems. It begins by distinguishing between formal and informal governance structures, emphasizing the need for cohesive approaches to address complex environmental issues. Formal institutions provide binding frameworks for conservation, while informal institutions, rooted in local customs and practices, play an essential role in resource management and community involvement.

This chapter examines India's governance mechanisms for coastal blue vegetated ecosystems, detailing the roles of various ministries and institutions in their protection. Despite these efforts, governance remains fragmented, with gaps in scientific understanding, inadequate integration of local knowledge, and economic pressures from rapid development often undermining conservation outcomes.

It also explores emerging market-based mechanisms, such as carbon credit markets and India's Carbon Credit Trading Scheme, which aim to incentivize conservation through economic benefits. While these initiatives offer potential financial support for ecosystem restoration, they also pose risks, including resource conflicts and the marginalization of traditional livelihoods.

The chapter concludes by emphasizing the need for an integrated governance model that prioritizes ecological integrity, actively involves local communities, and ensures long-term sustainability in conservation and management efforts.

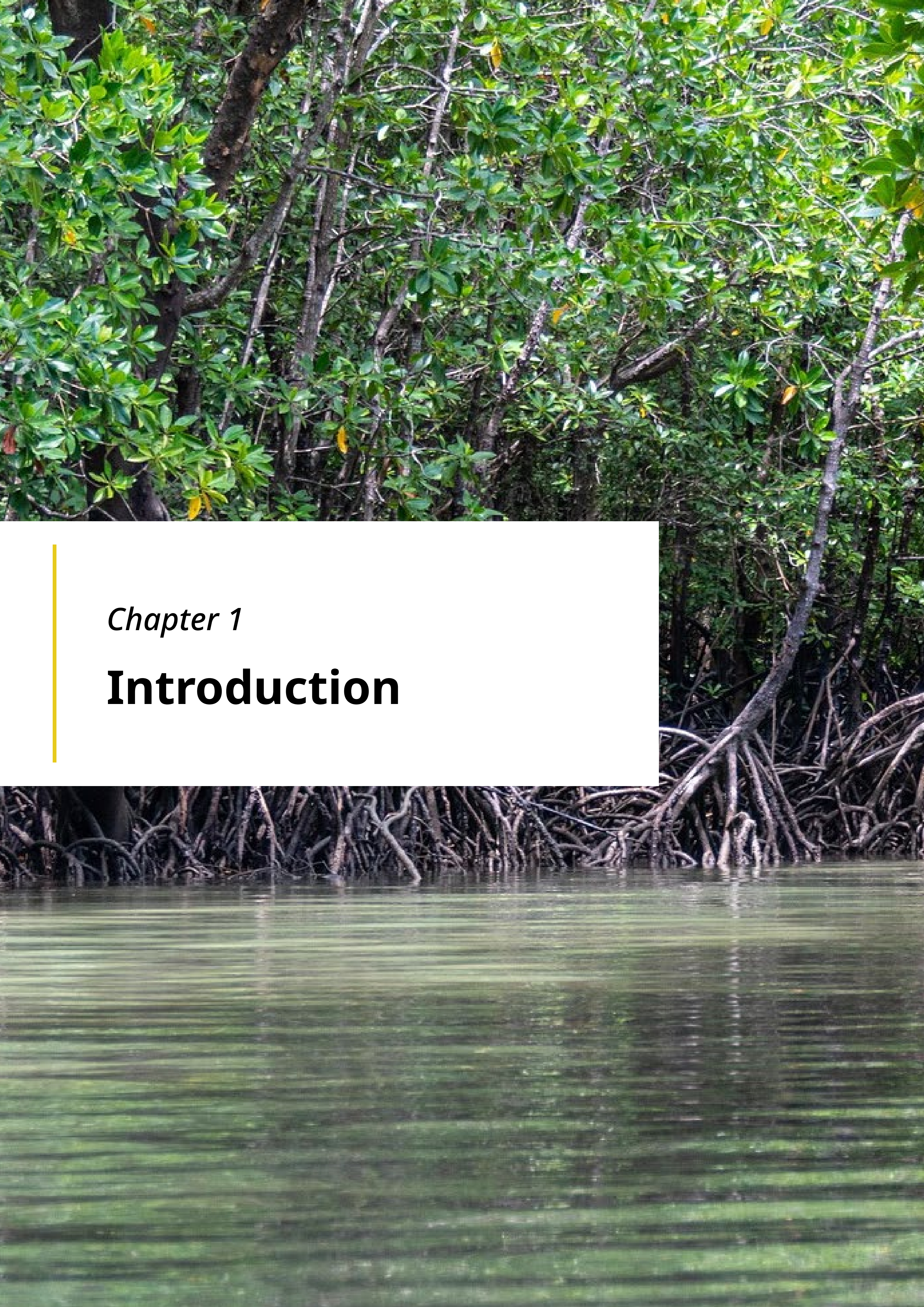
Chapter 6:
Mapping India's Coastal Blue Ecosystems: Key GIS & Remote Sensing Initiatives

Chapter 6 highlights the significance of mapping coastal blue vegetated ecosystems, such as mangroves, salt marshes, and seagrasses, for conservation and sustainable management. Geographic Information Systems (GIS) and Remote Sensing (RS) technologies are essential for monitoring these ecosystems, as they provide crucial spatial data on land use changes, habitat health, and climate impacts. This chapter details the contributions of key Indian initiatives, including the Forest Survey of India's mangrove assessments, NCSCM's Coastal Regulation Zone mapping, and the National Wetland Atlas, among others. Additionally, it introduces the Global Mangrove Watch, a platform offering global mangrove data for conservation and climate action. These mapping efforts enable informed decision-making for biodiversity protection and sustainable livelihood support in coastal communities.

Chapter 7:
Conservation and Management of Coastal Blue Vegetated Ecosystems in India: Gaps, Strategic Pathways and Immediate Action Agenda

Chapter 7 outlines a strategic framework for the conservation and management of India's coastal blue vegetated ecosystems, underscoring the urgency of immediate and coordinated action. Drawing from the scoping study, it identifies critical gaps in knowledge, governance, and implementation that impede conservation efforts. These include inconsistent ecosystem definitions, limited research on emerging threats, underutilization of traditional ecological knowledge, and the lack of accessible data repositories.

To address these challenges, the chapter proposes actionable pathways that emphasize fostering resilience, equity, and sustainability. It presents an immediate action agenda focused on ecosystem restoration, cross-sectoral collaboration, and capacity building for vulnerable communities. The chapter calls on policymakers, researchers, funders, and civil society to collectively reposition coastal blue vegetated ecosystems as central pillars of India's climate resilience and sustainable development.



Chapter 1

Introduction

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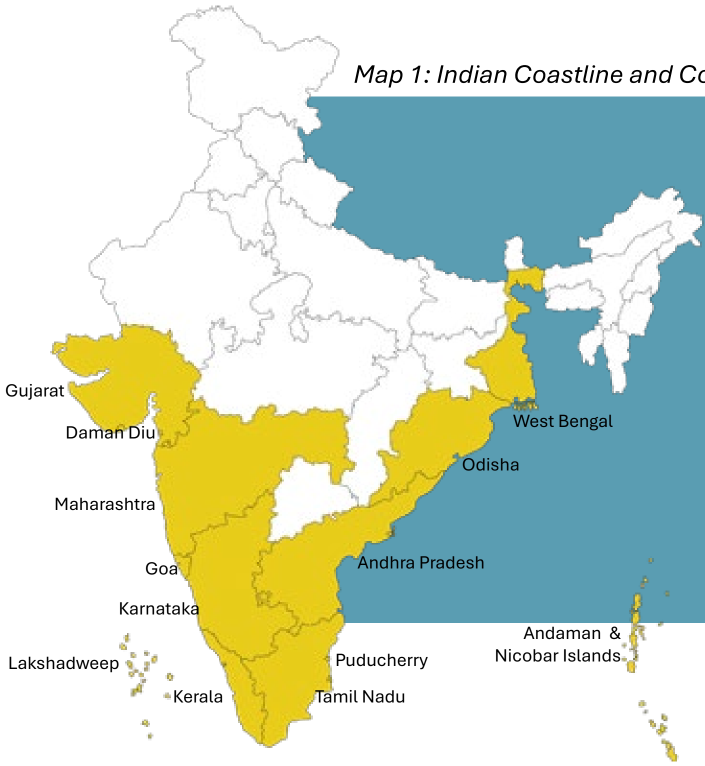
1.1
India's Coastline: A Hotspot of Biodiversity and Cultural Heritage

India boasts an extensive coastline that stretches approximately **7,517 kilometers**, encompassing nine states and four union territories. This coastline is divided into two distinct regions: the **western coastline**, which includes the states of Gujarat, Maharashtra, Goa, Karnataka, and Kerala, and the **eastern coastline**, comprising West Bengal, Odisha, Andhra Pradesh, and Tamil Nadu. Additionally, the union territories of Daman and Diu are located along the west coast, while Puducherry is situated on the east coast (Map 1). This vast maritime territory not only includes the mainland coastal areas but is also enriched by a multitude of offshore islands. India is home to **1,382 islands**, which consist of both inhabited and uninhabited regions. To the southeast, the Andaman and Nicobar Islands are nestled in the Bay of Bengal, while the Lakshadweep Islands can be found in the Arabian Sea (Map 1). The coastline supports a coastal population of **171 million people** and houses **3,432 fishing villages** across **78 coastal districts**, making it a vital area for both ecological diversity and human livelihoods (NCSCM, n.d.).

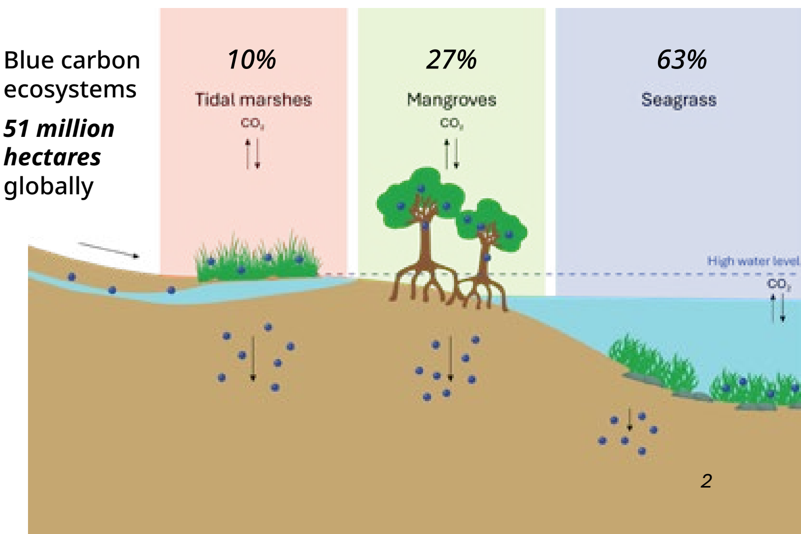
Together, these islands and the mainland coastline play a crucial role in maintaining ecological balance, preserving cultural heritage, and supporting the economic activities of the nation.

Map 1: Indian Coastline and Coastal States



India's coastlines are a living mosaic of estuaries, lagoons, mangroves, backwaters, salt marshes, rocky shores, sandy beaches, and coral reefs, each teeming with distinct flora and fauna that thrive in these vibrant ecosystems.

Fig 1:
Coastal Blue Vegetated Habitats- Guardians of the Shoreline



The coastal regions are characterized by a diverse range of ecosystems that contribute significantly to India's rich biodiversity. Among these diverse ecosystems, **mangroves**, **seagrasses**, and **salt marshes**—collectively known as coastal blue vegetated ecosystems or **blue carbon ecosystems**—stand out for their immense ecological and climate-related significance. About **51 million hectares** are covered by blue carbon ecosystems **globally**, of which **63% are seagrasses, 27% are mangroves**, and **10% are salt marshes** (Choudhar et al., 2024).

1.2
Why Coastal Blue Vegetated Ecosystems Matter?

The 'cradle of biodiversity', the 'lungs of our planet', or perhaps a 'bioshield'—however you choose to describe them, coastal blue vegetated ecosystems provide an abundance of ecosystem services that are vital to sustaining life on Earth. Here are a few highlighted below:

Biodiversity Support:
Provide essential habitats for a diverse range of marine and terrestrial species.

Carbon Powerhouses:
Store five times more carbon than rainforests, playing a critical role in mitigating climate change.

Natural Defenders:
These ecosystems provide natural protection for millions of people against the adverse effects of storms, coastal flooding, and erosion.

Economic Importance:
Sustain livelihoods through agriculture, fisheries, tourism, and other activities that boost local economies.

Food Security:
Ensure access to vital resources, supporting local food security and nutrition.

Cultural Heritage:
Preserve traditional practices and enrich community identity, fostering a sense of belonging.

Increasingly, these ecosystems are recognized for their critical role in the blue carbon economy and as nature-based solutions to global climate challenges. However, their sustainability is under severe threat due to anthropogenic pressures and climate change.

1.3
Vital Coastal Ecosystems at Risk: A Call for Urgent Action

Despite their immense ecological and economic value, India's coastal blue vegetated ecosystems are rapidly deteriorating. Unsustainable urban expansion, infrastructure development, agriculture, aquaculture, and upstream pollution have severely impacted these habitats.

Climate change exacerbates these challenges, with rising sea levels, ocean acidification, and extreme weather events jeopardizing the survival of these ecosystems. Degraded ecosystems release stored carbon as CO_2, further accelerating global warming.

Addressing these challenges requires urgent, comprehensive conservation strategies that integrate ecological restoration with sustainable governance frameworks. Immediate action is essential to protect these ecosystems and their vital contributions to climate mitigation, biodiversity preservation, and community resilience (IUCN & Conservation International, 2023).

1.4
About this report

India's coastal blue vegetated ecosystems, which play a critical role in climate regulation, biodiversity conservation, and livelihood security, are increasingly under threat from unsustainable development, pollution, and climate change. Realizing these challenges, an eight-week rapid scoping study was undertaken to identify knowledge gaps, urgent conservation needs, priority intervention areas, and effective approaches for safeguarding India's coastal blue vegetated ecosystems.

The study provides a foundational analysis of the present situation and outlines a strategic agenda for immediate action, emphasizing interdisciplinary approaches, community involvement, and robust policy measures. By advocating for deeper investigations and sustained efforts, the study serves as both a catalyst for urgent intervention and a guide for long-term conservation planning. While offering timely insights, it acknowledges the need for further comprehensive research and action to address complex conservation and management challenges.

The scoping study was exploratory in nature, and this report presents its key findings. The report is structured as follows:

- An overview of India's coastal blue vegetated ecosystems.
- An analysis of threats and vulnerabilities.
- An evaluation of governance and management frameworks.
- Recommendations and an agenda for immediate action.

While this report is not an exhaustive scientific document, it has been designed to engage a broad audience, including policymakers and community stakeholders. The information is presented in a simple and accessible format to foster engagement across diverse disciplines and sectors of society. This study encourages collaboration and collective action, ensuring the findings resonate with a wide range of readers, ultimately driving informed decision-making and garnering widespread support for conservation efforts.

Methodology:

The scoping study was designed as an eight-week rapid assessment to identify the vulnerabilities and urgent conservation needs of India's coastal blue vegetated ecosystems, including mangroves, seagrasses, and salt marshes. The study aimed to provide a foundational understanding of key gaps and priority areas for intervention.

The methodology employed three primary approaches:

Desk Research

A comprehensive review of publicly available online literature, reports, and datasets was conducted to collate existing knowledge about the health, distribution, and vulnerabilities of these ecosystems. Sources included peer-reviewed journal articles, government publications, policy documents, news articles, and gray literature from non-governmental organizations. The desk research aimed to map the current state of knowledge, identify gaps, and document available data on ecological, socio-economic, and governance aspects.

Expert Consultations

Consultations with ecologists, policymakers, practitioners, and CSOs were conducted to gain qualitative insights and validate findings from desk research. These discussions provided critical context, highlighted on-ground challenges, and identified feasible intervention strategies. A detailed summary of expert inputs is included in Annexure-II (Expert Consultation Report). The scoping study was exploratory in nature, and this report presents its key findings. Two consultations were convened jointly by ClimateRISE Alliance and SaciWATERs to gather these insights:

First Consultation (1 August 2024)

This session focused on defining and understanding the significance and threats to blue ecosystems. Experts discussed key challenges such as reduced freshwater flow, rising salinity, and the need for an inclusive, interconnected approach to conservation. They emphasized methodologies like GIS mapping, remote sensing, and the integration of traditional ecological knowledge for ecosystem assessment.

Second Consultation (26 August 2024)

Centered on community and governance aspects, this consultation addressed region-specific vulnerabilities and socio-economic disparities. Experts highlighted the critical role of local communities in conservation efforts and the importance of cohesive, integrated policies. Participants stressed viewing communities as active stewards of blue ecosystems and advocated for intersectional approaches to address climate-related challenges effectively.

Knowledge Gap Identification

Based on the findings from desk research and expert consultations, a knowledge repository was developed to systematically document existing gaps. This repository categorized gaps into ecological, socio-economic, and governance dimensions, providing a structured framework for prioritizing interventions. The knowledge repository is presented in Annexure-III.

The methods were intentionally designed to be rapid and resource-efficient, given the time constraints of the study.

Limitations of the Study:

This scoping study is a rapid, eight-week situational analysis conducted within the constraints of limited resources and time. It primarily relies on secondary data gathered through desk research of online materials, expert consultations, and the prior field experience of the study team. While these sources provide valuable insights, they may not fully capture the nuances or evolving dynamics of the topic. The study adopts an intentionally broad scope, offering an overview of key issues and gaps in the field while emphasizing the need for further, more in-depth research, governance reforms, and sustainable collective action. As such, the conclusions drawn should be viewed as preliminary, with the understanding that more comprehensive studies are necessary to validate and expand upon these insights.

Terminologies Used:

We have primarily adopted the term ***'Coastal Blue Vegetated Ecosystems'*** to describe ***mangroves, seagrasses, and salt marshes***—popularly known as coastal blue carbon ecosystems. This term emphasizes their unique coastal habitats, defined by habitat-forming plant species and their proximity to the ocean. It effectively conveys their significance in marine and coastal ecology, acknowledging their roles in carbon sequestration, supporting biodiversity, protecting coastlines, and providing various other vital ecosystem services.

However, in certain sections of this report, we also use terms such as ***'blue ecosystems'*** and ***'coastal ecosystems'*** in specific contexts. These terms address broader areas like governance and conservation, extending beyond mangroves, seagrasses, and salt marshes to highlight the interconnectedness of diverse coastal and marine ecosystems. Their use also reflects practical considerations related to governance and management.

A detailed discussion on the evolution of various terminologies, along with their respective advantages and limitations, is presented in ***Chapter 4.***

Chapter 2

Know the Unsung Heroes of India’s Coastline: An Introduction to Coastal Blue Vegetated Ecosystems

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Know the Unsung Heroes of India's Coastline: An Introduction to Coastal Blue Vegetated Ecosystems

This chapter offers an overview of India's coastal blue vegetated ecosystems, which encompass **mangroves, seagrasses**, and **salt marshes**. These unique habitats flourish along India's extensive coastline, each exhibiting distinct characteristics and ecological roles. We will explore the features of these ecosystems, their distribution across India, and the specific conditions that facilitate their growth. This sets the stage for a deeper understanding of each ecosystem's contributions to coastal environments, as well as the threats they face.

2.1 Mangroves: The Blue Forest

What Are Mangroves?

Mangroves are nature's coastal champions, thriving where rivers meet the sea. These salt-loving trees and shrubs stand tall, weaving their magical roots into the shore, bridging the worlds of land and water in tropical and subtropical regions.

How Scientists Describe the Marvels of Mangrove Forests:

Mangrove forests are unique ecosystems located along coastlines, shallow waters, and intertidal areas in tropical and subtropical regions. The trees and shrubs within these forests are specifically adapted to survive in saline environments, growing from sea level up to the spring tide line, under harsh environmental conditions of salinity, temperature, tides, sedimentation, and muddy anaerobic soils (Holguin et al., 2001; McKee et al., 2012). Often referred to as "tidal forests," "coastal woodlands," or "oceanic rainforests," mangrove forests are essential components of coastal ecology (Kathiresan et al., 2015).

The Two Types of Mangroves:

Mangroves aren't one-size-fits-all. Based on their habitat and physiological adaptations, they can be categorized into two main types:

1. **True (Exclusive) Mangroves –**
   These thrive in the core intertidal zones (the "mangal") and are rarely found elsewhere.

"The mangroves are the guardians of our traditions; they preserve our land and enrich our lives. Without them, the seas are empty, and our hopes for tomorrow vanish!"

- Ms. Sandhya Jana Maity, a fisherwoman from the Sundarbans.

2. **Associate (Non-exclusive) Mangroves –**
   These typically occupy the landward margin of the mangal, often creating transitions between mangroves and other ecosystems like rainforests, salt marshes, or lowland freshwater swamps.

The debate over how many true mangrove species exist continues. Depending on how they are classified, estimates range from 50 to 70 species. Tomlinson (2016) recognized 51 species across 20 genera and 15 families, while Spalding et al. (2010) counted 73 species and hybrids in 29 genera and 21 families, with 36 species considered "core" mangroves (FAO, 2023).

Global Reach: Mangroves Across Continents

According to the Global Forest Resource Assessment 2020 (FAO, 2023), mangrove forests span approximately 14.79 million hectares across 113 countries. The distribution is as follows:

- Asia: ***5.55 million hectares*** *(largest area)*
- Africa: ***3.24 million hectares***
- North & Central America: ***2.57 million hectares***
- South America: ***2.13 million hectares***
- Oceania: ***1.30 million hectares*** *(smallest area)*

Notably, over 40% of the global mangrove area is concentrated in just four countries:

- Indonesia: ***19%*** of the total
- Brazil: ***9%***
- Nigeria: ***7%***
- Mexico: ***6%***

Why Are Mangroves Coastal Champions:

Ultimate Survivors: Mangrove species thrive in tough conditions like waterlogged, salty soils, frequent cyclones, and tidal surges, thanks to their special adaptations.

Natural Bio-shields: These coastal forests protect shorelines from extreme weather events, acting as barriers against storms and erosion.

Biodiversity Hotspots: Mangroves provide refuge for a wide variety of coastal species, fostering rich ecosystems.

Lifeline for Communities: Coastal populations, particularly in rural areas, rely on mangroves for livelihoods, using them for biomass and resources.

Carbon Absorbers: Mangroves hold on average, a remarkable 394 tonnes of carbon per hectare in their living biomass and in the top meter of soil. Some mangrove areas, such as those in the Philippines, have average values of over 650 tonnes per hectare (GMA, 2024).

Mangroves in India: A Snapshot

Map 2: Distribution of Mangrove Forests in India (Source: DasGupta and Shaw, 2013)

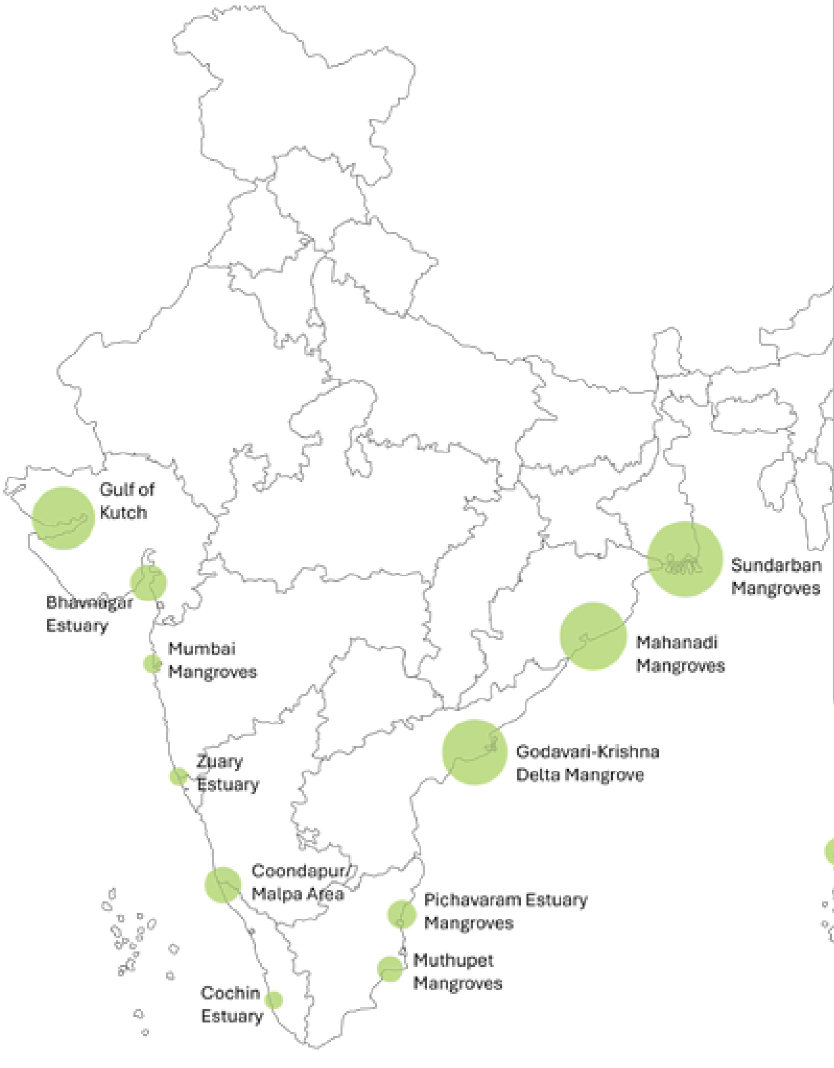
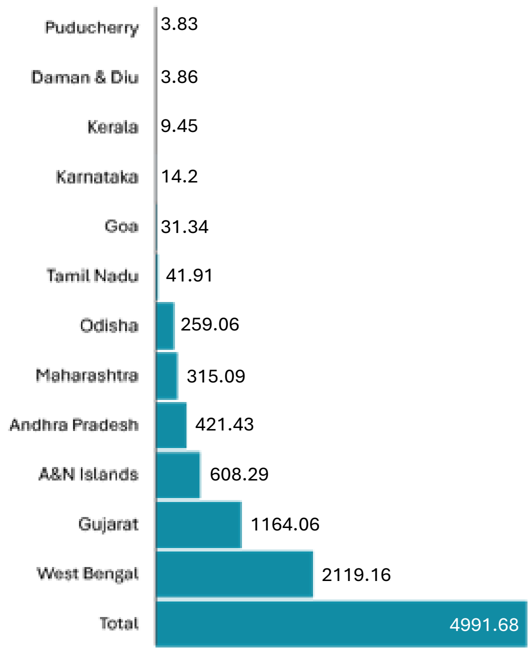


Fig 2: Mangrove cover in coastal states of India (km²)



Source: FSI (2023)

State/Union Teritory	Very Dense Mangrove	Moderately Dense Mangrove	Open Mangrove	Total	Change with respect to 2021 assessment
Andhra Pradesh	0	213.90	207.53	421.43	13.01
Goa	0	23.75	7.59	31.34	1.95
Gujrat	0	179.09	984.97	1164.06	-36.39
Karnataka	0	3.15	10.94	14.20	2.54
Kerala	0	4.73	4.72	9.45	0.02
Maharashtra	0	89.82	225.27	315.09	12.39
Odisha	81.67	94.61	82.78	259.06	1.55
Tamil Nadu	1.19	25.07	15.65	41.91	0.00
West Bengal	981.63	703.79	433.74	2119.16	1.41
A & N Islands	399.37	162.64	46.28	608.29	-4.65
Daman & Diu	0	0.21	3.65	3.86	0.56
Puducherry	0	0.08	3.75	3.83	0.18
Total	**1463.97**	**1500.84**	**2026.87**	**4991.68**	**-7.43**

Table 1: Mangrove Cover Assessment (km^2) as per the India State of Forest Report (FSI, 2023)

Quick Facts on Mangroves in India!

Total Mangrove Cover: **4,991.68 km^2**

Very Dense Mangroves: 1,463.97 km^2

Moderately Dense Mangroves: 1,500.84 km^2

Open Mangroves: 2,026.87 km^2

Net Decrease Since 202: **7.43 km^2**

Source: The India State of Forest Report (FSI, 2023)

Covering approximately 10,000 km^2, the Sundarbans, which spans India and Bangladesh in the Northern Bay of Bengal, is the largest contiguous mangrove forest on Earth.

Mangrove Health Check

- **Net decrease of 7.43 square kilometers** in mangrove cover compared to 2021!
- **States Leading the Way**: Notable increases in Andhra Pradesh and Maharashtra.
- **41%** of India's Mangrove Forests: Classified as poor, with a canopy density of less than **40%**.
- **Gujarat** saw a decline of **36.39 km^2** and **Andaman & Nicobar Islands** of **4.65 km^2.**

"Mangrove cover in India has seen growth, but most of it has been in open mangroves, with much less expansion in the denser forests,"

Shared Ms. Ajanta Dey, Mangrove Specialist, during the expert consultation.

India's Mangrove Ecosystems: A Biodiversity Powerhouse

India is home to one of the richest mangrove ecosystems in the world. Spread across the country's eastern and western coasts, as well as the Andaman and Nicobar Islands, these unique ecosystems harbor a wide variety of species, many of which are endemic to specific regions. The Andaman and Nicobar Islands host several exclusive mangrove species, including Lumnitzera littorea, Rhizophora lamarckii, Rhizophora mohanii, Rhizophora mucronata, Rhizophora apiculata, Sonneratia urama, Sonneratia gulngai, Sonneratia griffithii, Sonneratia lanceolata, Sonneratia alba, and Sonneratia ovata (FSI, 2023).

The total number of mangrove species reported in India differs across various publications due to variations in criteria for identification, classification, and reporting. Here are some key figures that range from:

Indian Council of Forestry Research and Education (ICFRE, 2020): Reports **44** true mangrove species in its publication, A Handbook on Indian Mangroves: Insights, Interventions, and Implications.

Kathiresan (n.d.): Indicates **43** true mangrove species among an extensive assemblage of 4,107 species of plants and animals.

Ragavan et al. (2016): Lists **46** true mangrove species across 14 families and 22 genera, which include 42 species and 4 natural hybrids.

Kumar et al. (2015): Acknowledges **37** true mangrove species in the Spectral Library Database for the Mangroves of India.

IUCN's Mangroves for the Future (MFF) Initiative (2010): Reports **34** species of true mangroves in India.

Botanical Survey of India (1989): Identifies **59** mangrove species across 41 genera and 29 families in its Identification Manual.

Green Climate Fund (GCF) and MoEFCC's Enhancing Climate Resilience of India's Coastal Communities (ECRICC) Project: Estimates **69** mangrove species in India, with 63 species along the east coast, 37 species on the west coast, and 44 species in the bay islands.

"Adaptability to adverse and inhospitable conditions is a key characteristic of these ecosystems that should be considered when defining blue forests"

Emphasized by Prof. K. Kathiresan, Mangrove Scientist, during the expert consultation.

Important species of Mangrove ecosystems in India include *Avicennia officinalis, Rhizophora mucronata, Sonneratia alba, Avicennia alba, Bruguiera Cylindrica, Heritiera littoralis, Phoenix paludosa, Morinda citrifolia,* and *Ceriops tagal* (FSI, 2021). In Annexure-I, a list of 43 mangrove species reported by Prof. K. Kathiresan, an authority on Indian mangroves, is provided for further reference.

Fascinatingly Unique: Facts About Indian Mangroves!

The mangroves of India are globally unique, making the country the second richest in the world for mangrove biodiversity, after Indonesia (Ragavan, 2015; Kathiresan, 2018, 2019).

India harbors 43 true mangrove species. The country holds the world record for the highest number of mangrove associates species, with a remarkable total of 85 species.

Indian mangrove forests exhibit unparalleled biodiversity, hosting a total of 5,746 species. Among these, 84% are fauna and 16% are flora, indicating that the number of animal species is 5.3 times greater than that of plant species (Kathiresan, K.,2019).

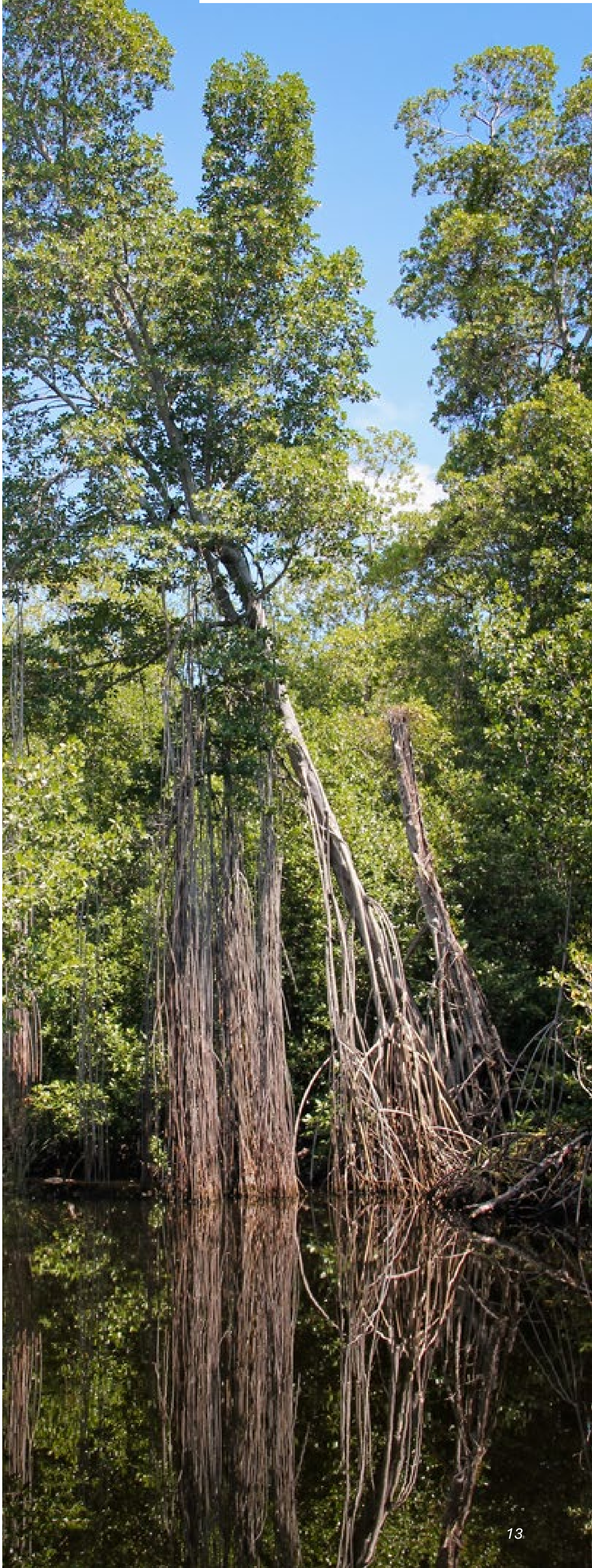
Bhitarkanika in the state of Odisha is globally regarded as a 'mangrove genetic paradise,' akin to the Baimaru area in Papua New Guinea. An island known as "Kalibhanj Dia" in Bhitarkanika spans about 900 hectares and is home to 96 species of mangroves and mangrove associates.

The Sundarbans is the only mangrove-tiger kingdom in the world, famous for its unique blend of mangrove habitats and royal Bengal tigers.

India is home to two globally threatened true mangrove species: *Heritiera fomes* and *Sonneratia griffithii*, underscoring the need for conservation efforts.

Mangroves sequester carbon (C) equivalent to more than 21 billion tons of CO2 and can absorb four to five times more C emissions compared to terrestrial tropical forests. For Indian mangroves, the total sediment carbon stock is estimated to be approximately 41.5 teragrams of carbon (TgC). The Andaman mangroves are estimated to hold 13.8 TgC, while the Sundarbans on the east coast (8.7 TgC) and Gujarat mangroves on the west coast (7.7 TgC) have the highest sediment carbon stocks (MoEFCC,2022).

(Source: Kathiresan. K. n.d. Mangrove Forests of Coastal India, Sahyadri E-News (Online), Issue – LXXIX http://wgbis.ces.iisc.ernet.in/biodiversity/newsletter/issue/79/index.html).



2.2
Seagrasses: Oceanic Meadows Sustaining Life

What Are Seagrasses?

Seagrasses are the ocean's lush meadows, flourishing beneath the waves and creating vibrant underwater landscapes. These remarkable flowering plants not only grace the sea floor but also provide shelter and sustenance for a diverse array of marine life.

How Scientists Describe the Wonders of Seagrass Meadows!

Seagrasses are flowering plants that thrive in marine environments and are present on every continent except Antarctica. These plants possess roots, stems, and leaves, and are capable of producing flowers and fruits. They are closely related to terrestrial plants, having likely evolved from land-based angiosperms (flowering plants) millions of years ago. In terms of land relatives, seagrasses share a connection with monocots, which include grasses, lilies, and palms (Sekar, 2019). Seagrass serves as an indicator of ecosystem health, acts as a sink for atmospheric carbon, and provides a habitat for endangered species (NCSCM, 2022).

Seagrass Habitats: Where Coastal Waters Meet Sunlight and Tides

Seagrasses thrive in coastal regions with clear, shallow waters, where sunlight easily penetrates for photosynthesis. Some species, like *Halodule wrightii* and *Cymodocea rotundata*, adapt to the intertidal zone—the area between the highest and lowest tide lines—which gets exposed as tides recede. These species often grow near mangroves and can withstand both heat and the drying effects of low tide due to the high surrounding humidity. Others, like *Thalassia* species, prefer more stable substrates in this zone. In contrast, species such as *Halophila, Halodule,* and *Enhalus acoroides* (commonly known as tape grass) stay submerged in the sub-tidal zone. *Zostera* (or eelgrass) is typically found in estuarine environments, particularly in Europe. Under favorable conditions, these seagrass species can form vast underwater meadows, some large enough to be visible from space (Sekar, 2019).

Why Seagrasses are Called “Ecosystem Engineers”?

Seagrasses are vital contributors to marine ecosystems, and their unique characteristics earn them the title of “ecosystem engineers”. Here’s how they shape their environment:

Improve Water Quality:
Seagrasses trap sediments and particles, enhancing water clarity. This increased clarity allows more sunlight to penetrate, promoting further growth.

Reduce Nutrient Levels:
By absorbing excess nutrients, seagrasses help prevent algal overgrowth, maintaining a balanced ecosystem.

Stabilize the Sea Bottom:
With extensive root systems, seagrasses anchor the sea floor, akin to how terrestrial grasses prevent soil erosion.

Provide Food and Habitat:
Seagrass meadows serve as critical habitats for various marine species, including fish, octopuses, shrimp, blue crabs, oysters, and endangered species like the dugong and green turtle, seahorses and sharks.

Filter Pollutants:
Seagrasses act as natural filters, trapping pollutants and excess nutrients from land-based industries before they reach sensitive ecosystems like coral reefs.

Sequester Carbon:
These plants absorb atmospheric carbon and bury organic carbon in ocean sediments, playing a significant role in mitigating climate change.

Support Commercial Fisheries:
Seagrass meadows function as nurseries for commercially important fish species, contributing to local fisheries and economies. Seagrasses support an estimated 20% of the world’s biggest fisheries (Potouroglou et al., 2022).

Global Distribution and Coverage of Seagrasses

Global Presence:

There are about **72 species** of seagrass in the world. Seagrasses are found in **159 countries** across six continents (Potouroglou et al., 2022).

Coverage Estimates:

The total area covered by seagrasses is poorly mapped, with estimates ranging from **160,000 km^2 to 600,000 km^2**. This area is approximately the size of France (Potouroglou et al., 2022).

Seagrass Area Coverage in India (2014-2017)

Total Estimated Coverage:

The study conducted by the National Centre for Sustainable Coastal Management (NCSCM) estimated the total seagrass area coverage in India to be approximately **516.59 km^2**.

As per NCSCM, the largest concentration of seagrass:

- **Palk Bay**: This region holds the largest concentration of seagrass, covering **329.70 km^2**.
- **Chilika Lake**: The second-largest area is found in Chilika Lake, which spans **85.47 km^2**.
- **Gulf of Mannar**: This area contributes **69.11 km^2** to the total seagrass coverage.

Smaller Dispersed Patches:

Although the following areas are smaller in scale, they still contain significant seagrass patches:

- **Gulf of Kachchh, Gujarat**: This region has **16.99 km^2** of seagrass.
- **Lagoons of Kadmat and Kalpeni, Lakshadweep**: These lagoons together host approximately **0.72 km^2** of seagrass.
- **Andaman and Nicobar Islands**: This area contains about **14.6 km^2** of dispersed seagrass patches.

Spatial distribution of seagrass meadows in India (in sq m):

Gujarat:

16.99

Lakshadweep:

0.72

Tamil Nadu:

398.81

Odisha:

85.47

Andaman & Nicobar Islands:

14.6

Map 3: Spatial Distribution of Seagrass Meadows in India (Source: NCSCM)

Seagrass Diversity in India: A Snapshot of Coastal Richness

India is home to 16 seagrass species across 7 genera—*Ruppia, Enhalus, Halophila, Thalassia, Syringodium, Cymodocea,* and *Halodule*—contributing to the rich marine biodiversity and supporting vital coastal ecosystems. However, the reported diversity of seagrass flora varies, with 14 species identified by Abhijith et al., (2024), 15 species by Seal et al. (2023), and 16 species by Thangaradjou and Bhatt (2018). An exhaustive list of these 16 species and their distribution is provided in Table 2 of Annexure-II.

Here's a glimpse of India's most abundant seagrass regions, as identified by Thangaradjou and Bhatt (2018):

- ***Palk Bay and the Gulf of Mannar***: These regions boast the highest seagrass diversity, with 14 species thriving in their waters. Known for extensive seagrass beds, they play a crucial role in sustaining marine ecosystems.

- ***Andaman and Nicobar Islands***: Famous for their pristine waters, these islands are home to 12 seagrass species. Their biodiversity supports marine species like dugongs and turtles.

- ***Lakshadweep Islands***: Clear lagoons and coral atolls of Lakshadweep host 10 seagrass species, critical for maintaining coral reef health and marine life.

- ***Odisha***: The Odisha coastline nurtures 8 species, playing a key role in supporting local fisheries and protecting coastal habitats from erosion.

- ***Gujarat***: Similarly, Gujarat's waters support 8 seagrass species, contributing to the biodiversity of the Gulf of Kachchh and offering critical marine habitats.

The Ocean's Lungs: Captivating Insights into Seagrasses!

- **Largest Concentration of Seagrass**: To date, around **1,250** species of **flora and fauna** have been documented in this fragile ecosystem, including endangered species such as the dugong and green turtles (Thangaradjoua and Bhatt, 2018).

- Seagrasses are often referred to as "**the lungs of the sea**" due to their ability to release oxygen into surrounding waters through photosynthesis.

- One square metre of seagrass can produce up to 10 litres of oxygen per day (CSIR-NISCAIR, 2013)

- The carbon stored in seagrass ecosystems can influence water pH levels and enhance the **calcification of coral reefs**, helping to alleviate the impacts of ocean acidification.

- The Blue Carbon seagrass ecosystem plays a critical role in carbon sequestration within sediment. Although seagrasses occupy only about **0.1 percent** of the ocean floor, they are capable of **sequestering 11 percent** of the carbon buried in seabeds.

- Globally, seagrass meadows are estimated to capture up to **83 million metric tons of carbon** annually (approximately 83 grams of carbon per square meter per year), translating to global storage rates between 27 and 40 teragrams of carbon per year, making their carbon capture 35 times more effective than that of tropical rainforests. (Abhijith and Shilta, 2024)

- Global Value of Seagrasses: Ranked as the **third most valuable ecosystem per hectare**, after estuaries and wetlands (Mellors and McKenzie, 2008).

- Economic and Ecological Contributions: Provide an average of **US$19,004 per hectare** annually for nutrient cycling and seagrass products (Costanza et al., 1997).

- **Nutritional and Medicinal Benefits**: High in nutrition and secondary metabolites. Exhibits antibacterial, antifungal, and antiviral properties (Premnathan et al., 1992; Kumar et al., 2008; Ravikumar et al., 2010, 2011). Seagrasses have been traditionally utilized in medicine to address various ailments, including fever, skin conditions, muscle pain, wounds, and digestive issues. They are also used to alleviate stings from certain rays and as a calming agent for infants.

- Known for insecticidal properties (Shanmugapriya et al., 2001; (Gnanambal & Patterson (2006).

- **Traditional and Agricultural Applications**: Used as bio **fertilizer** for coconut plantations along Kerala's coast; documented as liquid fertilizer for various crops (Sobithabai et al., 2005; Asir et al., 2004, 2007).

- In India, local fishers consume ***Cymodocea* species**, known for their sugarcane-like taste, and the seeds of Enhalus, while in the Philippines, researchers have developed flour from dried seeds of ***Enhalus acoroides*** as a potential food source for small islands (CSIR-NISCAIR, 2013)

- In addition to their uses as food and traditional medicine, seagrasses serve as insulation and roofing materials, help stabilize sand dunes, are used as feed for livestock, and are utilized in crafting items such as mats and paper (CSIR-NISCAIR, 2013).

2.3
Tidal Salt Marshes

What Are Tidal Salt Marshes?

Where land meets sea through the gentle touch of saltwater and the rhythmic dance of the tides, salt marshes are coastal wetlands that flourish in this unique environment. Resilient plants brave the salty air and shifting waters, creating dynamic ecosystems that serve as bustling nurseries for fish, homes for countless birds, and guardians of our coastlines. In their quiet strength, they weave the story of nature's resilience.

Tidal Salt Marshes Described Scientifically:

Salt marshes are coastal wetlands located in the upper tidal zones, regularly experiencing tidal inundation at consistent or seasonal intervals. Salt marshes are communities of halophyte (salt-tolerant) plants that thrive at the interface of land and sea, where fresh and saline waters converge. These marsh communities are typically found in the upper intertidal zone of coastal ecosystems around the globe and comprise approximately 500 species (Mcowen et al., 2017).

How Are Tidal Salt Marshes Different from Mangroves?

In the intertidal zone of sheltered coasts—particularly in bays, lagoons, and estuaries. Both ecosystems host salt-tolerant plants that can withstand frequent inundation by saltwater and thrive in anaerobic conditions. However, their vegetation differs significantly: mangroves consist of **various tree species and shrubs**, while **salt marshes are dominated by grasses and herbs**. Mangroves are primarily found in tropical regions and the lower latitudes of the subtropics, where they serve as the dominant intertidal vegetation. In contrast, salt marshes occur throughout mid- and high-latitude regions and may also be present in some tropical areas (Davidson-Arnott, 2009).

"Tidal Salt Marshes are the Most Neglected and Least Studied Coastal Ecosystems"

— Dr. Amrit Kuma, Marine Scientist, during the expert consultation.

Why Tidal Salt Marshes Matter?

Tidal salt marshes are invaluable ecosystems that provide numerous essential benefits:

Coastal Protection: They act as natural barriers, absorbing wave energy and reducing the impact of storms, thus protecting coastal communities from erosion and flooding.

Biodiversity Hotspots: Salt marshes offer critical habitats for a wide range of species, including fish, migratory birds, and other wildlife, supporting rich biodiversity.

Carbon Sequestration: These wetlands are highly efficient at capturing and storing carbon, helping to mitigate the impacts of climate change by reducing atmospheric carbon dioxide levels.

Water Filtration: Tidal salt marshes improve water quality by trapping pollutants and sediments, filtering runoff before it reaches open waters.

Support for Fisheries: They serve as nurseries for fish and other marine organisms, sustaining fisheries and local economies.

Extent and Diversity of Salt Marshes in India

- **Total Extent**: The estimated total extent of salt marshes in India is about 290 km^2. This highlights the limited but significant area they cover along the extensive Indian coastline (Viswanathan et al., 2020).

- **Species Diversity**: Indian salt marshes host around 14 salt marsh species, which belong to 11 genera and 6 families. This includes a variety of plant species adapted to saline conditions (Patro et al., 2017). Most Diverse Family: The ***Amaranthaceae* family** is noted for its diversity within Indian salt marshes. This family includes several *halophytes*, which are plants adapted to survive in high salinity environments (Viswanathan et al., 2020).

A comprehensive checklist of salt marsh species along the Indian coast by Viswanathan et al. (2020) is provided in Table 3 of Annexure-I.

Salt Marsh Species Distribution in India

Map 4: Distribution of salt marsh patches along the coastal states of India (Viswanathan et al., 2020)

There are 14 species of salt marsh plants found along the Indian coast (Viswanathan et al., 2020):

West coast supports all 14 species

- All **14** salt marsh species are present along the west coast of India.
- Gujarat harbors the highest number of true salt marsh species, with **14** recorded along its coast.

East coast and islands have fewer species

- The east coast of India hosts **13** species.
- The island groups have **12** species.

Common species: *Sesuvium portulacastrum*

This species is the most widespread, thriving across various coastal states and Union Territories (UTs).

Restricted species: *Urochondra setulosa*

Urochondra setulosa has a limited distribution, found only in select coastal stretches of Gujarat and Daman & Diu (Viswanathan et al., 2020).

Variations in Salt Marsh Species Numbers and Area Estimates in India

Variation in Total Number of Salt Marsh Species

- Salt marsh vegetation is often considered as *halophytes*, mangroves, and coastal vegetation by many researchers, leading to disparities in the reported number of salt marsh species in India (Viswanathan et al., 2020).

- As noted by Mishra and Farooq (2022), India's salt marshes were previously reported to consist of **45 species** (Kathiresan and Ramanathan, 2004). However, this number has been reduced to **14 true salt marsh species**, excluding various plants that can survive under freshwater conditions (Patro et al., 2017; Viswanathan et al., 2020).

Salt Marsh Cover in India: Variation in Estimates

- The National Centre for Sustainable Coastal Management (NCSCM) estimates that the salt marsh cover in India is approximately **290 km^2** for the period between 2014 and 2018 (Viswanathan et al., 2020).

- The extent of salt marshes in India was estimated to be about **1,698 km^2** during the 1992–1993 period (Garg et al., 1998) and approximately.

- **1,611 km^2** during the 2007–2008 period (SAC, 2011a).

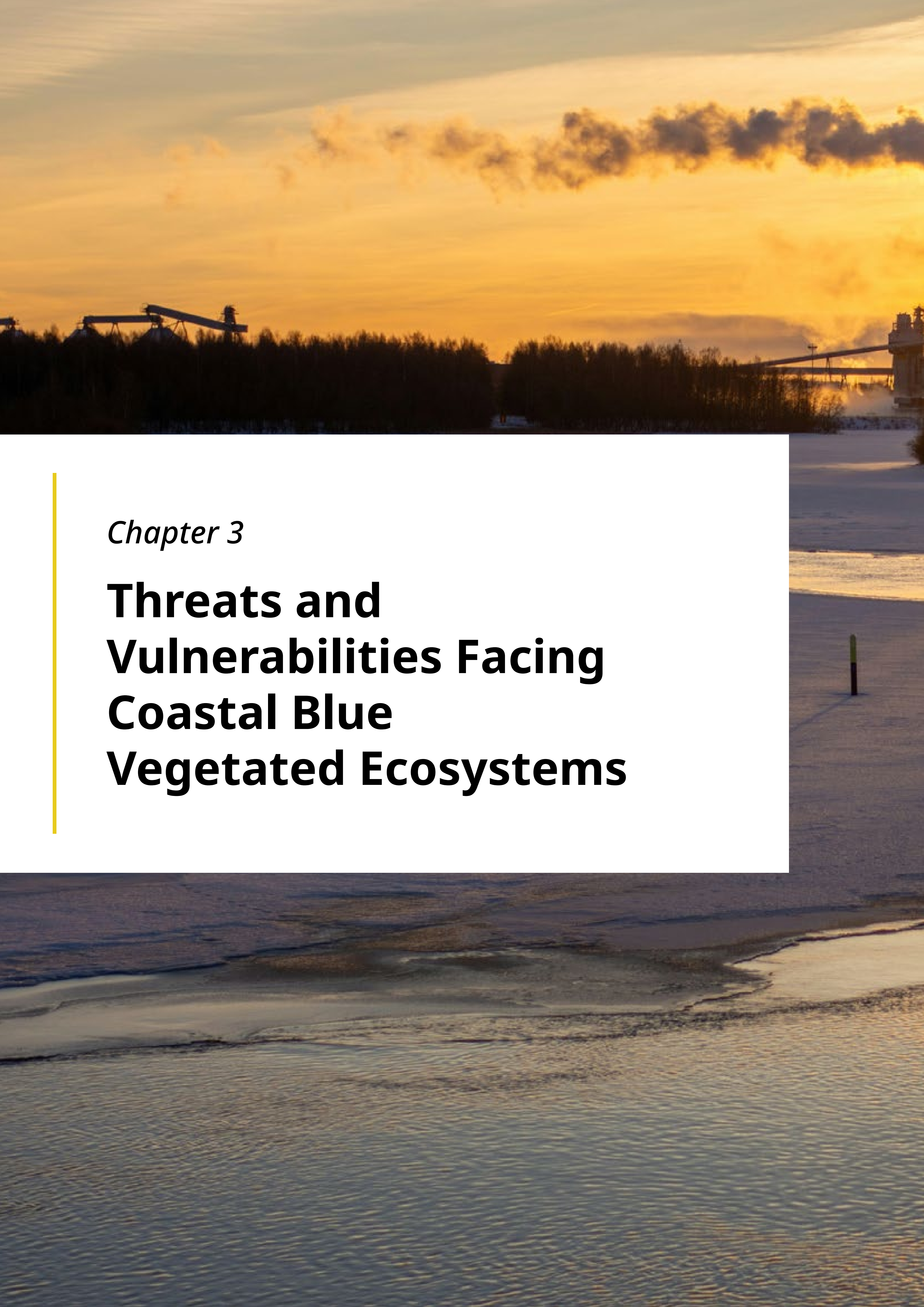
- Viswanathan et al. (2020) attribute the significant variations among these estimates to several factors. One primary reason is the inconsistency in the classification of salt marsh species, which contributes to the substantial differences in the areal extent reported across different studies. Additional reasons for the variations include discrepancies in the base data, such as spatial resolution, spectral bands, mapping scales, and data analysis procedures. Furthermore, the deterioration of salt marshes due to extensive reclamation of wetlands for industrial and agricultural activities may also explain the decline in the extent of salt marshes among India's coastal wetlands.

2.4
Coastal Blue Ecosystems & Communities

India's coastal ecosystems are more than just physical landscapes; they are living cultural spaces deeply woven into the heritage of indigenous and local communities. These ecosystems— including mangroves, coral reefs, estuaries, salt marshes, and sandy beaches—offer essential services that sustain traditional livelihoods and reinforce cultural identities. The connection between these communities and their environment reflects a longstanding knowledge of ecological systems, preserved and transmitted through generations as traditional ecological knowledge (TEK) (Newmaster et al., 2011).

The provisioning services offered by coastal ecosystems are crucial for the economic stability of local populations. Many coastal communities depend on fishing and aquaculture as primary sources of income, which are directly tied to the health of marine ecosystems. The depletion of fish stocks due to overfishing and environmental degradation poses a significant threat to these livelihoods, thereby impacting cultural practices that are centered around fishing, livelihoods and marine resource utilization (Eckert et al., 2018; Cisneros Montemayor et al., 2016).

In addition to economic benefits, coastal ecosystems also provide cultural and spiritual value. Many indigenous communities view these ecosystems as sacred spaces that are integral to their cultural narratives and identity. For instance, certain species of fish and plants may hold spiritual significance, and their conservation is often linked to cultural practices and rituals (Mucioki et al., 2021). The loss of these ecosystems not only threatens biodiversity but also erodes the cultural fabric of these communities, leading to a disconnection from their ancestral heritage (Aledo et al., 2023).



Chapter 3

Threats and Vulnerabilities Facing Coastal Blue Vegetated Ecosystems

SaciWATERs
SOUTH ASIA CONSORTIUM FOR INTERDISCIPLINARY WATER RESOURCES STUDIES

climate RISE alliance

Threats and Vulnerabilities Facing Coastal Blue Vegetated Ecosystems

Coastal blue vegetated ecosystems that are mangroves, seagrasses, and salt marshes, are fragile and highly sensitive to changes in their environment. Shifts in salinity, temperature, and water quality can stress these ecosystems, making it harder for them to thrive. Many of these ecosystems have limited resilience, meaning once they are damaged, their ability to recover is slow. These vulnerabilities are compounded by significant external threats, leading to severe damage to the ecosystem.

These coastal ecosystems face a multitude of threats that significantly impact their ecological integrity and functionality. The primary threats include climate change, anthropogenic activities, hydrodynamic changes, and invasive species (Table 2). This section underscores the key threats and vulnerabilities faced by these coastal ecosystems.

Pics: Litter accumulation near the Cooum River mouth and Chennai's public beaches in December 2021, a consequence of the flash floods that occurred the previous month. (All pictures credited to National Centre for Sustainable Coastal Management (NCSCM)).

An Overview of Drivers and Threats to Coastal Blue Vegetated Ecosystems in India

Drivers of Degradation	Leading Threats	Impacted Ecosystems
Coastal Development and Urbanisation	• Habitat loss from construction of infrastructure (ports, roads, settlements, etc.). • Increased erosion, sedimentation, and turbidity, blocking sunlight for growth. • Increased vulnerability to storm surges and flooding.	Mangroves, Seagrasses, Salt Marshes
Hydrological Changes (Dams, River Diversion, etc.)	• Reduced freshwater flow increases salinity, affecting ecosystem health. • Altered sedimentation patterns reduce nutrient supply. • Decreased resilience to rising sea levels.	Seagrasses, Salt Marshes
Climate Change	• Rising sea levels submerge habitats. • Increased storm intensity causes erosion. • Rising sea temperatures and ocean acidification harm ecosystems	Mangroves, Seagrasses, Salt Marshes
Aquaculture and Agriculture	• Conversion of mangrove areas into shrimp farms, leading to habitat degradation. • Increased salinity and water pollution from fertilisers. • Disruption of hydrological balance critical for mangroves.	Mangroves
Pollution (Agricultural Runoff, Industrial Waste, etc.)	• Nutrient loading causes eutrophication, leading to algal blooms that block sunlight and deplete oxygen, harming vegetation. • Chemical pollutants and toxins damage ecosystems.	Seagrasses, Salt Marshes
Resource Exploitation	• Overharvesting for mangroves for timber, fielwood, and fodder leading to deforestation. • Unsustainable fishing practices damaging mangrove roots. • Grazing impedes natural regeneration.	Mangroves
Boating and Anchoring	• Physical damage from boat propellers and anchors. • Sediment disturbance increases turbidity, impacting seagrass growth.	Seagrasses
Unsustainable fishing practices	• Destructive fishing methods (eg., trawling) damage seagrass beds and disturb sediment.	Seagrasses
Invasive species	• Invasive species outcompete native vegetation, reducing biodiversity and altering ecosystem structure.	Mangroves, Seagrasses, Salt Marshes
Tourism development	• Unregulated tourism leading to habitat disturbance and waste accumulation. • Construction of infrastructure (hotels, resorts) fragmenting habitats.	Mangroves
Unscientifically Planned Mangrove Plantation drives	• Displacement of native salt marshes vegetation, leading to the loss of biodiversity. • Alteration of habitat structure and ecosystem services.	Salt Marshes

Table 2: An Overview of Drivers and Threats to Coastal Blue Vegetated Ecosystems in India
Source of information: Sahu et al (2015), Chanda (2022), and Viswanathan et. al, 2020

Building on this overview, the following sections will delve into the specific threats faced by mangroves, seagrasses, and salt marshes, each of which plays a crucial role in maintaining the health of coastal ecosystems and supporting the livelihoods dependent on them. It is important to recognize that these coastal ecosystems are interconnected; harm to one ecosystem invariably leads to negative repercussions for others, as they share essential ecological functions, nutrient cycles, and habitat structures.

"Natural calamities and human-induced activities present substantial threats to coastal ecosystems, but these threats are often site-specific, necessitating targeted conservation strategies. Vulnerability is complex and varies across regions, influenced by a range of factors such as distinct community dynamics and ecological drivers."

— Ms. Marianne Manuel and Dr. Ch. Praveen Kumar, Dakshin Foundation, during the expert consultation

3.1 Mangroves at Risk

Mangroves in India face numerous significant threats that contribute to their degradation and loss (Table 2). One of the primary threats is the expansion of aquaculture and agriculture, leading to the destruction of mangroves over the last century. Additionally, logging for timber, fuel, and charcoal is prevalent due to the wood's high calorific value and industrial applications.

India has lost approximately 40% of its mangrove area over the last century, with the east coast experiencing a loss of about 26%, the west coast about 44%, and the Andaman and Nicobar Islands around 32%. An assessment by Sahu et al., 2015 covering the period from 1987 to 2013 revealed a mean annual change in mangrove area of 24.25 ± 82.57 km^2. While most states reported a mean annual increase in mangrove area, Andhra Pradesh and the Andaman and Nicobar Islands showed declines of -5.95 ± 15.70 km^2 and -3.41 ± 52.32 km^2, respectively. These reductions are attributed to the 2004 tsunami's impact on the Andaman and Nicobar Islands and agricultural and developmental activities in Andhra Pradesh.

Invasive species, such as *Prosopis* and various aquatic weeds, disrupt the ecological balance within mangrove ecosystems. Natural calamities like tropical cyclones and tsunamis further harm these ecosystems. Although India has seen a significant increase in mangrove coverage over the past decade, largely due to plantation efforts, much of this growth has occurred in open-canopy mangrove areas. Despite these gains, anthropogenic activities continue to pose serious threats, not only from direct coastal development but also from upstream sources.

It is important to note that protecting mangroves requires more than just physical preservation, as significant threats often originate far from the immediate habitat. These ecosystems face not only local pressures but also remote impacts from upstream activities. Water diversion for agriculture, industrial use, and urban demands has drastically reduced the flow of freshwater into mangrove ecosystems, leading to increased salinity levels and altered hydrological patterns. Additionally, untreated waste discharge into rivers degrades water quality, further stressing these ecosystems. These upstream activities, combined with localized pressures, are undermining the long-term health and resilience of India's mangroves.

The India State of Forest Report (FSI, 2021) recorded a marginal nationwide increase of 17 square kilometers in forest cover. However, Gujarat, which has the second-largest mangrove cover after the Sundarbans, experienced a decline of 2 square kilometers compared to 2019. The report attributes this loss to biotic pressure and natural calamities, both of which continue to pose significant threats to mangrove ecosystems. Additionally, land reclamation for agriculture and industrialization along coastlines, coupled with the discharge of untreated domestic sewage and industrial effluents, has further accelerated mangrove degradation. River training activities, natural erosion, and accretion have also disrupted sediment dynamics and ecological flows, which are essential for flushing out silt and waste. Compounding these stressors, commercial shrimp farming, severe grazing, and lopping during flowering seasons have not only damaged mangrove stock but also depleted propagules crucial for natural regeneration (Kateshiya, July 27, 2024).

The ISFR 2023 presents an even graver picture, reporting a net decrease of 7.43 square kilometers in mangrove cover since 2021. While states such as Andhra Pradesh and Maharashtra recorded gains, Gujarat saw a sharp decline of 36.39 square kilometers, and the Andaman & Nicobar Islands lost 4.65 square kilometers. Furthermore, 41% of India's mangrove forests are now classified as poor, with canopy density falling below 40%. These findings underscore the worsening threats to India's mangrove ecosystems and reinforce the urgent need for science-driven conservation strategies to curb further degradation and strengthen the resilience of these critical coastal buffers (FSI, 2021 & 2023).

The reduction of freshwater and tidal flows from dam construction and river siltation increases salinity and hinders mangrove regeneration. Finally, climate change exacerbates these challenges through rising temperatures and sea levels, increasing the frequency of tropical storms and tsunamis. As sea levels rise, mangroves tend to move landward, but human encroachment prevents this shift, resulting in a decrease in the width of these vital ecosystems (Sahu et al., 2015).

Did You Know? The Sundarbans mangroves are under threat from air pollution!

"A recent study by researchers from the Indian Institute of Technology (IIT) Kanpur and Bose Institute, Kolkata, has uncovered that significant amounts of pollutants, mainly enriched with black carbon and soot particles, are arriving from not just the Kolkata metropolis but the entire Indo-Gangetic Plain (IGP) region, critically deteriorating the health of the Sundarbans." Ghosh et al. (2024).

The study by Ghosh et al. (2024) reveals that the advection of biomass burning plumes significantly enhances aerosol acidity and oxidative stress, adversely affecting the health of the Sundarbans mangrove ecosystem.

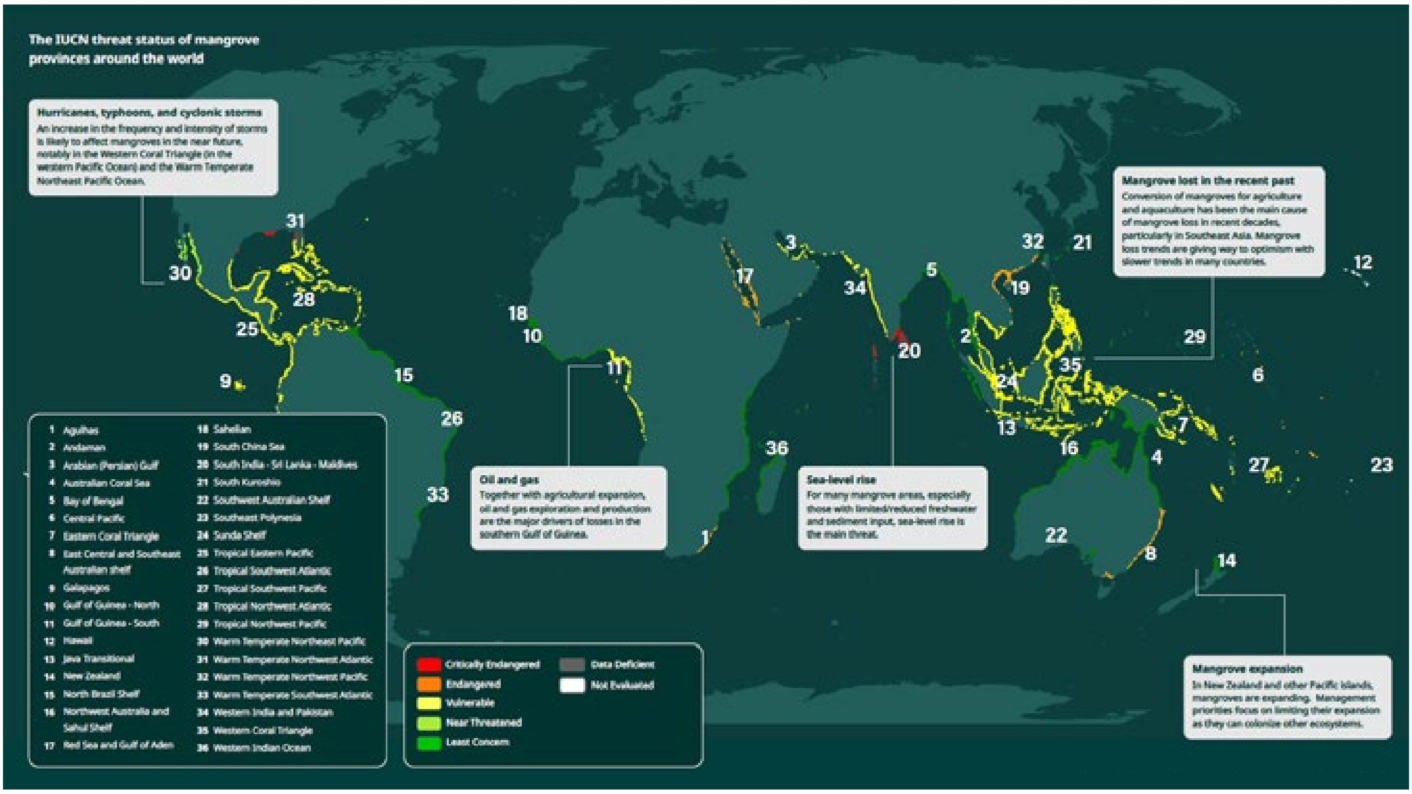
Wake-Up Call: South India’s Mangrove Ecosystems at Risk of Collapse, Warns IUCN

Fifty percent (50%) of the assessed mangrove ecosystems are at risk of collapse, classified as vulnerable, endangered, or critically endangered.

The Red List of Mangrove Ecosystems, released by the International Union for Conservation of Nature (IUCN), marks the first comprehensive global assessment of mangrove ecosystems. Launched on the International Day for Biodiversity in 2024, it reveals that the world’s most critically endangered mangrove ecosystems include the “Warm Temperate Northwest Atlantic” and “South India, Sri Lanka, and Maldives (Map 5).”

In South India, mangroves are classified as critically endangered, primarily due to the threat posed by sea-level rise. This is especially concerning for mangrove areas with limited freshwater and sediment input, where rising sea levels accelerate habitat loss.

On India’s west coast, mangroves are classified as vulnerable. The ecosystems in the Bay of Bengal region shared by India and Bangladesh are categorized as least concern.



Map 5: The IUCN threat status for 36 mangrove provinces globally indicates varying levels of risk (Picture Source: Leal, Maricé and Spalding, Mark D (editors), 2024 The State of the World’s Mangroves 2024. Global Mangrove Alliance.)

Mangrove areas and major threats

Mangrove area	Major Threats
West Bengal	Agriculture, prawn seed collection, reduction in freshwater flow and environmental pollution.
Odisha	Natural calamities, prawn farming, encroachment and rehabilitation.
Tamil Nadu	Reduction in freshwater flow, invasion of alien species and over-exploitation of mangroves.
Andhra Pradesh	Agriculture, grazing, developmental activities, invasion of alien species and aquaculture.
Maharashtra	Urbanisation and pollution
Karnataka	Agriculture, tree felling and pollution
Kerala	Unsustainable mode of aquaculture practices, mangrove wood for fuel, industrialisation and urbanisation, bio-pollution
Andaman & Nicobar Islands	Agriculture, exploitations for wood and wood products, tourism, development encroachment and natural calamities such as cyclone, storm and tsunami.

Table 3: Mangrove areas and major threats
(Sahu et al, 2015 and other scientific studies)

3.2
Seagrasses Under Threat

Despite their critical role in marine ecosystems, seagrasses are facing significant threats. The primary drivers of this decline include ocean acidification, coastal development, and rising ocean temperatures resulting from climate change (UNEP, 2023).

Threats to Seagrasses:

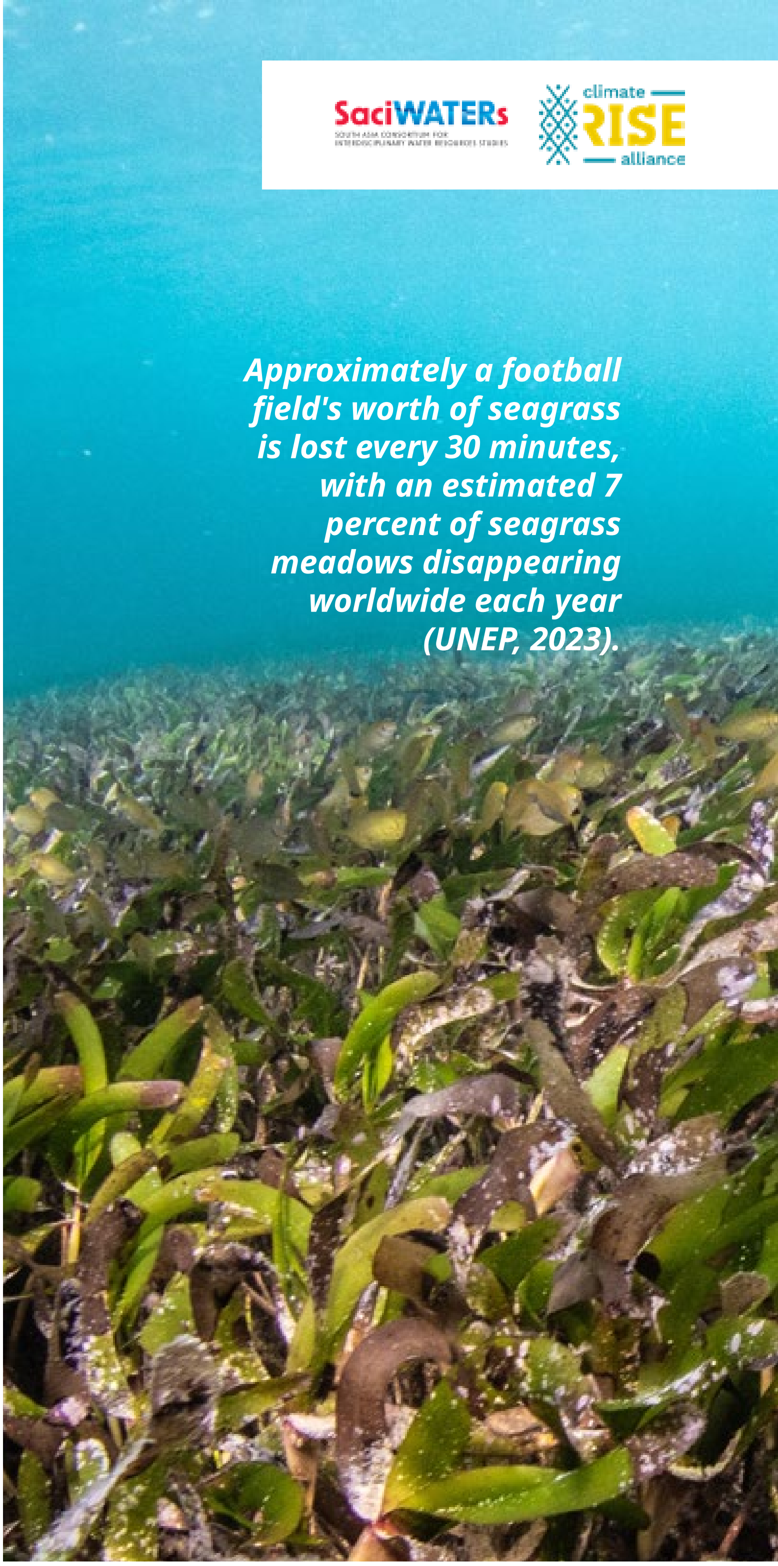
Seagrass meadows in India face multiple threats, primarily driven by human activities and climate change:

Human activities:
Coastal construction and development, siltation, overfishing, and pollution from sources like agricultural runoff, industrial waste, and urban sewage severely impact seagrass ecosystems.

Climate change:
Rising ocean temperatures and ocean acidification hinder seagrass growth and survival, while rapid sea level rise threatens to submerge these meadows.

Cyclones:
High-energy cyclones can uproot and damage seagrass beds, further diminishing their resilience.

This loss also poses severe risks to species reliant on seagrasses, such as the endangered Dugong (Sea Cow) and Green Turtle, which depend on these habitats for survival (Sundararaju, 2020).



Highlights of Seagrass Threats and Loss in India

Palk Bay
Bottom trawling and other unsustainable fishing practices have degraded extensive areas of seagrass, leading to biodiversity losses and threatening endangered species such as dugongs and green turtles (Arasamuthu et al., 2018).

Gulf of Mannar
Coastal development and aquaculture have reduced seagrass cover by approximately 14% from 1989 to 2015, disrupting essential habitats for numerous marine species (Haque, 2023).

Andaman & Nicobar Islands
Cyclonic events, such as Cyclone Lehar in 2013, led to nearly 68% seagrass loss in certain areas, primarily

due to powerful waves and storm surges that destabilize and erode seagrass beds (Sachithanandam et al., 2022).

Chilika Lagoon, Odisha
Urban expansion and the spread of aquaculture activities have resulted in a 33% reduction in seagrass coverage from 1996 to 2006, causing habitat loss and endangering local fish populations (Haque, 2023).

Lakshadweep Islands
The 2004 tsunami, along with subsequent erosion, destroyed approximately 73 hectares of seagrass, diminishing critical habitats for marine fauna such as the endangered hawksbill turtle Thangaradjou & Bhatt (2018).

Gulf of Kachchh
Increased sedimentation from industrial activities has caused over 65% seagrass loss since 2008, affecting the biodiversity of this fragile marine environment (Bjork et al., 2008; Adhavan et al., 2022).

3.3 Salt Marshes in India: The Overlooked Coastal Ecosystems Facing Imminent Threats

The threats to salt marshes in India are multifaceted and significant. One major concern is their patchy distribution, characterized by relatively low species richness and low vegetation density.

Among the 14 identified species in these salt marshes, nine are classified as endangered, vulnerable, or near threatened, indicating a worrying decline in their populations and the overall health of these ecosystems.

The identified threats to salt marshes include overgrazing, excessive agricultural use, and urbanization, which lead to habitat loss and degradation. Additionally, rising infrastructure, including drainage systems, seawalls, and retaining walls, further disrupt natural processes and hydrology. Recreational activities and coastal erosion also impact these vital ecosystems. Pollution from industrial wastewater and improper waste disposal further exacerbate the adverse conditions faced by salt marshes, highlighting the need for effective management and conservation strategies as reported by Jagtap et al., 2002.

Coastal development poses another serious threat, as many salt marsh areas are being reclaimed for uses such as aquaculture and salt production, leading to habitat destruction and limiting the growth and establishment of salt marsh species. The invasion of non-native species, notably *Prosopis juliflora*, is also a major concern, as invasive species can outcompete native vegetation, disrupting the ecological balance.

The altered hydrology resulting from coastal developments hinders the flow of saline water, preventing regular tidal inundation and creating conditions that can negatively impact the health of salt marshes. Climate change exacerbates these threats, with projections indicating sea level rise of 3.5 to 34.6 inches between 1990 and 2100, rendering coastal areas increasingly vulnerable. Moreover, low plant density in salt marshes results in reduced wave attenuation, diminishing their effectiveness in coastal protection and erosion control. Disturbances within these ecosystems may lead to the release of stored carbon into the atmosphere, counteracting their role as carbon sinks and contributing to climate change. Although tropical salt marshes in India have low floristic diversity, they support higher biodiversity, including fish and macrofaunal assemblages, thus, the loss or degradation of these areas could significantly impact marine biodiversity and fisheries output. Collectively, these threats underscore the urgent need for effective conservation measures to protect and restore salt marsh ecosystems in India. Viswanathan et al., 2020.

Indian Salt Marshes: The Most Neglected & Least Studied Coastal Blue Vegetated Ecosystems in India

In the Indian context, salt marshes play a significant role alongside other coastal blue vegetated ecosystems, such as mangroves and seagrasses. These ecosystems present India with a valuable opportunity to enhance its Intended Nationally Determined Contributions (INDCs) towards climate change mitigation by increasing carbon sinks (INDC goal #5). Despite their extensive distribution along the Indian coastline, salt marshes remain one of the most overlooked and neglected coastal ecosystems in the country. In fact, they are recognized as the least studied blue carbon ecosystems in India (Banerjee et al., 2017).

The case study aims to illuminate the challenges faced by salt marshes through the example of *Porterasia coarctata*, an important salt marsh species. The insights shared in this case study apply to other similar salt marsh species as well. The findings presented are based on the review paper authored by Amrit Kumar Mishra and Syed Hilal Farooq, which highlights the ecological significance of salt marshes and the urgent need for increased attention and research to support their conservation efforts in India (Mishra and Farooq 2022).

Case Study:
The Silent Disconnect: The Plight of Salt Marshes in India

Salt marshes along the Indian coastline are ecologically significant yet largely overlooked by policymakers and the public. These coastal ecosystems support diverse marine life, stabilize sediments, and play a crucial role in carbon sequestration. Despite their importance, recent studies indicate a decline in salt marsh species and area, highlighting the urgent need for informed conservation efforts. Recent research has categorized a mere 14 true salt marsh species, excluding various *halophytes* capable of surviving in freshwater conditions, down from a previous total of 45 (Kathiresan and Ramanathan, 2004; Patro et al., 2017), covering an area of approximately 290 km^2 (Viswanathan et al., 2020).

Among these salt marshes, *Porterasia coarctata* (or *Oryza coarctata*), known as “wild rice,” stands out not only for its ecological significance but also as a vital resource for coastal communities. This species’ extensive root system facilitates coastal sediment accretion, effectively creating habitats for diverse marine life and contributing to the structural integrity of neighboring ecosystems like mangroves. Intriguingly, *P. coarctata* serves as a nursery for various intertidal invertebrates and fish species while providing habitat for endangered horseshoe crabs and commercially important mangrove crabs on India’s east coast.

However, despite their importance, salt marshes in India remain among the most overlooked and least studied coastal ecosystems. In the shadow of this ecological importance lies a troubling reality: despite the evident interdependence between salt marshes and mangroves, unscientifically designed mangrove restoration projects systematically jeopardize salt marsh habitats. For example, mangrove saplings are often planted directly within salt marsh areas, disrupting the delicate balance required for both ecosystems to thrive. The resulting changes lead to anoxic conditions that inhibit the growth of *P. coarctata* and diminish the health of the entire salt marsh community. On the other hand, restoration of *P. coarctata* on the seaward side has been successfully utilized for mangrove restoration on the landward side in Sundarbans, West Bengal (Begam et al., 2017), highlighting the important role of this salt marsh species in sediment stabilization and erosion prevention, creating suitable habitats for mangrove restoration.

This mismanagement and negligence have dire implications. Of the 14 salt marsh species identified along the Indian coast, nine are now classified as endangered, vulnerable, or near threatened (Viswanathan et al., 2020). While climate change exacerbates these threats through alterations in seawater chemistry, thermal regimes, and salinity changes, it is the anthropogenic pressures—especially the poorly planned restoration efforts and unsustainable coastal development—that serve as immediate catalysts for population decline of salt marshes. The misinterpretation and mismanagement of salt marshes pose grave risks not just to their survival, but also to the health of interconnected ecosystems, including mangroves and associated biodiversity.

Adding to the complexity, salt marshes are frontline ecosystems in the fight against climate change. They serve as vital carbon sinks, capable of sequestering significant amounts of carbon dioxide (Kaviarasan et al., 2019; Banerjee et al., 2022). However, with ongoing habitat destruction and inadequate scientific understanding of these ecosystems, their ability to serve this purpose is increasingly compromised.

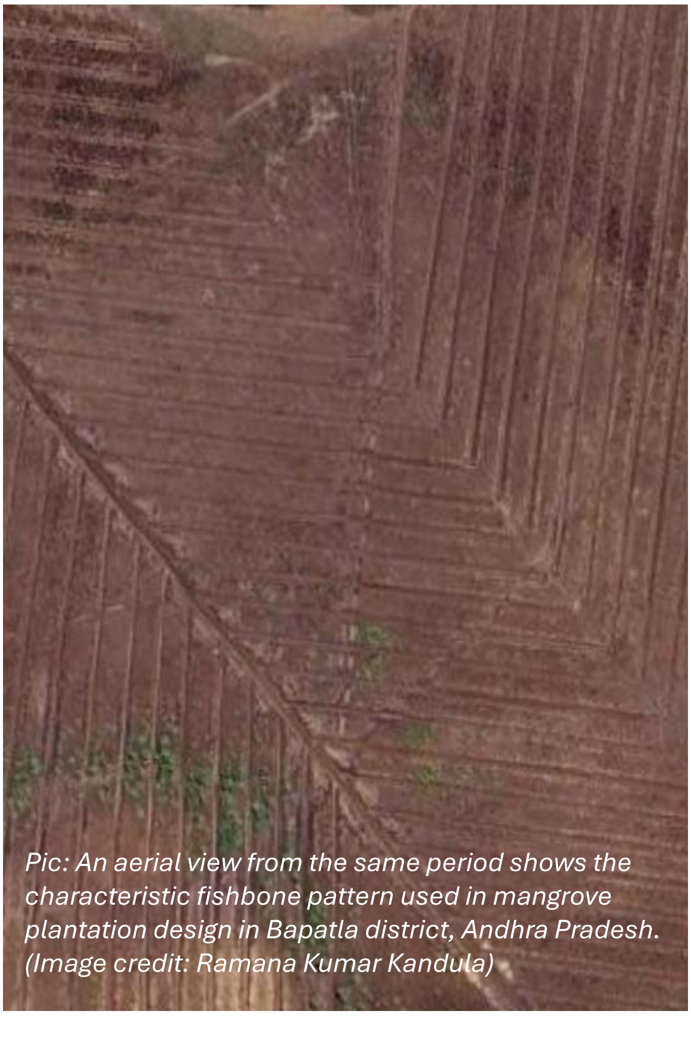
As we move forward, we must advocate for an integrated approach that values all coastal blue ecosystems. There is an urgent need to raise awareness about the biological, ecological, and socio-economic significance of salt marshes across India.

Pic: Tidal salt marshes converted into mangrove plantation sites in the Bapatla district of Andhra Pradesh. (Image credit: Ramana Kumar Kandula)

"These pictures show that hectares of intertidal marshlands in Bapatla District have been converted into mangrove plantation sites.

Unfortunately, we will be losing these precious marshlands, which play an important ecological role. They receive stormwater from the surrounding scrub jungle in the reserve forest, situated at an elevation above sea level, and slowly release it into the sea during low tide periods through the Suryalanka estuary. Additionally, these marshlands receive seawater during high tides. This process helps prevent coastline erosion and filters out nutrients and pollutants that can harm marine wildlife. Furthermore, marshlands are vital bird habitats, supporting many species of migratory birds, particularly waders that utilize the Central Asian Flyway for feeding and roosting."

- Ramana Kumar Kandula, a wildlife conservationist from Bapatla, Andhra Pradesh



Pic: An aerial view from the same period shows the characteristic fishbone pattern used in mangrove plantation design in Bapatla district, Andhra Pradesh. (Image credit: Ramana Kumar Kandula)

Why Protecting Coastal Blue Vegetated Ecosystems is Even More Crucial in the Context of Climate Change?

Conserving Coastal Blue Vegetated Ecosystems, popularly known as blue carbon ecosystems, is increasingly critical in the context of climate change. Without adequate protection, anthropogenic environmental degradation significantly harms these ecosystems, undermining their ecological processes and reducing their effectiveness in mitigating climate change. Consequently, instead of fostering resilience for biodiversity and communities, these degraded ecosystems lose their capacity to sequester carbon and begin releasing stored greenhouse gases back into the atmosphere (Arathy et al., 2022), further exacerbating climate change and diminishing ecological integrity. This reverses the climate adaptation and mitigation benefits they offer to local communities and the global unity as a whole. ***(UNEP, n.d.)*** Additionally, their unique abilities to reduce coastal flooding and erosion, provide storm protection, and support job creation and food security are severely compromised.

Moreover, less resilient blue carbon ecosystems themselves become increasingly vulnerable to the impacts of climate change, creating a detrimental feedback loop. This cycle not only threatens the health of these vital ecosystems but also endangers the communities that depend on them, worsening the situation for both biodiversity and human populations. Therefore, the urgent protection and restoration of blue carbon ecosystems are essential to breaking this cycle and ensuring their continued role in climate change mitigation and community resilience

3.4 Threats to Coastal Ecosystems and Socio-economic Implications for Vulnerable Populations

Coastal blue vegetated ecosystems, including mangroves, seagrasses, and salt marshes, serve as crucial buffers that protect coastal regions from extreme weather events, support fisheries, and contribute to the livelihoods of millions. However, these ecosystems face significant threats from climate change, which not only degrades their ecological health but also heightens the socio-economic vulnerabilities of the communities that rely on them. As these ecosystems weaken, their capacity to provide essential services diminishes, exacerbating challenges for coastal populations who depend on them for food security, economic stability, and protection against climate-related impacts.

Climate change is intensifying the socio-economic vulnerabilities of India's coastal populations through a cascade of environmental impacts. Coastal states like West Bengal, Andhra Pradesh, and Gujarat are among the most affected, with communities heavily reliant on agriculture and natural ecosystems for their livelihoods.

As climate change progresses, it amplifies the frequency and intensity of extreme weather events, such as tropical cyclones, which disrupt agriculture, threaten water resources, and compromise food security. For example, in the Sundarbans, rising sea levels and intensified storm surges increase the salinity of both soil and water. This salinization damages mangrove ecosystems, reduces agricultural productivity, and heightens health risks, deepening poverty and making socio-economic recovery increasingly challenging (Dasgupta et al., 2020).

Salinity intrusion, particularly in coastal agricultural zones, is a critical issue as rising sea levels and changing rainfall patterns gradually salinize soils, making them unsuitable for traditional crops. States with expansive coastlines are increasingly affected, with agricultural output declining as crop yields fall in response to poor soil health. This decline in productivity directly threatens the food security of coastal communities (Kumar et al., 2021; Rahman et al., 2014). As crop failures and reduced yields become more common, migration pressures grow, pushing residents to seek livelihoods elsewhere (Reimann et al., 2023).

The loss of traditional livelihoods, such as farming and fishing, further destabilizes coastal economies, especially as environmental degradation escalates. For instance, the impact of Cyclone Tauktae on Gujarat's coastal region exemplifies the devastating socio-economic consequences of such events, where loss of life, property damage, and disrupted agricultural cycles led to severe setbacks for local communities (Keriwala & Patel, 2022). Coastal communities in Andhra Pradesh are similarly vulnerable, where agriculture remains highly sensitive to climatic shifts (Kantamaneni et al., 2020).

Beyond agriculture, the degradation of coastal ecosystems, including mangroves and coral reefs, diminishes natural protection against storms and flooding. This ecological erosion leaves coastal populations increasingly exposed to severe weather impacts, thereby amplifying risks to both life and livelihood (Nicholls, 2011). Decreased ecosystem health reduces resilience and adaptability, creating a persistent cycle of vulnerability and socio-economic insecurity (Hardy & Hauer, 2018).

The interconnected impacts of climate change, from natural disasters and environmental degradation to salinization and declining productivity, require a holistic approach that integrates both environmental and socio-economic responses. Effective governance and conservation strategies must consider these multifaceted challenges to support India's coastal populations in adapting to and mitigating the impacts of climate change. The case study that follows on Odisha's Bhitar Kanika region illustrates how these vulnerabilities intersect and amplify one another, underscoring the need for comprehensive and inclusive policy solutions.

Case Study: Interconnected Ecological and Socio-Economic Vulnerabilities in the Bhitar Kanika Region, Odisha

The interconnected impacts of climate change, from natural disasters and environmental degradation to salinization and declining productivity, require a holistic systems thinking approach that integrates both environmental and socio-economic responses. Effective governance and conservation strategies must consider these multifaceted challenges to support India's coastal populations in adapting to and mitigating the impacts of climate change. The case study that follows on Odisha's Bhitarkanika region illustrates how these vulnerabilities intersect and amplify one another, underscoring the need for comprehensive and inclusive policy solutions.

The Bhitarkanika region in Odisha is a significant mangrove repository with high species density, yet it faces substantial vulnerabilities that are deeply intertwined with ecological and socio-economic factors. As highlighted by **Mr. Saumya Jain from the Socratus Foundation for Collective Wisdom**, the challenges facing this coastal ecosystem are not merely environmental; they are fundamentally economic as well. The region is the most cyclone-prone area in India, placing its communities on the front lines of climate change related risks. These interconnected vulnerabilities necessitate an integrated approach to ecological conservation that accounts for both economic integrity and community resilience.

One major ecological vulnerability is the increased soil salinity, which negatively impacts agricultural potential. As rising salinity reduces the land's fertility, local communities are compelled to turn to alternative livelihoods, including industrial-level shrimp cultivation. These activities often involve the use of high levels of bleach and other chemicals, leading to further environmental degradation as effluents flow into the waterways, polluting the already fragile ecosystem.

Moreover, the socio-economic vulnerabilities in Bhitarkanika are accentuated by migration patterns. The region has one of the highest rates of migration in India, with many individuals leaving their homes due to job scarcity and economic pressures. Many residents migrate to places like Kerala in search of better employment opportunities, leaving behind communities that suffer from both population loss and a detachment from their traditional environmental stewardship roles. This migration is often referred to as "sustenance migration," as these individuals seek to provide for their families and escape the dire economic conditions exacerbated by climate impacts.

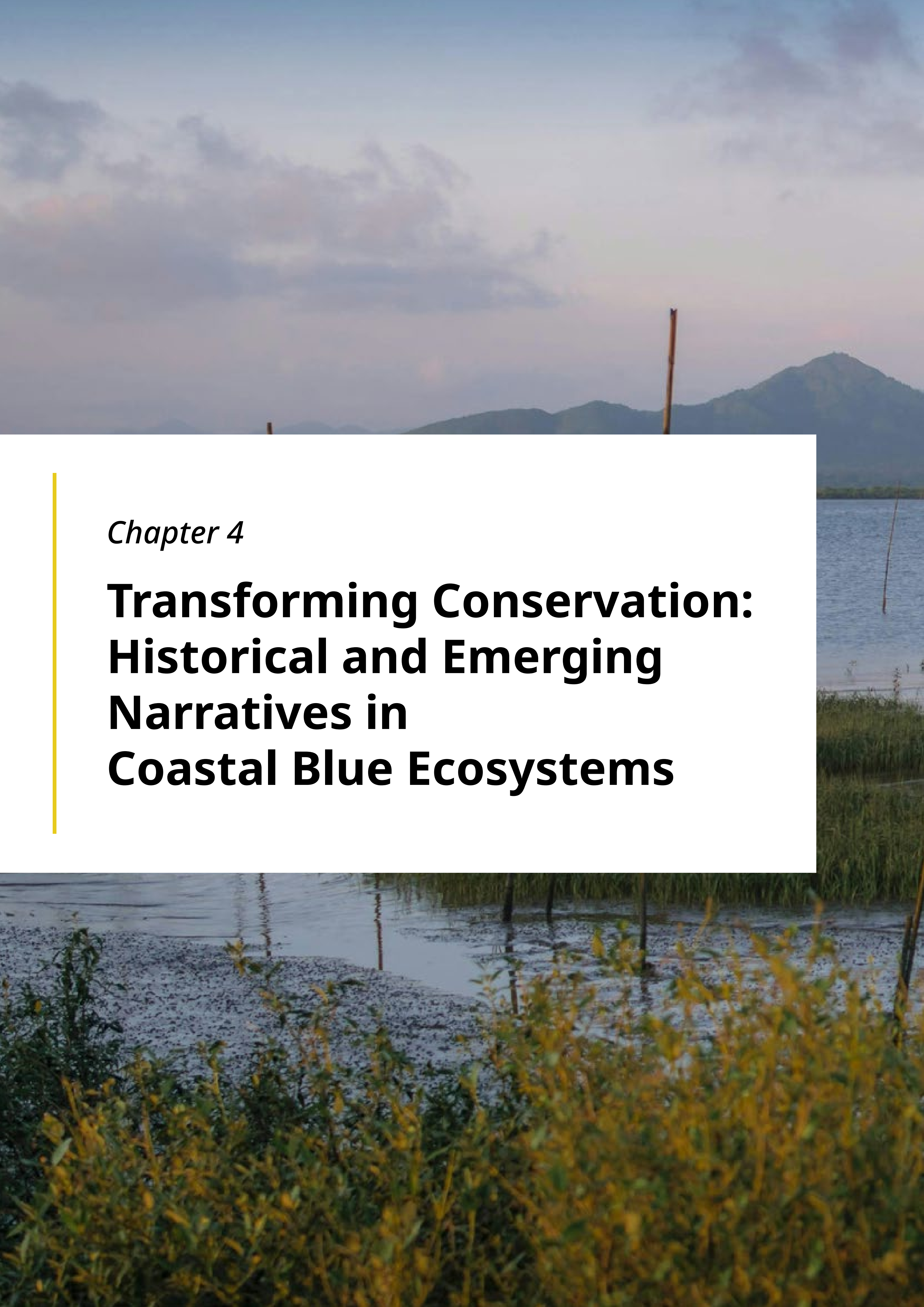
Adding to the complexities of the region's vulnerabilities is the impact of government-imposed restrictions. Although the intentions behind declaring Bhitarkanika a national sanctuary and park may have been good, the sudden removal of local communities' rights over the mangrove region has led to more significant environmental challenges. Saumya pointed out that while these policies are designed to protect the ecosystem, they also disconnect communities from their historical relationship with the land, which is critical for resource management. The blanket bans on practices such as non-timber forest produce collection and traditional fishing deprive these communities of sustainable livelihoods, intensifying their reliance on environmentally harmful alternatives.

This combination of ecological degradation, socio-economic pressures, and migration issues illustrates the urgent need for integrated management approaches that involve local communities in decision-making processes. Recognizing the interconnectedness of ecological and socio-economic vulnerabilities is essential for developing effective conservation strategies in the Bhitarkanika region, which start with restoring the relationship between nature and people. By fostering community engagement and understanding the socio-economic dynamics at play, stakeholders can work collaboratively toward restoring both the ecosystem and the livelihoods of those who depend on it instead of focusing on interventions that have a zero-sum game between ecology and economy.

Assessing vulnerabilities in communities dependent on blue ecosystems requires understanding the unique intersection of social, ecological, and environmental factors in each region. Climate change, habitat destruction, pollution, and socio-economic challenges vary by context, influenced by historical and social dynamics, such as education, economic status, and legal rights. Recognizing these interconnected vulnerabilities is essential for crafting conservation and livelihood strategies that holistically address community needs, enhancing conservation effectiveness and inclusivity.

"Crucially, communities should not be viewed as a single homogeneous group; rather, an intersectional approach is vital to accurately assess their vulnerabilities. In particular, the coastal fisher community serves as a poignant example of this concept. Many individuals within this community face significant barriers due to their very low literacy levels, which limit their ability to pursue alternative livelihoods. Unlike farming communities in the same geographical area, who possess land rights and who may have some degree of habitat and economic security, coastal fisherfolk typically lack property rights and habitation security. Furthermore, the apparent lack of legal, social, and economic disadvantage becomes particularly pronounced during disasters or when their habitat areas are encroached, degraded or when they are evicted. Such drastic measures leave them extremely vulnerable as they confront huge risks and uncertainties, without having access to resources or means to sustain their existence".

- Prof. S. Janakararajan shared during the expert consultation



Chapter 4

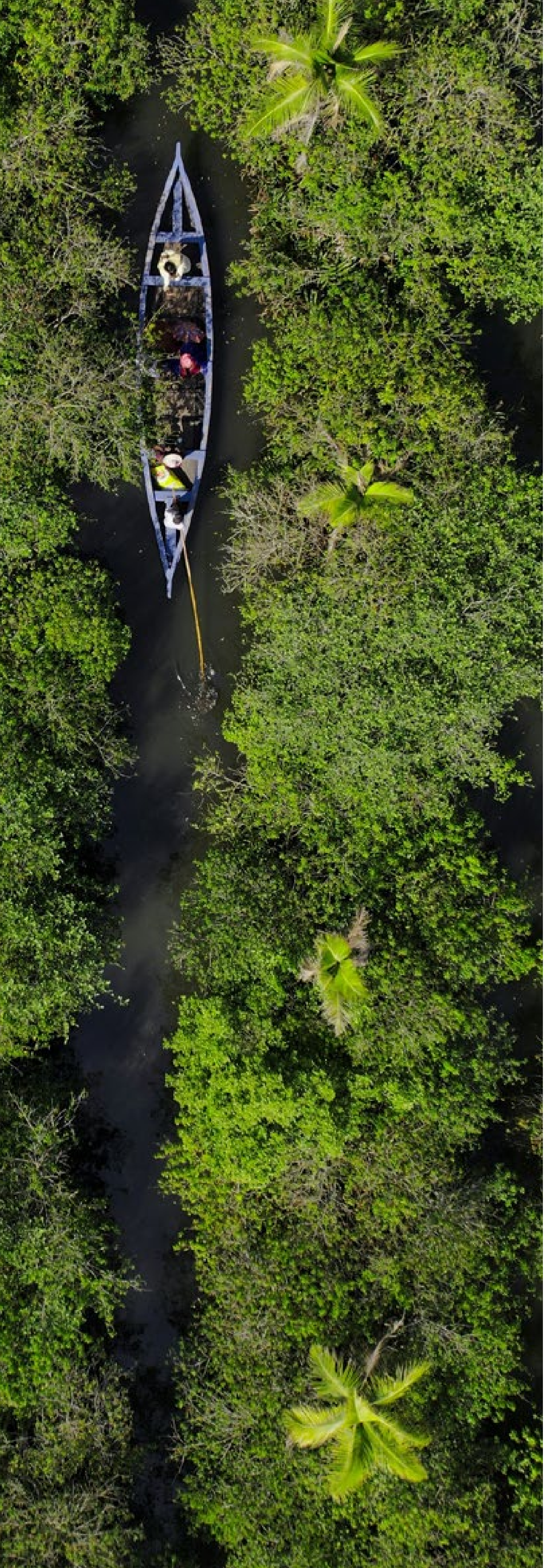
Transforming Conservation: Historical and Emerging Narratives in Coastal Blue Ecosystems

4.1
Historical Context, Emerging, and Re-emerging Conservation Narratives

Coastal blue vegetated ecosystems are increasingly gaining recognition for their significant role in carbon sequestration and climate change mitigation, as demonstrated by extensive global research. Various ecosystems and species have been studied for their effectiveness in capturing carbon and trapping greenhouse gas emissions, and it has been proven that coastal blue vegetated ecosystems outperform many others in this regard, earning them the designation of "blue carbon ecosystems." The rising focus on the blue economy and carbon credit markets has introduced new stakeholders to this field. It is interesting to observe how conservation perspectives have evolved and how important narratives surrounding communities and traditional knowledge related to these ecosystems are emerging—or reemerging. Tracking these developments is essential for mindfully guiding future sustainable strategies and actions.

Understanding the timeline and evolution of coastal blue carbon ecosystem conservation is crucial for several reasons. It highlights the historical context of human interaction with these ecosystems, revealing how cultural practices, exploitation, and scientific understanding have shaped current conservation strategies. This knowledge enables us to appreciate the resilience of indigenous practices while recognizing the consequences of industrialization and climate change, guiding future efforts toward sustainable management and restoration of these vital ecosystems. By learning from past narratives, we can develop more effective and inclusive approaches to conservation that respect both ecological integrity and community rights.

Coastal communities have long celebrated the practical benefits of coastal blue vegetated ecosystems for centuries, mangroves served as vital sources of timber, fuel, and food, while seagrasses created essential habitats for juvenile fish and shellfish—key staples in coastal diets (Feng, 2023; McLeod et al., 2011). Tidal salt marshes played an equally important role as grazing lands for livestock



and salt production sites, underscoring their economic value. Indigenous peoples developed sustainable harvesting practices that respected natural cycles, safeguarding resources for future generations (Lovelock & Duarte, 2019).

The cultural significance of coastal blue vegetated ecosystems extends far beyond their economic value. These ecosystems are deeply intertwined with the cultural narratives and spiritual beliefs of local communities. Thus, the preservation of these habitats is not just an ecological concern but also a matter of cultural heritage and identity.

The communities actively celebrate their coexistence with their coastal ecosystems. In many coastal regions, festivals and rituals celebrate the harvesting of resources from these ecosystems, strengthening community bonds and reinforcing cultural practices. Knowledge and traditions associated with the sustainable use of these habitats are often passed down through generations, fostering a profound connection between communities and their environments.

During the Age of Exploration, colonial powers began to scientifically document the ecological functions of mangroves and salt marshes, noting their roles in coastal protection and sediment stabilization. However, this period also marked the onset of significant exploitation of these ecosystems for timber and land conversion, leading to early signs of degradation.

Colonialism, itself rooted in the control of natural resources, created new forms of inequality and exacerbated existing ones (Murombedzi, 2016). It fundamentally disrupted the relationship between indigenous communities and their ecosystems by treating these communities as outsiders and establishing centralized control over natural resources (Germond-Duret, 2022). This approach led to increased exploitation and a diminished sense of ownership and responsibility among indigenous peoples regarding their ancestral lands. Moreover, colonial conservation strategies prioritized modern scientific practices while dismissing the traditional ecological knowledge developed by indigenous communities over centuries. This disregard has contributed to significant environmental degradation and large-scale habitat loss.

The **19th century** saw an improved understanding of the ecological roles of coastal blue vegetated habitats. Emerging scientific studies highlighted the importance of mangroves for coastal protection and their contributions to fisheries. The concept of ecosystem services began to develop, framing these habitats as critical for supporting biodiversity and human livelihoods (Ahmed et al., 2016; Bennett, 2024). Despite this growing awareness, industrialization and urban expansion increased pressures on these ecosystems.

By the **early to mid-20th century**, signs of ecological degradation became more pronounced, particularly due to increasing rates of mangrove deforestation resulting from land conversion for agriculture and urban development. For example, according to the Government of India (1987), the country lost 40 percent of its mangrove area in the previous century. Seagrass meadows also declined as a result of pollution and physical disturbances. Meanwhile, newly established nations inherited colonial practices of natural resource governance. Nonetheless, some communities continued to utilize traditional ecological knowledge to advocate for the protection and sustainable use of these vital habitats.

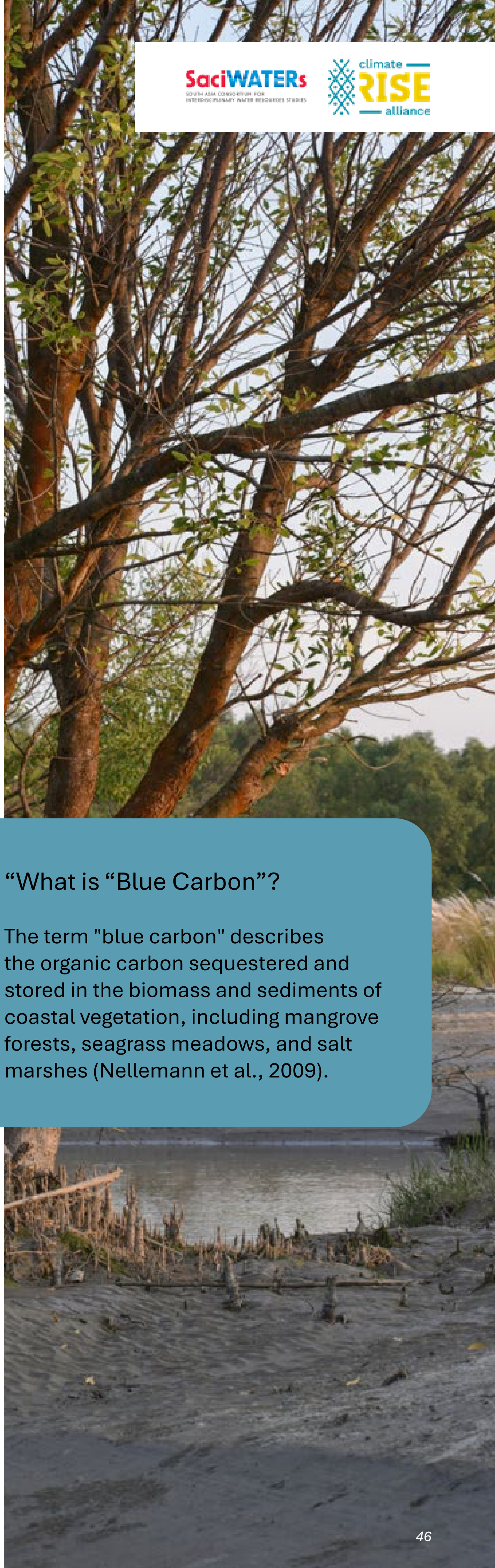
In the **late 20th century**, as climate change emerged as a primary planetary existential threat, there was a growing recognition of the ecological importance of blue vegetated habitats. Research highlighted their significant carbon sequestration capabilities, which spurred an increased focus on their conservation as a strategy for climate change mitigation (Quevedo et al., 2022; Bandh et al., 2023). This period also witnessed the rise of community-led conservation initiatives that integrated local knowledge and stewardship into restoration efforts.

In the 21st century, the term "blue carbon" was officially coined in 2009 to refer to the carbon sequestration capabilities of coastal vegetated habitats.

Recognition of the role of blue vegetated habitats in climate change mitigation and biodiversity conservation has gained momentum. International agreements, such as the Paris Agreement, emphasize the importance of protecting and restoring these ecosystems to meet global climate goals (McLeod et al., 2011).

Community engagement has become essential, with local stakeholders increasingly recognized as key players in the sustainable management of these habitats. Contemporary initiatives often blend traditional ecological knowledge (TEK) with scientific approaches, contributing to a more comprehensive understanding of these ecosystems.

The recognized carbon potential of coastal blue vegetated ecosystems has driven efforts for their



“What is “Blue Carbon”?

The term "blue carbon" describes the organic carbon sequestered and stored in the biomass and sediments of coastal vegetation, including mangrove forests, seagrass meadows, and salt marshes (Nellemann et al., 2009).

protection through increased research, financing, and political commitments outlined in national climate change mitigation and adaptation action plans. However, some unsustainable practices have emerged, such as promoting monocultures or specific species known for their higher carbon sequestration potential through poorly designed plantation initiatives in the booming carbon credits market. These practices disrupt the natural integrity of ecosystems, compromise biodiversity, and undermine essential ecosystem services, as well as the traditional livelihoods that depend on them. This poses long-term dangers to the entire ecosystem. Therefore, there is an urgent need for cautiously designed, holistic approaches, combined with effective regulatory and monitoring mechanisms.

Historical community practices **Pre-Colonial Era**	• Sustainable practices by indigenous communities; mangroves used for timber, fuel, food, and salt marshes for grazing. • Cultural and spiritual significance; sustainable harvesting methods ensure long term ecosystem health.
Colonial Disruption **Age of exploration 15th - 17th century**	• Centralised control reduces indigenous stewardship. • Early signs of degradation due to over-exploitation and disruption of indigenous relationships with ecosystems.
Scientific Recognition of Ecosystem Services **19th century**	• Recognition of mangroves for coastal protection; ecosystem services emerges as scientific interest in blue ecosystems grows. • Increased deforestation and urbanisation despite growing ecological awareness
Industrialisation and Habitat Loss **20th century**	• Industrialisation accelerates degradation; mangrove deforestation for agriculture and urban development. • Significant habitat loss and environmental degradation.
Climate-Driven Conservation Focus **Late 20th century 1970s - 1990s**	• Climate change prompts research on carbon sequestration potential of blue ecosystems; community-led conservation initiatives emerge. • Blending of traditional ecological knowledge with scientific approaches for ecosystem restoration.
Blue Carbon Concept & Market driven conservations **2009 onwards - 21st century**	• 'Blue Carbon' officially defined, recognising carbon stored in coastal ecosystems; rising focus on carbon credits & blue economy. • Risk of monocultures and market-driven conservation initiatives.
Call for Holistic Conservation	• Emphasis on biodiversity and traditional knowledge integration to maintain ecological balance and community benefits.

Fig 3: Evolution of Coastal Blue Carbon Ecosystem Conservation

4.2 The Evolution of Research on Blue-Carbon Ecosystems: A Data-Driven Analysis

The term mapping of the Elsevier database from 2001 to 2023 reveals a substantial increase in academic and research publications related to “blue-carbon ecosystem,” totaling approximately 60,237 publications over this period. Initial figures from 2001 indicate that there were only 314 publications, but this number surged to 11,186 by the end of 2023. This remarkable growth of 3,464.6% underscores a significant uptrend in the research focus on blue-carbon ecosystems, reflecting an increased recognition of their critical ecological roles (Fig 4).

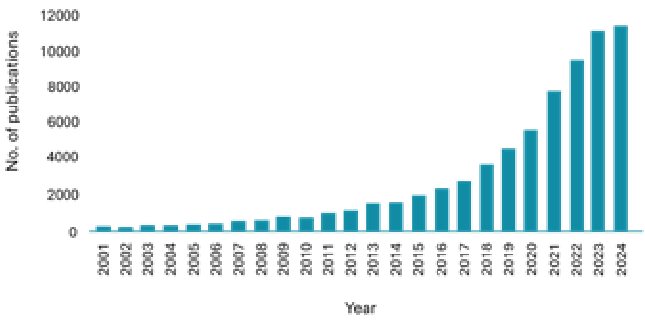


Fig 4: Publications on Blue Carbon Ecosystems (Global) 2001-2024 Source: Elsevier, 2024

Research on seagrasses also showed considerable growth, rising from 233 publications in 2001 to 1,143 in 2023, which equates to a 390.6% increase (Fig 5).

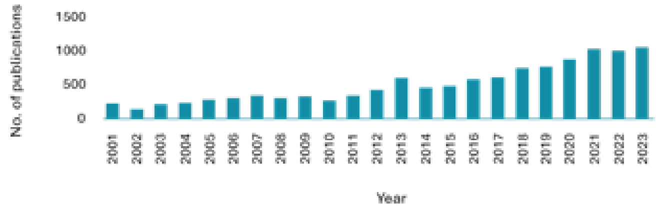


Fig 5: Publications on Seagrasses (Global), 2001-2023

Delving deeper into specific components within the blue-carbon ecosystem demonstrates similar patterns of growth. Notable increases were observed in the literature concerning mangroves, seagrasses, and salt marshes, each of which plays a key role in the overall functioning of blue-carbon ecosystems. For instance, publications related to mangroves grew from 423 in 2001 to 3,123 in 2023, representing a 638% increase (Fig 6).

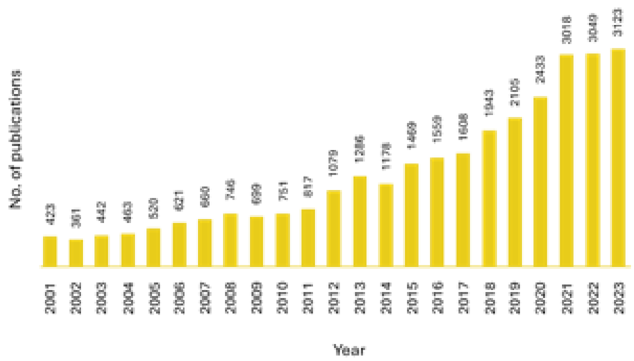


Fig 6: Publications on Mangroves (Global), 2001-2023

Salt marshes similarly saw their publication count increase from 564 in 2001 to 1,529 in 2023, marking a growth of 171.2% (Elsevier, 2024) (Fig 7).

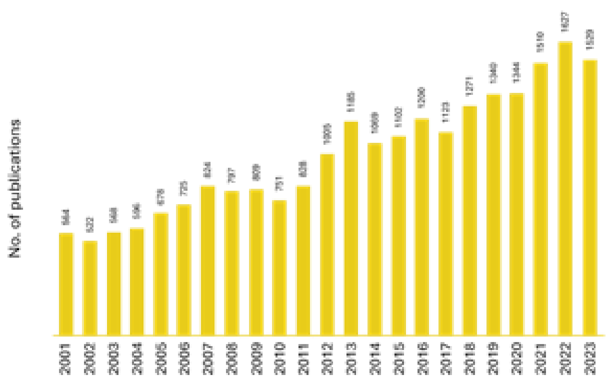


Fig 7: Publications on Salt marshes (Global), 2001-2024 Source: Elsevier, 2024

There has been a greater emphasis on mangrove research, as evidenced by the higher number of publications and the significant percentage increase over the years compared to seagrass and salt marshes. This trend suggests that mangroves are receiving more scholarly attention and continue to be a focal point for research within the blue-carbon ecosystem.

The significant rise in publications concerning blue-carbon ecosystems from 2001 to 2023 indicates a notable shift in scientific discourse, signaling heightened awareness of their ecological and economic contributions. This upward trend in research output is especially relevant in the context of climate change and emphasizes the importance of sustained conservation efforts for these ecosystems as they continue to be recognized as vital components of global environmental strategies.

4.3 Blue Carbon Ecosystems vs. Blue Forest Ecosystems

Can the terms "Blue Carbon ecosystem" and "Blue Forest" be used interchangeably? As defined by UNEP (13 Apr 2017), "Blue forests" are coastal and marine ecosystems, including mangrove forests, seagrass meadows, and tidal salt marshes. They play an important role in protecting marine biodiversity and supporting the livelihoods of coastal and island communities by providing habitats for fisheries, filtering water, guarding shorelines, and creating opportunities for tourism and recreation. Additionally, they can store up to ten times as much carbon per unit area as terrestrial forests.

Blue Carbon ecosystems and blue forest ecosystems are terms that often overlap but have distinct meanings in the context of coastal and marine ecology. Blue Carbon ecosystems specifically refer to the ability to capture atmospheric carbon dioxide (CO_2) and store it in both biomass and sediments. In contrast, the term "blue forest ecosystems" is less commonly used but typically emphasizes the forested aspects of these habitats, particularly mangroves, which can be viewed as the "forests" of the marine environment. This term highlights the structural complexity and biodiversity associated with mangrove forests, which can provide additional ecological benefits beyond carbon storage, such as habitat for fish and other wildlife (Huxham et al., 2018).

The distinction between these terms is important because while all blue forests can be considered blue carbon ecosystems, not all blue carbon ecosystems are blue forests. For instance, seagrass meadows and salt marshes, while integral to blue carbon storage, do not possess the tree-like structure that characterizes forests. Therefore, blue carbon ecosystems encompass a broader range of habitats, including those that may not fit the traditional definition of a forest (James et al., 2024).

Thus, Blue Carbon ecosystems and Blue Forest ecosystems cannot be used interchangeably, while describing a broader range of habitat.

Alternative Terminology:

In terms of alternative terminology for coastal vegetative ecosystems that include mangroves, seagrasses, and salt marshes, several terms can be employed. "Coastal vegetated ecosystems" is a broad term that captures all three types of habitats. Additionally, "marine vegetated habitats" or "coastal wetlands" can also be used to describe these ecosystems collectively. The term "intertidal ecosystems" may also be appropriate, especially when discussing the ecological functions and services provided by these habitats in relation to tidal influences (Leurs et al., 2023). These alternative terms can help to emphasize the ecological roles and interconnectivity of these ecosystems in coastal environments.

We propose the term '**Coastal Blue Vegetated Ecosystems**' to encompass mangroves, seagrasses, and salt marshes, emphasizing their unique coastal habitats characterized by habitat-forming plant species and their proximity to the ocean. This terminology effectively conveys their significance in marine and coastal ecology. Within the natural fabric of these ecosystems, it acknowledges their roles in carbon sequestration while equally emphasizing their importance in supporting biodiversity, protecting coastlines, and providing various other crucial ecosystem services.

In certain sections of this report, we also employ terms such as "blue ecosystems" and "coastal ecosystems" within specific contexts to address broader target areas that extend beyond mangroves, seagrasses, and salt marshes. These terminologies are used to highlight the interconnectedness of various coastal and marine ecosystems, including their biotic and abiotic components, as well as the coastal communities that depend on them.

What's in a name!

Although various terms exist to describe coastal blue vegetated ecosystems—mangroves, seagrasses, and salt marshes—the term chosen carries significant weight in shaping our approach to their development, conservation, and protection. The terminology not only defines the scope of our work but also reflects our broader objectives and priorities.

The following table compares the pros and cons of Blue Carbon Ecosystems and Coastal Blue Vegetated Ecosystems (Table 4):

	Blue Carbon Ecosystems Approach	Coastal Blue Vegetated Ecosystems Approach
Pros		
Biodiversity Focus	Highlights the role of ecosystems in carbon sequestration.	Emphasizes the importance of biodiversity and diverse natural habitats.
Ecosystem Services	Emphasizes their contribution to climate regulation and offers potential financial incentives through carbon markets.	Focuses on enhancing essential services such as coastal protection, nutrient cycling, nursery habitats, food security.
Community Engagement	Aligns with global climate goals, promoting formal policies for carbon credits and market players.	Fosters local stewardship and engagement through a focus on habitats, wildlife, livelihoods and food security.
Resilience Building	Directly addresses climate change by emphasizing carbon storage potential.	Supports ecosystem resilience against climate change impacts. Coastal blue vegetated ecosystems can be integrated into broader coastal management strategies, including fisheries management, creating synergies that enhance overall ecosystem health.
Cons		
Climate Mitigation	May overlook broader ecological and biodiversity benefits, leading to selective conservation of species with high carbon sequestration potential at the expanse of overall habitat integrity and local biodiversity.	May not directly address urgent carbon sequestration needs in climate policy contexts.
Funding and Policy	Risks prioritising immediate carbon storage over long-term ecological health and resilience.	Might attract less funding and policy focus compared to carbon-centered initiatives.
Local Benefits	Marginalisation of local benefits: could de-emphasize the value of these ecosystems for local communities, especially in terms of fisheries and other non-carbon-related livelihoods.	

Table 4: Pros and cons of Blue Carbon Ecosystems and Coastal Blue Vegetated Ecosystems

Sustainability Alert!

“Carbon Can Pay But Biodiversity Must Lead”

- Bond et al, 2024

There is a growing demand to align policies that address both the commitments of the Paris Agreement and the goals of the UN Decade on Ecosystem Restoration (2021-2030). However, current investment efforts have largely focused on climate change mitigation, particularly through the establishment of carbon markets, both voluntary and compliance-based (Bond et al., 2024).

Since there is no effective mechanism to regulate carbon markets, some carbon projects—such as nonnative monoculture tree plantations—can negatively impact biodiversity without facing penalties. This lack of oversight allows practices that prioritize carbon sequestration over ecological health to persist, potentially leading to harmful consequences for local ecosystems.

Carbon can also help biodiversity if they are designed to account for biodiversity impacts (UNEP-WCMC, 2023; Bond et al, 2024).

“Mangrove restoration: To Plant or not to Plant”

- Wetlands International

But nobody is really harmed by mangrove planting, right?

Unfortunately, that’s not true. First, planting a single species leads to monocultures that lack resilience to storms and surges. For instance, after Hurricane Haiyan in the Philippines, all the planted mangrove forests were wiped out. While mangroves do help reduce surges and waves, restored mangrove belts often stretch no more than 100 meters. Although this can mitigate small, everyday waves, it is insufficient against large waves or storm surges. If small, planted mangrove belts are seen as a full solution to all hazards, residents behind them may choose not to evacuate during hurricanes or storm surges, making them more vulnerable and potentially putting lives at risk.

In addition to compromising safety, planting mangroves in the wrong areas can harm local ecosystems. Vulnerable habitats like seagrass beds, which are vital feeding grounds for dugongs and nursery areas for fish and shellfish, can be destroyed by planting activities. Volunteers may also trample over natural mangrove seedlings or other delicate ecosystems while planting. Mangroves are even being planted in seagrass ecosystems, and on tidal flats, crucial feeding zones for shorebirds. A basic rule is not to plant mangroves where they were never naturally present.

Finally, failed mangrove planting efforts can erode people’s trust in ecosystem-based adaptation, which is unnecessary—since, when done correctly, it can be very effective. (Wetlands International, 2016 & 2021).

Chapter 5

Governance Frameworks For Sustainable Blue Ecosystems

SaciWATERs
SOUTH ASIA CONSORTIUM FOR INTERDISCIPLINARY WATER RESOURCES STUDIES

climate RISE alliance

5.1
Understanding Governance

The term *governance* contrasts with government and rose to prominence in the early 1990s. Today, governance is understood as ‘a dynamic, complex process of interactive decision-making that evolves in response to changing circumstances’ (Walters, 2004). Governance includes both formal and informal institutions. Peters (2002) highlights that governance extends beyond formal institutions, incorporating informal mechanisms that play a significant role in shaping governance processes.

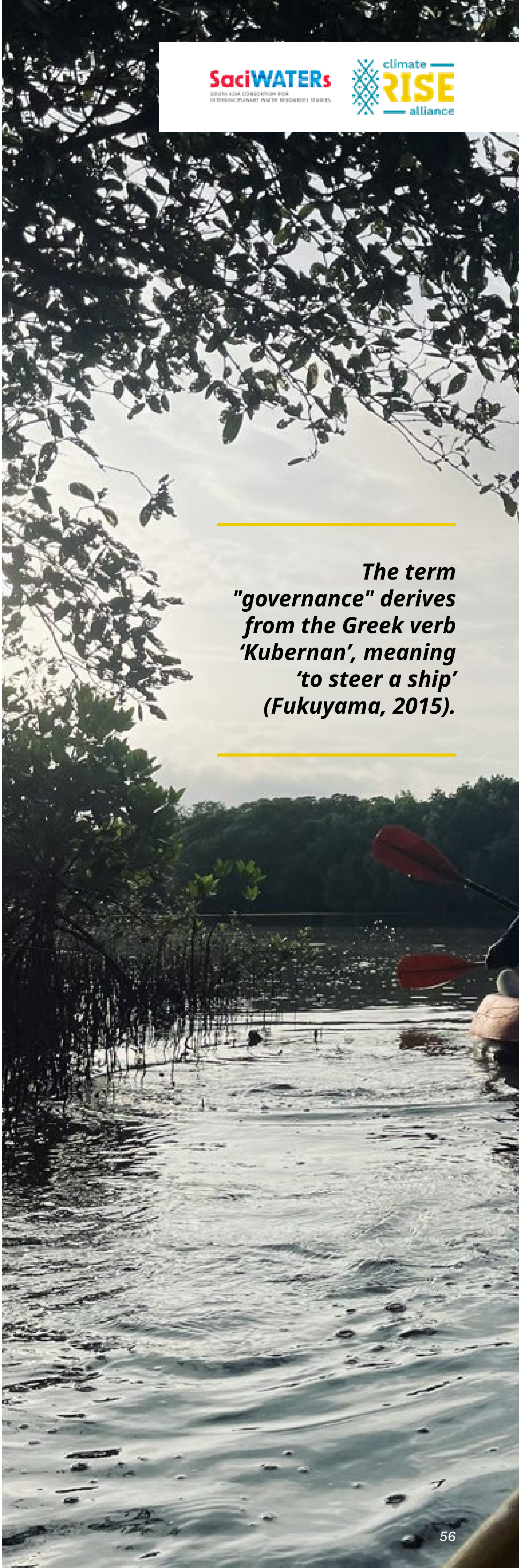
What is Environmental Governance?

Environmental governance is a system of rules, policies, practices, and institutions that guide how humans interact with the environment. It aims to ensure that human activities are sustainable, preserving natural resources and ecosystem health for future generations (Haque, 2023).

According to UNEP, environmental governance encompasses:

- Decision-making:
  Involves identifying who makes decisions, the processes used, and the methods of implementation.
- Scientific information:
  Ensures that necessary scientific data is available to inform decision-making.
- Public participation:
  Focuses on ways for the public and stakeholders to engage in the decision-making process.
- Whole system management:
  Promotes managing the entire ecosystem, integrating efforts from government, business, and civil society.

Governance can be categorized into formal and informal institutions. Peters (2002) emphasizes that governance extends beyond formal institutions to include informal mechanisms that significantly shape governance processes (Peters, 2022).



The term "governance" derives from the Greek verb ‘Kubernan’, meaning ‘to steer a ship’ (Fukuyama, 2015).

Formal and Informal Institutions:

Formal institutions are established by binding laws and regulations, while informal institutions are shaped by conventions, norms, and accepted practices (Leftwich, 2006). Informal institutions are embedded in social practices and can sometimes gain greater acceptance than formal rules (Figure 8). This dynamic reflects Samuel P. Huntington's top-down and bottom-up approaches, where formal arrangements are created by those in power, while informal arrangements often emerge from local traditions and may later gain formal recognition (Huntington, 1991). Using these concepts in the governance of blue ecosystems reveals the interplay of formal and informal structures. Establishing a nuanced understanding of global governance frameworks is crucial for exploring India's unique governance dynamics. The governance of blue ecosystems globally is complex, with competing state interests making it a challenge to create binding formal arrangements.

Governance

Formal Arrangements

Established through legal and regulatory structures, including laws, policies, and official institutions (e.g., government agencies, international organisations).

Informal Arrangements

These are unwritten rules and cultural practices that influence behaviour and decision-making within communities or among stakeholders.

Traditional & Indigenous Institutions

Local governance practices that may be formally recognised by the state but play a significant role in managing resources and resolving conflicts.

Regulatory Mechanisms

Top-down, enforce compliance with established rules, standards and guidelines, often through legislation, treaties, and formal agreements.

Accountability Systems

Involve official procedures for monitoring, evaluation, and enforcement, ensuring that actors adhere to the prescribed norms and regulations.

Bottom-up Approach

Builds from the local level, empowering communities to take an active role in shaping governance processes with the active participation of community members.

Fig. 8: Governance framework depicting the distinct roles of formal, law-based institutions and informal, tradition-based institutions in governance.

5.2
Global Governance Frameworks:

The framework for blue ecosystem governance supports developing strategic policies and incentive mechanisms for the conservation, restoration, and sustainable use of blue ecosystems worldwide (Herr, Pidgeon, & Laffoley, 2011). Increased global action through a strengthened governance framework is essential for achieving conservation and restoration outcomes.
Key international agreements—including the UNCLOS, UNFCCC, CBD, Ramsar Convention, and the SDGs—advocate for cohesive governance processes to safeguard and restore blue ecosystems. This integrated approach shifts from siloed methods to collaborative strategies that enhance ambition and accelerate implementation, motivating states to align their governance frameworks with national policies (IUCN, 2023; UN, 1982).

Integrated Multi-Layered Approach

The diagram (Figure 9) from International Union for Conservation of Nature (IUCN), Conservation International (CI), and the United Nations (UN) illustrates the multi-layered governance approach for blue ecosystems. By integrating various international frameworks and focusing on ambitious goals, it presents a comprehensive strategy to address the complex challenges facing coastal and marine environments (IUCN, 2023; UN, 1982).

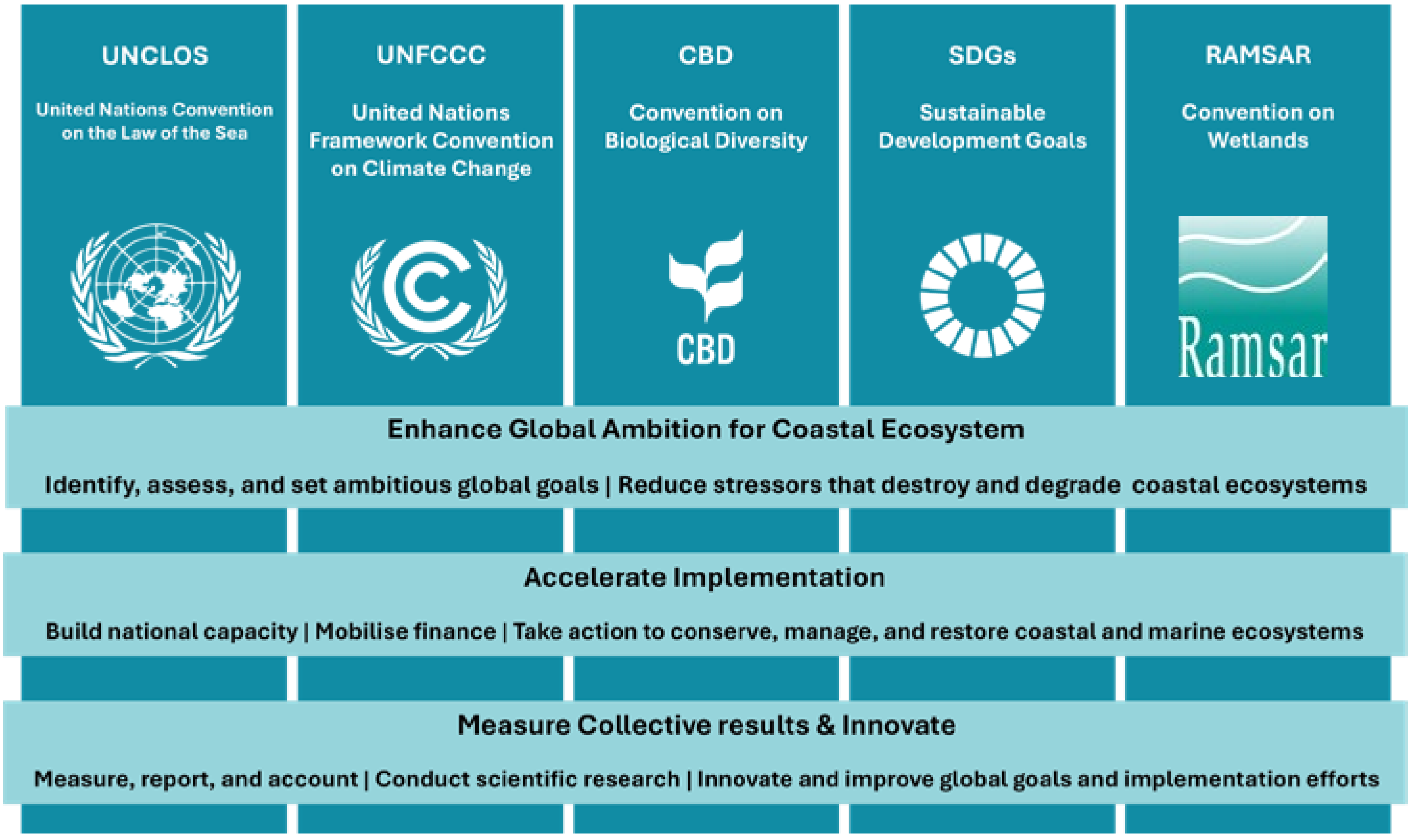


Fig. 9: Multi-layered Approach for the Governance of Blue Ecosystem.
(Source: Herr, Pidgeon, & Laffoley, 2011; UN, 1982)

Major Global Governance Mechanism of Blue Ecosystem

Table 5: The governance of blue ecosystems is shaped by several key international conventions and agreements, each addressing various aspects of marine protection and sustainable use.

Framework/Convention	Key Aspects
United Nations Convention on the Law of the Sea (UNCLOS)	• Addresses the protection and sustainable use of marine resources, including blue carbon ecosystems. • Promotes international cooperation on transboundary marine issues and emphasizes the need for conserving marine biodiversity. • Supports marine scientific research, which is essential for understanding and managing blue carbon ecosystems. • Offers mechanisms for resolving disputes related to marine environmental protection.
The Ramsar Convention on Wetlands of International Importance	• Wise use of wetlands • Designating and managing wetlands of international importance
The 2030 Agenda and the Sustainable Development Goals (SDGs)	• National frameworks and strategies for achieving Goal 14 (Life Below Water) and other relevant goals, Relevant SDGs: 1 (No Poverty), 6 (Clean Water). 13 (Climate Action), and 14 (Life Below Water)
Convention on Biological Diversity (CBD)	• Kunming-Montreal Global Biodiversity Framework (GBF): Goals A and B; Targets 1, 2, 3, 8, and 11. • Programme of Work on Marine and Coastal Biodiversity. • National Biodiversity Strategies and Action Plans (NBSAPs) Convention on Biological Diversity
United Nations Framework Convention on Climate Change (UNFCCC)	• Work Programme for Scaling Mitigation Ambition and Implementation. • Long-term Low Emission Development Strategies • Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs)

Source: Adopted from Herr, Pidgeon, & Laffoley, 2011; UN, 1982

Together, these frameworks create a comprehensive approach to the global governance of blue ecosystems, ensuring their protection, sustainable use, and resilience (UN, 1992). These mechanisms inform and shape national governance frameworks, which typically reflect global standards and targets.

Key Global Networks for Mangrove and Blue Carbon Ecosystems Conservation

Mangrove Alliance for Climate (MAC)
An intergovernmental alliance launched at COP27 (2022) to scale up mangrove conservation and restoration globally. Members include the United Arab Emirates, Indonesia, India, Sri Lanka, Australia, Japan, and Spain.
https://mangrovealliance4climate.org/

Global Mangrove Alliance (GMA)
Established at the World Ocean Summit (2018), GMA unites NGOs, governments, scientists, and funders to advance mangrove conservation. It is coordinated by **Conservation International, The International Union for the Conservation of Nature, The Nature Conservancy, Wetlands International, World Wildlife Fund, SaciWATERs, and Audubon Americas.**
https://www.mangrovealliance.org/gma/

Mangrove Breakthrough
A UN-backed initiative by the High-Level Climate Champions and GMA, mobilizing $4 billion for the sustainable management of 15 million hectares of mangroves. Launched at COP27 (2022). https://*www.mangrovealliance.org/mangrove-breakthrough/*

International Partnership for Blue Carbon (IPBC)
A global network of 60+ government and non-governmental entities dedicated to coastal ecosystem conservation. Founded at COP21 (2015) and now expanded worldwide.
https://bluecarbonpartnership.org/

5.3 Blue Ecosystems Governance in India

India's Blue Economy, supported by its rich Blue Ecosystem, contributes approximately 4% to the national GDP, with significant potential for growth. The objective is to enhance this contribution so that it shifts from single-digit to double-digit figures (FICCI, 2017). This goal aligns with the United Nations' designation of 2021-2030 as the "Decade of Ocean Science for Sustainable Development," underscoring the importance of sustainable practices in managing ocean resources (CAG, 2023).

However, the increasing human population, urbanization, and industrial development near the coastline and upstream, along with climate change, have placed tremendous pressure on these fragile Blue Ecosystems. Effective management and regulation of this sector will be key to achieving sustainable economic progress in the coming decades, balancing development with the conservation of its diverse and delicate Blue Ecosystem (FICCI, 2017; CAG, 2023).

The governance of coastal blue vegetated ecosystems in India encompasses both formal and informal institutions, each playing a vital role in the management and sustainability of these critical environments.

5.3.1 Formal Institutions in India

Formal institutions emerged prominently in India during the 1980s, establishing a framework for the governance of coastal ecosystems. Key governmental bodies involved in this governance include the **Ministry of Environment, Forest and Climate Change (MoEF&CC)** and the **Ministry of Earth Sciences (MoES)**. These ministries are responsible for developing policies, regulations, and frameworks aimed at the conservation and sustainable use of coastal resources, including mangroves, seagrasses, and salt marshes.

Institutions Related to Coastal Ecosystems within the Ministry of Environment, Forest and Climate Change (MoEFCC)

Table 6: The list below provides an overview of institutions directly under or affiliated with the Ministry of Environment, Forest and Climate Change (MoEFCC) that focus on the conservation and management of coastal ecosystems.

Sr. No.	Institution	Focus Area
1	Wildlife Institute of India (WII)	Training, research, and management of wildlife, including coastal and marine biodiversity.
2	Centre for Marine Living Resources and Ecology (CMLRE)	Research and management strategies related to marine living resources, contributing to the conservation of coastal ecosystems.
3	National Compensatory Afforestation Fund Management and Planning Authority (CAMPA)	Funds biodiversity conservation projects, including those related to coastal habitats.
4	Indian Council of Forestry Research and Education (ICFRE) - Coastal Ecosystem Centre (CEC)	Specialised research on forest biodiversity and management of forest genetic resources, with a focus on mangroves and coastal ecosystems in India.
5	National Biodiversity Authority (NBA)	Implements the Biological Diversity Act, focusing on the conservation and sustainable use of biodiversity, including coastal and marine species.
6	State Biodiversity Boards (SBBs)	Conservation and sustainable use of local biodiversity, including coastal ecosystems at the state level.
7	Pollution Control Boards: Central Pollution Control Board (CPCB) & State Pollution Control Boards	Monitor and regulate pollution, ensuring protection of coastal and marine ecosystems from contaminants.
8	Botanical Survey of India (BSI)	Conducts research and surveys on plant biodiversity, including coastal flora.
9	Zoological Survey of India (ZSI)	Documents and conserves fauna of India, including marine and coastal species.
10	National Marine Fisheries Research Institute (NMFRI)	Research on ecological status of marine and coastal ecosystems, contributing to sustainable marine resource management.
11	Central Institute of Coastal Engineering for Fishery (CICEF)	Provides research and technical assistance on coastal engineering issues affecting fisheries and coastal habitats.
12	Salim Ali Centre for Ornithology and Natural History (SACON)	Focuses on avian biodiversity and conservation research, particularly in coastal and wetland habitats, contributing to the conservation of critical coastal areas.

Table 7: The list below provides an overview of institutions directly under or affiliated with the Ministry of Earth Sciences (MoES) that focus on the conservation and management of coastal and marine ecosystems.

Sr. No.	Institution	Focus Area
1	National Institute of Oceanography (NIO)	Marine research, including studies on coastal ecosystems, marine biodiversity, and ocenographic processes.
2	Indian National Centre for Coastal Research (INCOIS)	Provides ocean data and information services, including predictive models for coastal phenomena crucial for coastal management.
3	National Centre for Coastal Research (NCCR)	Research on coastal and marine processes, coastal management, and eco-restoration projects aimed at enhancing the health of coastal ecosystems.
4	National Institute of ocean Technology (NIOT)	Develops world-class technologies and their application for sustainable utilisation of ocean resources; builds knowledge and institutional capabilities for ocean management.
5	National Centre for Earth Science Studies (NCESS)	Research and scientific understanding of earth processes, including aspects affecting coastal and marine environments.
6	National Centre for Antarctic and Ocean Research (NCAOR)	Primarily focused on polar research but conducts studies relevant to ocean science and coastal processes.
7	Indian Institute of Tropical Meteorology (IITM)	Research related to weather and climate, including studies that impact coastal ecosystems.

Table 8: In addition to the Ministry of Environment, Forest and Climate Change (MoEFCC) and the Ministry of Earth Sciences (MoES), which have a direct role in the governance of blue ecosystems, several other ministries and associated institutions in India serve as essential stakeholders in the management and conservation of coastal and marine ecosystems. The following overview outlines these key ministries and their relevant contributions to coastal and marine governance.

Sr. No.	Ministry	Institution/ Authority	Focus Area
1	Ministry of Fisheries, Animal Husbandry, and Dairying	National Marine Fisheries Research Institute (NMFRI) Central Institute of Coastal Engineering for Fishery (CICEF)	Conducts research on marine fisheries, focusing on sustainable practices and management of marine resources. Focuses on coastal engineering issues that impact fisheries and coastal habitats.
2	Ministry of Agriculture and Farmers' Welfare	Indian Council of Agricultural Research (ICSR) National Fisheries Development Board (NFDB)	Encompasses various institutes focusing on sustainable agricultural practices, research & technology transfer relevant to coastal ecosystems. Implements the Blue Revolution - Integrated Development and Management of Fisheries.

3	Ministry of Water Resources, River Development, and Ganga Rejuvenation	-	Engages in integrated water resource management approaches impacting coastal ecosystems, particularly through management of rivers flowing into coastal areas.
4	Ministry of Civil Aviation	National Airports Authority	While indirectly related, considers coastal environmental management in the planning and development of coastal airports and associated infrastructure.
5	Ministry of Shipping	Shipping Corporation of India	Engages in policies related to shipping activities, focusing on environmental regulations and coastal management impacts.
6	Ministry of Science and Technology	Department of Science and Technology (DST)	Engages in research funding and initiatives focused on marine and coastal research, often collaborating with academic institutions.
7	Ministry of External Affairs	Indian Ocean Rim Association (IORA)	Participates in regional initiatives for collaborative approaches to marine and coastal challenges affecting Indian Ocean countries.
8	Ministry of Urban Affairs	Jawaharlal nehru National Urban Renewal Mission (JNNURM)	Implements urban development programs in coastal cities, integrating urban planning with coastal management initiatives.
9	Ministry of Tribal Affairs	-	Focuses on the rights and livelihoods of tribal communities that are often dependent on coastal and marine resources for their sustenance.
10	State Coastal Zone Management Authorities (SCZMAs)	-	Each coastal state in India has dedicated authorities for implementing the Coastal Regulation Zone (CRZ) Notification and managing coastal ecosystems at the state level.
11	Ministry of Home Affairs	National Institute of Disaster Management (NIDM)	Operates under the Ministry of Home Affairs and plays a crucial role in disaster risk reduction and management, which is essential for coastal and marine areas that are susceptible to natural disasters like cyclones, floods, and rising sea levels.
12	Ministry of Defense	The Indian Navy & the Indian Coast Guard	Involved in monitoring dugings in India, along with other stakeholders such as the Wildlife Institute of India (WII), and state forest departments.

Although there is no singular framework dedicated solely to Coastal Blue Vegetated Ecosystems, a variety of laws and policies address aspects of marine and coastal governance. Important legislative acts include:

- **The Wildlife Protection Act, 1972**: This act establishes protected areas, including marine protected areas (MPAs), to conserve endangered species and their habitats.
- **The Environment (Protection) Act, 1986**: This act provides a framework for the protection and improvement of the environment, including coastal areas.
- **The Coastal Regulation Zone (CRZ) Notifications**: First issued in 1991 and updated in subsequent years, the CRZ regulations aim to restrict development in ecologically sensitive coastal areas to protect marine biodiversity and ecosystems.
- **The National Biodiversity Act, 2002**: This legislation aims to protect India's biological diversity and sustainably use resources by establishing guidelines for conservation efforts

The Major Policy Mechanisms Related to Governance as Formal Arrangements are Outlined in the Table Below:

Major Policy Mechanisms in India

Sr. No.	Name of Scheme/ Act/ Policy/ Programme	Year of Enactment	Focus Area	Brief Description	Type
1	The Wild Life Protection Act of India	9th September, 1972	There are a total of 31 major Marine Protected Areas in India covering coastal areas that have been notified under Wildlife Protection Act, 1972. In total, including minor and major, mainland India has 25 MPAs and the Andaman and Nicobar and Lakshadweep Islands consist of 106 MPAs.	The marine resources of India have been identified by the International Union for Conservation of Nature as one of the top twenty biodiversity's worldwide. An oceanic region designated as a marine protected area (MPA) has restrictions on human activities. India has designated four legal categories of protected areas: National Park, Wildlife Sanctuary, Conservation Reserve and Community Reserve under sections 18, 35, 36A, and 36C of the Act.	Act/Policy

2	The Indian Forest Conservation Act, 1980	1980	Forests including Mangrove Forests	Act was enacted to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.	Act
3	The Ramsar convention in India	February 1, 1982	Wetlands of international importance	Known as the Convention on Wetlands of International Importance, It is an intergovernmental treaty that promotes the conservation and wise use of wetlands. There are 85 Ramsar sites in India as of August 2024. The Indian Sunderbans (West Bengal), Bhitarkanika (Odisha) and Pichavaram (Tamil Nadu) are important mangrove areas which have been declared as Ramsar Sites.	Intergovernmental treaty
4	The Environment (Protection) Act	November 19, 1986	Protection and improvement of the environment and for matters connected therewith.	This Act empowers the central government to take measures to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the setting and/or operation of any industrial facility on environmental grounds.	Act/Policy
5	Coastal Regulation Zone Notification	February 19, 1991	Regulation of activities in the coastal areas of India to protect the coastal environment.	This notification classified the coastal areas into different zones and regulated activities and development in these zones to protect the coastal and marine environment.	Act/Policy

6	National Committee on Mangroves, Wetlands and Coral Reefs	1993	Advisory on policies and programmes for conservation of marine species.	This committee advises the government on the formulation and implementation of policies and programs related to the conservation and management of mangroves, wetlands, and coral reefs.	Committee/ Program
7	National Biodiversity Act	2002	Conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of benefits arising from the use of biological resources.	This Act aims to provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the utilization of genetic resources.	Act/Policy
8	Marine Fishing Policy/National Policy on Marine Fisheries (NPMF)	2004/ 2017	Sustainable marine fishing practices.	This policy provides guidelines for sustainable marine fishing practices, protecting marine biodiversity and ensuring the livelihoods of fishing communities.	Act/Policy
9	National Environmental Policy	2006	Mangroves and coral reefs which provide habitats for marine species	This policy advocates sustainable mangrove management into forestry regulations to support local livelihoods and coral reef regeneration techniques and include sea-level rise and coastal vulnerability in management plans and infrastructure norms	Policy
10	Integrated Development of Wildlife Habitats (IDWH)	2008-09	Wildlife Habitats	The Ministry funds the monitoring and conservation of marine turtles, marine dolphins and humpback whales under the PAN India IDWH. Marine Mega Fauna Stranding Guidelines', 'National Marine Turtle Action Plan, and project dolphin launched in 2021.	Scheme

11	Indian Ocean: Deep ocean observations and dynamics of lithospheric evolution (IODP and geoid low)	Joined IODP in 2009	Oceanic and Geological Research	India's participation in the International Ocean Discovery Program (IODP) for geological research, including the IODP-355 expedition in the Arabian Sea.	Action Plan
12	Integrated Coastal Zone Management (ICZM)	2010	Coastal Zone Management	ICZM that is assisted by the world bank is an initiative aimed at sustainable management and use of coastal resources through coordinated efforts among different stakeholders and sectors. The program covers various aspects like pollution control, biodiversity conservation, and livelihood security. Mangrove afforestation was undertaken on a large scale in the Coastal States of Gujarat (195.03 km2), Odisha (3.23 km2) and West Bengal (1.18 km2).	Project
13	National Green Tribunal (under the National Green Tribunal Act, 2010)	18th October 2020	Environmental Disputes	the NGT plays a significant role in adjudicating environmental issues concerning the protection of natural resources, including coastal ecosystems. It addresses cases related to violations of environmental laws and enforces penalties, promoting conservation efforts indirectly through its judicial processes.	Act/Policy
14	The Coastal Regulation Zone (CRZ) Notification	6th January, 2011	Coastal Zone Management	This notification provided updated guidelines and regulations for permissible and non-permissible activities in the coastal regulation zones, focusing on the conservation and sustainable development of coastal areas.	Act/Policy

15	Endangered Species Recovery Plans (ESRP)	2015	Endangered Species & their Marine Habitats	This project aims at implementing the "National Action Plan for Dugong Conservation in India" jointly with various stakeholders such as State Forest Departments, other line agencies and local communities to recover the population and habitat of dugong in India within next two decades. This program emphasizes the conservation of the Dugong, which has led to the designation of approximately 450 sq km in Palk Bay as a Dugong Conservation Reserve. This reserve is crucial for protecting Dugongs and their associated seagrass habitats.	Programme
16	Blue Revolution-Neel Kranti: Integrated Development and Management of Fisheries	2015-2020	Development and management of fisheries sector.	It aims to enhance the fisheries sector through integrated development, focusing on both marine and inland fisheries.	Scheme
17	The Coastal Regulation Zone (CRZ) Notification	18th January, 2019	Revised norms for permissible activities in coastal areas to promote sustainable development.	This notification introduced further revisions to the regulations governing activities in the coastal regulation zones, aimed at balancing development with conservation objectives in coastal areas. It aims for the management and conservation of Ecologically Sensitive Areas (ESAs), such as mangroves, seagrasses, coral reefs, and turtle nesting grounds. Developmental activities and waste disposal in these fragile ecosystems are prohibited.	Act/Policy
18	National Policy on Blue Economy for the country (Draft)	2022	Maritime domain, (living, non-living resources, tourism, ocean energy, etc.) for sustainable development of coastal areas	This policy document contains key recommendations on the National Accounting Framework for Blue Economy and Ocean Governance, Coastal Marine Spatial Planning and Tourism Priority, Marine Fisheries, Aquaculture and Fish Processing, Maritime Security and International Engagement, Manufacturing, Emerging Industries, Trade, Technology,	Policy

				Services and Skill Development, Logistics, Infrastructure and Shipping, Coastal and Deep-Sea Mining and Offshore Energy, and Security, Strategic Dimensions and International Engagement.	
19	The Enhancing Climate Resilience of India's Coastal Communities (ECRICC)	2019	Coastal resilience and livelihoods	The project is being implemented at the national level across India's 13 coastal states and UTs, with field implementation in 24 landscapes covering 12 districts in three coastal states of India.The target three coastal project states are Odisha, Maharashtra and Andhra Pradesh, whose coastal populations are vulnerable to extreme weather events and slow onset of climate change impacts. The project is implemented by the respective State Government'	Green Climate Fund (GCF) Project
20	Pradhan Mantri Matsya Sampada Yojana (PMMSY)	2020	Sustainable and responsible development of the fisheries sector.	Launched with an investment of Rs. 20,050 crores, implemented from 2020-21 to 2024-25, focusing on the sustainable development of the fisheries sector across States and UTs.	Scheme
21	Deep Ocean Mission	2021	Deep Sea Exploration and Biodiversity Conservation.	Focuses on the exploration and sustainable use of deep-sea resources, including minerals, energy, and biodiversity. Includes deep-sea technology development and climate change studies.	Project
22	Mangrove Initiative for Shoreline Habitats & Tangible Incomes (MISTHI)	2023	Mangrove coverage along coastlines and salt pan lands.	Increases mangrove coverage, implements best practices in mangrove plantation and conservation, supports climate change mitigation, and enhances local livelihoods. Envisages to promote development of 540 sq. kms Mangroves across 11 states and 2 Union Territories.	Scheme

Table 9: Major Policy Mechanisms in India

Coastal Regulation Zone (CRZ) Notification

The Coastal Regulation Zone (CRZ) notification is India's key legal tool for protecting coastal ecosystems. Issued under the Environment (Protection) Act of 1986, it mandates that proposed developments in coastal areas obtain prior environmental clearance from the Ministry of Environment, Forest, and Climate Change (MoEFCC) to assess ecological impacts.

Updates to CRZ Notification

1991:
Initial issuance to restrict development in ecologically sensitive areas.

2011:
Amended to improve coastal management practices.

2019:
Further revised to support sustainable development, streamline approvals, and incorporate climate adaptation strategies.

2019 CRZ Notification Highlights

The 2019 notification aims to conserve coastal environments while securing livelihoods for local communities. It designates India's coastal stretches and territorial waters (excluding Andaman, Nicobar, and Lakshadweep islands) as CRZs and promotes sustainable development, considering climate risks.

CRZ Classifications

CRZ-IA:
Ecologically sensitive areas (e.g., mangroves, coral reefs).

CRZ-IB:
Intertidal zones.

CRZ-II:
Developed urban areas.

CRZ-IIIA:
High-density rural areas; 'No Development Zone (NDZ)' up to 50 meters from High Tide Line (HTL).

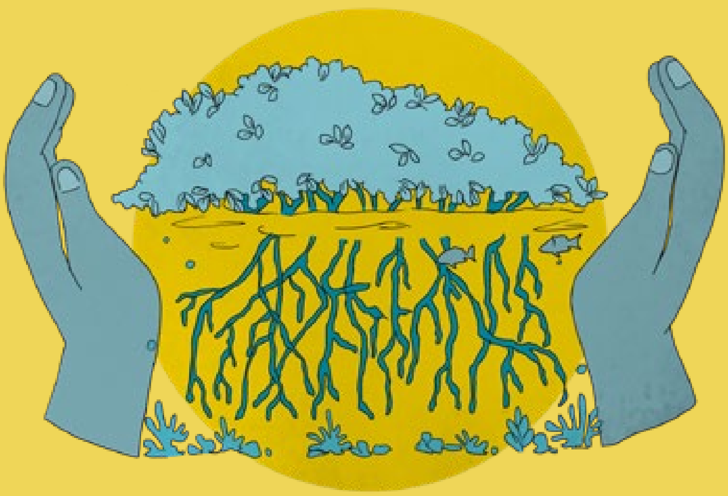
CRZ-IIIB:
Low-density rural areas; NDZ up to 200 meters from HTL.

CRZ-IVA:
Water and seabed area up to twelve nautical miles seaward.

CRZ-IVB
Tidal-influenced water bodies

Ecologically Sensitive Areas (ESAs)

CRZ-IA includes vital ecosystems like mangroves, coral reefs, sand dunes, national parks, turtle nesting grounds, seagrass beds, and archaeological sites, ensuring the preservation of biodiversity and coastal integrity (Table 10).



Sr. No.	Ecologically Sensitive Areas (ESAs) under CR-IA
1	Mangroves: A buffer of 50 meters is required if the mangrove area exceeds 1000 square meters
2	Coral and Coral Reefs
3	Sand Dunes
4	Biologically Active Mudflats
5	Protected Areas: Includes national parks, marine parks, sanctuaries, reserve forests, and wildlife habitats under the Wildlife (Protection) Act, Forest (Conservation) Act, and Environment (Protection) Act, as well as biosphere reserves.
6	Salt Marshes
7	Turtle Nesting Grounds
8	Horseshoe Crab Habitats
9	Seagrass Beds
10	Bird Nesting Grounds
11	Archaeological and Heritage Sites

Table 10: Ecologically Sensitive Areas (ESAs) under CR-IA

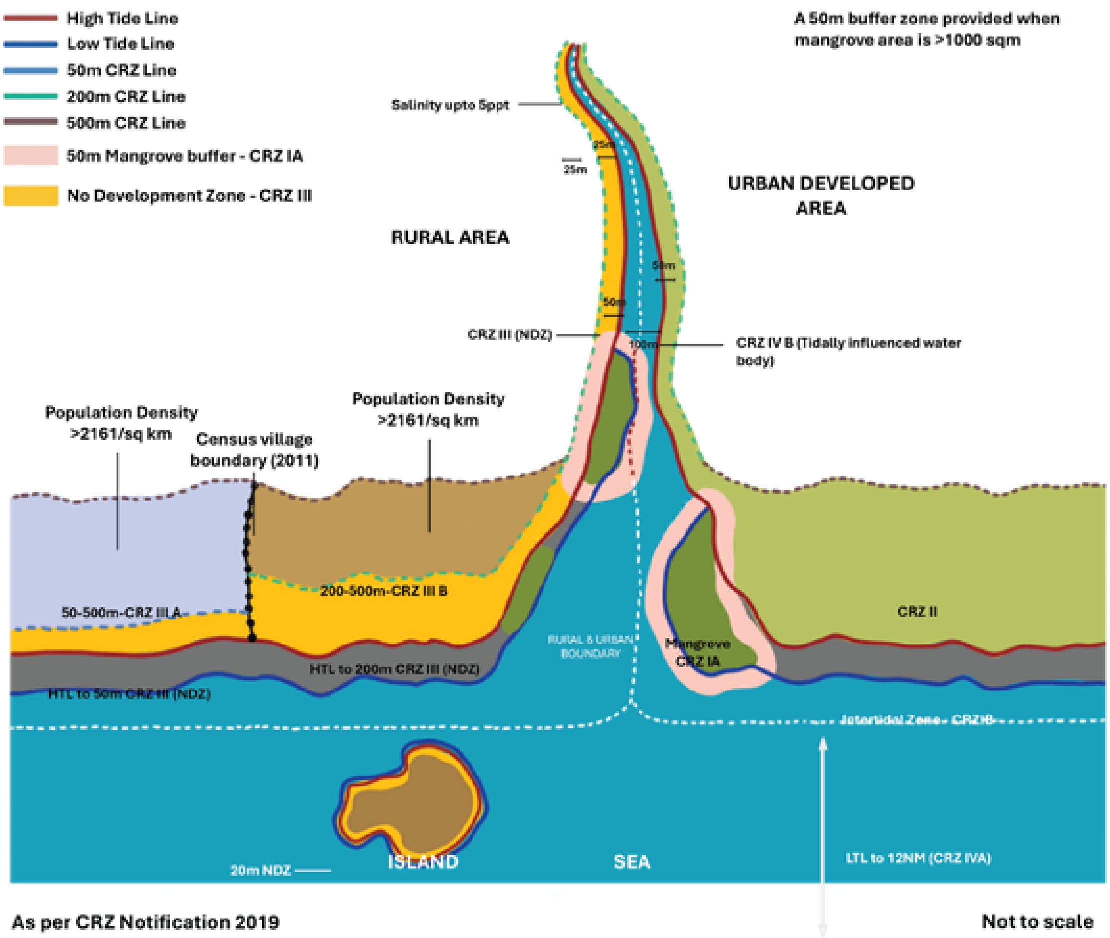


Fig 10: Conceptual Diagram of Coastal Zone Management Plan by NCSCM

Safeguarding India's Coastal Biodiversity: Marine Protected Areas (MPAs) and Important Coastal and Marine Biodiversity Areas (ICMBAs):

Marine Protected Areas (MPAs):

MPAs are designated ocean spaces where human activities are more strictly regulated to protect natural or historic resources, akin to land-based parks. These protections are granted by various government authorities to conserve marine biodiversity.

- Peninsular India:
  26 MPAs covering 7,300.51 km^2.
- Islands (Andaman, Nicobar, Lakshadweep):
  106 MPAs covering 2,314.41 km^2.

Important Coastal and Marine Biodiversity Areas (ICMBAs):

To fulfill National Biodiversity Target No. 6 and Aichi Target No. 11, India has prioritized ***106*** coastal and marine sites as ICMBAs, identified by the Wildlife Institute of India.

Distribution of ICMBAs:

West Coast:
62 sites

East Coast:
44 sites

By State:
Gujarat (***14***), Maharashtra (***16***), Goa (***3***), Karnataka (***10***), Kerala (***18***), West Bengal (***3***), Odisha (***12***), Andhra Pradesh (***17***), Tamil Nadu & Puducherry (***14***).

State Level Initiatives:

These initiatives support India's commitment to conserving coastal and marine biodiversity on both national and global levels.

India's diverse coastal states have launched targeted initiatives to conserve, restore, and sustainably manage critical coastal and marine ecosystems. These efforts, led by state governments, involve establishing dedicated institutions, collaborative projects, and community driven programs that align with ecological protection goals. From mangrove cell establishment to coastal disaster risk reduction, these state-level initiatives exemplify a growing commitment to safeguarding coastal environments against the effects of climate change, habitat loss, and human encroachment.

Key initiatives across several states address the unique needs of their coastal zones, focusing on biodiversity conservation, sustainable livelihoods, community engagement, and habitat restoration.

The table provides a summary of key state-level initiatives undertaken across various coastal states in India.

State	Initiative	Details
West Bengal	Mangrove cell	Established in June 2023 to preserve and manage mangrove forests, constituting about 40% of India's total mangrove cover. It developed an action plan for plantation, conducts research, and coordinates with NGOs, aiming to generate funds for conservation.
	Department of Sundarbans Affairs	Established in January 1994 to boost development in the Sundarban region, with the Sundarban Development Board under it, headed by the Minister of Sundarban Affairs.
Odisha	Mangrove Mitra Programme (MMP)	Initiated in 2021, focuses on the conservation and restoration of mangrove ecosystems through community participation in Kendrapara district, 25 families donated over 25 acres for plantation, demonstrating local involvement.
Gujarat	Mangrove Afforestation	380 km2 of mangrove area afforested through government initiatives (56.6 km2) and public-private partnerships (127.29 km2) involving communities.
	MoU with Reliance Industries	In July 2023, an MoU was signed for developing a mangrove forest over approx. 3,500 acres within the Marine National Park, under the MISHTI scheme.
Maharashtra	Mangrove Cell	Created in 2012; the first coastal state to declare a state mangrove tree species, Sonneratia alba, in 2020.
	Mangrove Suraksha App	Launched in March 2024 by the Maharashtra government through its Forest Department's Mangrove Cell, the initiative enables citizens to report mangrove destruction, enhancing complaint processing and data collection.
	Coastal and Marine Biodiversity	Launched in March 2024 by the Maharashtra government through its Forest Department's Mangrove Cell, the initiative enables citizens to report mangrove destruction, enhancing complaint processing and data collection.
	Coastal and Marine Biodiversity Centre (CMBC)	Established in April 2017 under the Forest Department at Thane Creek, CMBC features state-of-the-art facilities to educate visitors about Maharashtra's coastal and marine biodiversity and conservation. It utilises visual, auditory, and tactile elements to showcase the beauty and ecological importance of coastal biodiversity, along with the threats it faces. The visitor experience is enhanced through interactive computer screens and a cinema room for documentary films.
	The Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra - Mangrove Foundation	Established in September 2015 as an autonomous body under the Revenue & Forests Department with a corpus of Rs. 115 crores, the Foundation focuses on conserving coastal and marine biodiversity, conducting research, and promoting sustainable livelihoods. It works on mangrove conservation, supports livelihood activities through the "Mangrove Conservation and Livelihood Generation Scheme', and conducts capacity-building programs for stakeholders.

Goa	Coastal Zone Management Plan (CZMP)	Focuses on balancing tourism with environmental conservation, beach cleanliness, and protecting coastal biodiversity.
	Mangrove Management Plan	A five-year initiative first prepared in 1991-1992, implementing 100 hectares of mangrove planting annually; currently in its second phase.
Kerala	Reserved Forest	2.36 km^2 of mangroves notified as 'Reserved Forest' under the "Kannur Mangrove Mission".
	Suchitwa Sagarm Project	A waste collection and recycling project aimed at cleaning coasts and promoting eco-friendly fishing practices.
Tamil Nadu	Coastal Disaster Risk Reduction Program (CDRRP)	Includes ecosystem-based adaptation measures, early warning systems, and habitat restoration to reduce disaster risks.
	Marine Elite Force	Launched in March 2024 by the Tamil Nadu government in Ramanathapuram, to protect marine resources and biodiversity in the Gulf of Mannar and Palk Bay, focusing on fragile ecosystems. (The coastal zones of Ramanthapuram are among the country's most biodiverse and sensitive, featuring fragile ecosystems such as coral reefs, mudflats, salt flats, and mangroves).
	Tamil Nadu Coastal Restoration Mission	Launched in January 2024 with World Bank assistance, involving an investment of Rs. 1,675 crore to combat sea erosion and marine pollution, and establish the Tamil Nadu blue Carbon Agency for preserving coastal ecosystems like mangroves, seagrass, and salt marshes. This mission aims to enhance ecosystem services and create a framework for trading carbon credits.

Table 11: State level initiatives

Mangroves for the Future (MFF) initiative of International Union for Conservation of Nature (IUCN)

India is part of the Mangroves for the Future (MFF) initiative by the International Union for Conservation of Nature (IUCN), focusing on enhancing scientific knowledge to improve coastal and marine ecosystem management. MFF also aims to promote sustainable livelihoods for coastal communities and build resilience to climate change and natural disasters through community participation. The initiative is guided by a National Coordination Body (NCB) and the National Strategy and Action Plan (NSAP). Five states have been identified as priority areas based on criteria such as human pressure, pollution, and biodiversity. These states are West Bengal and Gujarat for their extensive mangroves, Odisha and West Bengal for biodiversity richness, and Andhra Pradesh and Tamil Nadu for their tsunami-affected mangroves.

Challenges in Governance and Conservation of Coastal Ecosystems

Despite the existence of various formal arrangements, programs, and schemes, our coastal ecosystems face severe environmental challenges. Although the policies and initiatives appear promising on paper, there is a significant gap in their execution and monitoring. Governance within the realm of coastal and marine ecosystems remains fragmented, with a multitude of policies and initiatives operating in isolation. This disjointed approach underscores the urgent need for a unified and cohesive governance mechanism that can effectively integrate these diverse efforts under a common framework. These challenges are further illustrated through a case study from Goa in the later part of this section.

Furthermore, despite various initiatives and investments from different stakeholders aimed at protecting coastal ecosystems, achieving the desired results has been challenging. This difficulty arises from the concurrent peak in industrial and coastal infrastructure development along-with the unsustainable practices upstream, which often prioritizes immediate economic gains with a short-term vision. The ever-growing demand for resources driven by India's expanding population further complicates these efforts, creating contradictions that hinder effective conservation. A comprehensive source-to-sea and river basin approach should be adopted, recognizing that the health of coastal ecosystems is intrinsically linked to the entire watershed. A participatory integrated strategy will facilitate better management of natural resources, ensuring that both developmental needs and environmental protection are balanced.

5.3.2
Informal Institutions:

On the other side of blue forest governance lies a realm of informal arrangements that have existed since time immemorial, long before formal systems were established. The concept of informality often carries a negative connotation; some scholars have equated it with chaos or disorganization (Perry et al., 2007), and the term is frequently associated with illicit behaviors such as corruption and nepotism (Helmke and Levitsky, 2004). However, a more nuanced understanding of informal institutions has emerged.

Informal institutions can be viewed through various lenses; some interpretations focus on customary laws or social norms that govern community resource management but remain uncodified (Otsuka and Place, 2002). These institutions are built on community-based principles and approaches wherein members share a common interest in fostering trust, forming local groups, and enhancing networks within their communities (North, 1990). Such arrangements significantly influence collective action and behavior. Moreover, institutional failure can result from governmental interference in indigenous management systems, as well as the government's inability to identify, negotiate, and implement trade-offs among the diverse interests of multiple stakeholders. These challenges, coupled with anthropogenic pressures, have led to resource depletion and diminished ecosystem service flow (McShane and Wells, 2004).

Informal institutions reflect the community-based principles that have developed over centuries, addressing the specific needs and concerns of local resource management. Indigenous community members generally work to build trust, foster local groups, and enhance communal networks (North, 1990). While formal institutions, such as local administrative bodies and village level committees, are intended to promote democratic governance, representation, and accountability, informal networks of social and political power often uphold traditional knowledge systems, customary laws, and societal norms embedded within local animistic belief systems. In many cases, these informal arrangements predate their formal counterparts.

Islam (2002) underscores the significance of informal institutions, particularly the 'samaj' and the 'sabha,' in shaping the lives and livelihoods of people in South Asia. The 'samaj' serves as an integral institutional space for collective worship, rituals, and festivals, extending its influence to shape social norms related to resource management (Islam, 2002).

Although a variety of informal mechanisms have been practiced across the country, their documentation and recognition in mainstream academic and research discourse remain limited. Nonetheless, several well-established cases highlight the effectiveness of these informal mechanisms in managing blue ecosystems, as detailed in the following section.

“Forest Fishers – worship Bonbibi and neither deplete nor disturb nature: they respect the forest because they enter it ‘with peace’, consider the tigers to be their ‘brothers’ and consequently share the products of the forest equitably between wild animals and themselves” (31).

“Such a beautiful description of sustainability and harmonious coexistence!
About Bonbibi Worship - A Religion of the Forest in the Sundarbans:(Bonbibi is the goddess worshiped by Hindu, Muslim, Christian, and tribal communities).

Source: Life in the Sundarbans Mangrove Forest of India and Bangladesh-Cultural Beliefs, Religious Practices, and Environmental Degradation
https://uddin.digital.conncoll.edu/sundarbans/regional/bonbibi-worship/

Coastal ecosystems in India are not merely geographical features, they are vibrant cultural landscapes that hold immense significance for indigenous and local communities. These ecosystems such as mangroves, coral reefs, estuaries, salt marshes and sandy beaches, provide a plethora of ecosystem services that are intricately linked to the traditional customs, livelihoods, and cultural identities of these communities. The relationship between these communities and their coastal environments is characterized by a deep-rooted understanding of ecological dynamics, which has been passed down through generations as traditional ecological knowledge (TEK) Newmaster et al. (2011). Traditional knowledge plays a crucial role in the informal governance of coastal ecosystems in India, exemplified through various case studies of local communities. These governance systems reflect cultural beliefs and sustainable resource management practices that have evolved over generations. Below are key examples:

Examples of Traditional Knowledge-Based Informal Governance in India

Case	Location	Belief System	Resource Management	Initiative
Bonbibi in the Sundarbans	Sundarbans, West Bengal	The local communities worship Bonbibi, the guardian spirit of the forest, who protects people from dangers including tigers.	The worship of Bonbibi includes respecting the forest's resources, particularly the mangroves, which are seen as her domain. People collect resources sustainably.	Annual rituals and festivals in honour of Bonbibi reinforce the belief in sustainable use and the protection of the Sundarbans ecosystem.
Onges and Tangi Akini in the Andaman & Nicobar Islands	Andaman and Nicobar Islands	Onges communities believe in the sacredness of mangroves, associating them with deities and spirits that protect the islands.	The tribe practices sustainable harvesting and follows a strict taboo against cutting mangroves, ensuring their preservation, contributing to the conservation of these vital ecosystems, which protect the islands from erosion and support marine biodiversity.	Rituals and offerings to the spirits of the mangroves during festivals reinforce the commitment to preserving these ecosystems.
Padu System	Tamil Nadu and Kerala	Local community-based management system for fishing rights.	Defines group of rights holders, resource boundaries, and fishing sites; caste-specific, gear-specific (stake-nets, and species-specific (shrimp); uses lottery for rotational access.	Padu system functions as a traditional institution to manage access and resolve conflicts; utilises traditional knowledge of fish aggregation based on wind direction. Practices include specific net types for different fish, crab fattening, and boat building. Knowledge is passed down through generations.

Table 12: Examples of Traditional Knowledge-Based Informal Governance in India.
Source: Adopted from Lobe & Berkes, 2004; Arora, 2018; Chakrabarty, 2021

In the Sundarbans of West Bengal, the Bonbibi belief system venerates Bonbibi as the guardian spirit of the forest, providing protection from dangers such as tigers. This spiritual reverence translates into sustainable resource management practices, where local communities gather forest resources in a manner that respects the mangroves, which are considered sacred (Chakrabarty et al., 2021). Annual rituals and festivals celebrating Bonbibi reinforce the community's commitment to preserving the delicate ecosystem of the Sundarbans.

Similarly, the Onges community in the Andaman and Nicobar Islands regards mangroves as sacred, associating them with protective deities and spirits. Their traditional practices include sustainable harvesting and strict taboos against cutting mangroves, which are vital for preventing erosion and supporting marine biodiversity (Arora, 2018). Rituals and offerings during festivals further emphasize their dedication to mangrove conservation.

The Padu system in Tamil Nadu and Kerala represents a local, community-based approach to managing fishing rights, characterized by specific rights holders, resource boundaries, and designated gear types. This system incorporates traditional knowledge, such as using wind direction for fish aggregation, and employs practices like stake nets and rotational access through lotteries (Lobe & Berkes, 2004). Functioning as a traditional institution for conflict resolution and resource management, the Padu system ensures sustainable fishing practices and preserves knowledge passed down through generations.

The cultural significance of coastal ecosystems is particularly evident in the practices of various indigenous groups, such as the Kolis and Ramponkars along the western coast of India. These communities have developed unique fishing techniques and sustainable practices that reflect their intimate knowledge of marine biodiversity and ecosystem health. Traditional fishing methods, such as pole and line fishing and shore seine, are not only a means of subsistence but also integral to their cultural identity and social structure (Fernandes, 2021). The coastal zones serve as nursery grounds for many marine species, which are vital for maintaining the ecological balance and supporting the livelihoods of these communities (Fernandes, 2021).

These traditional informal governance mechanisms, which have thrived and adapted over generations, exemplify successful management of blue ecosystems long before formal systems of governance were established.

The role of women in coastal communities further highlights the cultural significance of these ecosystems. Women often play a crucial role in managing coastal resources, from collecting shellfish to participating in local fisheries. Their traditional knowledge and practices are essential for sustaining both the ecological integrity of coastal environments and the cultural traditions of their communities (Ochieng et al., 2023; Pellowe & Leslie, 2020). However, the impacts of climate change and coastal development pose challenges to these roles, necessitating adaptive strategies that empower women and integrate their knowledge into broader conservation efforts (Dias et al., 2022).

The integration of indigenous knowledge into contemporary environmental management practices is vital for the conservation of coastal ecosystems. Collaborative approaches that involve local communities in decision-making processes can enhance the effectiveness of conservation initiatives while respecting cultural values (Reeder-Myers et al., 2022; Delevaux et al., 2018). For instance, the recognition of culturally significant species and habitats can inform management strategies that align with the values and practices of indigenous communities, fostering a sense of stewardship and responsibility towards the environment (Arjjumend & Beaulieu-Boon, 2018; Goolmeer et al., 2022).

Furthermore, the impacts of climate change on coastal ecosystems are particularly pronounced, affecting the livelihoods and cultural practices of indigenous communities. Rising sea levels, increased frequency of extreme weather events, and changes in marine biodiversity threaten the very foundations of these communities' existence (Katili et al., 2018; Riechers et al., 2022). Addressing these challenges requires a holistic approach that combines scientific research with traditional ecological knowledge, ensuring that the voices of indigenous peoples are heard and their rights respected in climate adaptation strategies (Datta, 2024; Kaiser et al., 2019).

Ultimately, the traditional customs and cultural significance of coastal ecosystems in India are deeply intertwined with the livelihoods, identities, and spiritual beliefs of indigenous and local communities. The preservation of these ecosystems is not only crucial for maintaining biodiversity but also for sustaining the cultural heritage and social fabric of these communities. Recognizing and integrating traditional ecological knowledge into contemporary environmental management practices can enhance the resilience of coastal ecosystems and the communities that depend on them, fostering a sustainable future that honors both ecological integrity and cultural diversity as outlined in the following table.

5.4 Emerging Market Players in Blue Carbon Ecosystems

The landscape of blue carbon ecosystems in India is evolving with the emergence of market-based mechanisms such as carbon credit markets and the Green Credit Program (GCP). These initiatives aim to incentivize the protection and restoration of critical coastal and marine ecosystems that play an essential role in climate mitigation.

In recent years, several organizations and businesses have entered the blue carbon economy in India, driven by a growing recognition of the carbon sequestration potential of ecosystems like mangroves and seagrasses. Market players include private companies involved in ecosystem restoration, NGOs that leverage funding for conservation projects, and local communities working collaboratively in partnerships. Notably, innovative carbon credit frameworks are being established that facilitate the trading of credits generated from blue carbon projects, allowing stakeholders to profit from investments in sustainable natural resource management (MoEFCC, 2023).

A paradigmatic example is the GCP, initiated by the Indian government to reward voluntary environmental actions. This initiative invites participation from a range of stakeholders, including businesses looking to offset their carbon footprint through investment in blue carbon ecosystems. These emerging market players are also often tasked with implementing methodologies that ensure project legitimacy, accountability, and environmental effectiveness. As new players increasingly participate in this domain, they introduce both significant opportunities and notable threats to local ecosystems and communities as outlined in the following table.

Category	Opportunities	Threats
Investment in Conservation Projects	Blue Carbon initiatives attract substantial funding for restoring and conserving coastal ecosystems, enabling large-scale restoration that benefits both the environment and local communities.	The focus on maximising carbon sequestration may promote planting selective species, leading to monocultures that compromise biodiversity and ecosystem resilience (Duarte et al., 2013).
Economic Incentives for Communities	Local communities can gain economically from blue carbon projects through payments for ecosystem services (PES) (Engel et al., 2008), offering alternative livelihoods, especially in regions with declining traditional industries.	Economic incentives may sideline traditional livelihoods and cultural practices if coastal resource use is restricted for carbon credits, potentially fostering resentment toward conservation efforts (Bennett et al., 2017).
Capacity Building and Job Creation	Blue carbon projects provide education and training for communities in ecosystem management and sustainable practices (Bennett et al., 2017), creating jobs in conservation, eco-tourism, and sustainable harvesting.	Market mechanisms for carbon credits may increase competition over resources, leading to conflicts among communities, businesses, and government over land rights and resource access (Agrawal & Redford, 2006).
Strengthening Local Governance	Community involvement in blue carbon projects empowers locals in decision-making for resource management, fostering strong governance structures and sustainable practices (Plummer & FitzGibbon, 2004).	Market-based approaches may prioritise short-term economic gains over long-term ecological health, risking practices that could undermine the sustainability of blue carbon habitats (Nellemann et al., 2014).
Climate Change Resilience	Blue carbon projects contribute to resilience against climate impacts like storm surges and coastal erosion, potentially benefitting coastal communities and ecosystems.	Blue carbon ecosystems are vulnerable to climate change pressures such as sea-level rise and temperature fluctuations, which may compromise their long-term effectiveness and sustainability.

Table 13: Significant opportunities and notable threats to local ecosystems and communities

While market-based approaches to blue carbon ecosystems in India present significant opportunities for both conservation efforts and local communities, they also carry considerable threats that must be addressed. It is essential to strike a balance that incorporates local knowledge, respects traditional livelihoods, and promotes biodiversity, ensuring that ecological integrity remains at the forefront of blue carbon initiatives. Holistic, community-inclusive approaches are crucial for the sustainable development of blue carbon economies that genuinely benefit both ecosystems and the communities that depend on them.

India's Market-Based Carbon and Green Credit Schemes

1. India's Carbon Credit Trading Scheme (CCTS)

India's CCTS is a market-based program to reduce greenhouse gas (GHG) emissions and promote sustainable development. Established under the Energy Conservation (Amendment) Act, 2022, it enables entities to trade carbon credits to meet emission targets. Key features include:

- Governance:
  Managed by the National Steering Committee for the Indian Carbon Market (NSCICM), which sets regulations, emission targets, and monitors compliance.

- Mechanisms:
  The CCTS has two main components:

  - Compliance Mechanism:
    Targets high-energy industries with specific GHG targets, rewarding those who exceed reductions with carbon credits.

  - Voluntary Offset Mechanism:
    Allows non-obligated entities to earn credits by voluntarily registering emission-reduction projects.

- Carbon Credits:
  Each credit represents one ton of CO_2 reduced or removed.

- Market Operations:
  Administered by the Bureau of Energy Efficiency (BEE), CCTS uses digital platforms for transparent trading.

The CCTS supports India's climate targets under the Paris Agreement, aiming to cut GHGs and promote green tech. Updates in 2024 permit voluntary participation, with a compliance phase planned for 2025-2026. International market involvement decisions are anticipated this year.

2. Green Credit Program (GCP)

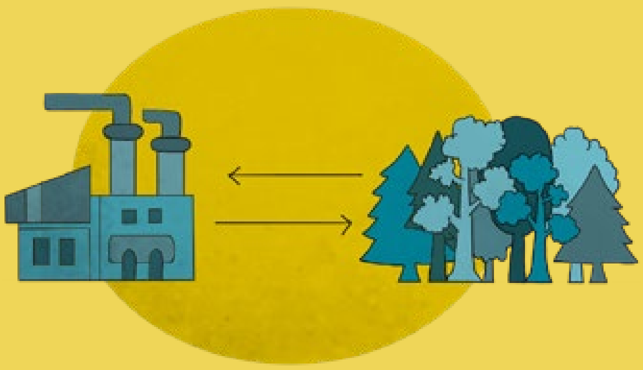
Launched in October 2023, GCP is a market-based mechanism to incentivize environmental actions across sectors, engaging individuals, communities, and industries.

- Governance:
  Overseen by an inter-ministerial committee, with ICFRE as the Administrator, managing implementation, monitoring, and operations.

- Focus Areas:
  Initially prioritizes water conservation and afforestation, with draft methodologies for Green Credits developed for measurable impact.

- Digital Platform:
  A digital platform will enable project registration, verification, and trading. Entities register activities for Green Credits via a government app or site, with verified activities awarded a Green Credit certificate, tradable on the platform.

The GCP promotes eco-friendly practices, contributing to climate resilience and sustainable resource use across India.



5.5 Integrating Coastal Blue Vegetated Ecosystems into India's NDCs for Climate Mitigation:

India's coastal blue carbon ecosystems—mangroves, seagrasses, and salt marshes—are critical yet underutilized assets in the global fight against climate change. These ecosystems not only mitigate climate change through their exceptional carbon sequestration capabilities but also offer co-benefits such as biodiversity conservation, coastal resilience, and enhanced livelihoods for vulnerable communities.

Mangroves, covering approximately 4,992 km^2 (India State of Forest Report, 2021), store an impressive 394 tonnes of carbon per hectare in biomass and soil (Global Mangrove Alliance, 2024). This translates to a carbon sequestration potential of over 21 billion tons of CO_2 equivalent in India. Key sediment carbon stocks are concentrated in regions such as the Andaman and Nicobar Islands (13.8 TgC), the Sundarbans (8.7 TgC), and Gujarat (7.7 TgC) (MoEFCC, 2022).

Seagrasses, though covering only 516.59 km^2, capture up to 83 million metric tons of carbon annually, making them 35 times more efficient in carbon storage than tropical rainforests (Abhijith and Shilta, 2024; NCSCM, 2014–2017). These ecosystems, which occupy a mere 0.1% of the ocean floor, play a vital role in supporting marine biodiversity hotspots like Palk Bay and Chilika Lake.

Tidal salt marshes, although covering a smaller area of 290 km^2, are also significant carbon sinks and contribute to coastal resilience by mitigating erosion (NCSCM, 2014–2018).

Incorporating these ecosystems into India's Nationally Determined Contributions (NDCs) would enhance climate mitigation efforts and position India as a leader in sustainable development. By prioritizing mangroves, seagrasses, and salt marshes, India can leverage nature-based solutions to meet its climate goals while simultaneously fostering biodiversity conservation and supporting vulnerable coastal communities.

5.6 Understanding the Disconnect: Policy vs. Practice in India's Blue Ecosystem Conservation

Despite India's array of robust policies and initiatives aimed at conserving blue ecosystems—such as the Coastal Regulation Zone (CRZ) framework, the National Mangrove Conservation Program, and various state-led conservation schemes—desired outcomes remain elusive. These policies are often commendable on paper but fall short in implementation due to several systemic challenges. Chief among these are fragmented governance structures, lack of community involvement, and insufficient integration of local knowledge and needs into policy frameworks.

Governance around blue ecosystems in India tends to be siloed, with various institutions working independently, often leading to conflicting objectives. For instance, large-scale tourism development projects and industrial projects can overshadow conservation efforts, creating a substantial gap between policy intentions and ground realities. In fact, it is important to recognize that plans driven by short-term economic gains can undermine long-term well-being. For instance, unsustainable tourism, which leads to the gradual degradation of ecosystems, may ultimately have negative consequences for the tourism industry itself. Additionally, the disconnection between policymakers and the communities most affected results in a system that fails to address the socio-economic factors essential for effective conservation. Addressing these issues requires proper awareness, sensitization, and large-scale capacity building.

As a case in point, let us look closely at the situation in Goa, where the juxtaposition of ambitious policies and the on-ground experiences of local communities starkly illuminate these gaps.

Insights shared by Puja Mitra, Founder and Director of Terra Conscious, during the expert consultations are presented in the following box, illustrating why the conservation of these ecosystems remains fraught with challenges.

Beyond the Surface: Governance Gaps in Goa's Blue Ecosystems

Ms Puja Mitra from Terra Conscious shared her narratives on the complexities of blue ecosystem governance in Goa, highlighting significant challenges that illustrate the fragmented nature of conservation efforts in India.

"In Goa, the way we define space directly influences how we manage it. When we limit our definition of what constitutes a blue ecosystem or blue forest, we overlook the interconnectedness of species that inhabit these areas. For instance, India hosts 33 species of marine mammals, including whales, dolphins, and porpoises, that reside within a mere 50 feet of depth along the shoreline. The Indian Ocean humpback dolphin has been noted hunting right up to the mangroves, yet these critical connections are often excluded from biodiversity assessments.

Another pressing issue is the current push for seaweed cultivation as a major alternative for blue carbon capture. Unfortunately, much of the seaweed introduced is invasive, disrupting local ecosystems. In Goa, for example, 11 crores were allocated for seaweed cultivation, but there is no clarity on market mechanisms or how these initiatives impact existing biodiversity. When initiatives are presented as solutions to economic hardships caused by declining fishing or trawling, we must critically assess the long-term viability and ecological ramifications of such approaches.

The fragmented governance in Goa exacerbates these concerns. All activities related to mangroves, dolphins, and corals are classified underwater sports, thereby excluding the Forest Department from regulatory roles. This lack of interdepartmental collaboration results in conflicting policies and visions for tourism, fisheries, and conservation. There is the necessity of interdepartmental collaboration. The Forest Department, Biodiversity Board, Tourism Department, and Fisheries Department must coordinate for effective governance. She asserted the importance of strengthening the capacity of these departments to manage ecosystems, stating, "We need to enhance their understanding of the ecosystems they govern while building community capacity."

Marine spatial planning is often unclear, there is a lack of clarity regarding the sustainable capacity of the coastline. For instance, Gujarat boasts a vast coastline of 1,600 kilometers; constructing a port here may have minimal impact 500 kilometers away. However, in Goa, where the coastline spans only 105 kilometers, plans to expand and create a 51-million-ton coal port within 10 kilometers of corals, mangroves, and river mouths pose significant threats. This development will inevitably undermine aquaculture, fishing, and tourism initiatives intended to benefit the local community.

Moreover, defining coastal communities is complex in places like Goa, where migration from states such as Bihar and Jharkhand has altered local demographics. This transformation complicates conservation as these communities—who may not have traditional connections to the ocean—require different approaches to stewardship.

She highlighted how wealthy players in the tourism industry marginalize local communities due to misguided policy decisions. This financial strain forces local fishermen and operators to engage in volume-based tourism rather than quality offerings, leaving them economically vulnerable and alienated from the benefits of their natural resources. She also addressed the broader issue of climate change, noting that locals involved in tourism lost many business days each year due to adverse weather. She emphasized that if we were promoting tourism as a new industry under the blue economy, it was imperative to integrate climate resilience into industry planning.

It is essential to focus on market linkages at the intersection of tourism and conservation to ensure sustainable development. The confusion surrounding jurisdiction, particularly regarding carbon credit programs related to mangroves, complicates community benefits, as defining which community benefits becomes challenging due to the nature of land use.

Puja concluded, "We need to broaden our definition of blue forests to include interconnected species and ecosystems, and recognize the hybrid roles of community members. Our conservation strategies must integrate both ecological and social factors to ensure that they are effective and sustainable."

Such insights and illustrations highlight the urgent necessity for a paradigm shift in blue ecosystem governance, emphasizing the need for more inclusive and collaborative frameworks. The fragmentation observed within existing policies and programmes highlights the importance of integrating multiple stakeholders—from local communities to government agencies—in a cohesive dialogue that respects traditional ecological knowledge and fosters sustainable livelihoods. By positioning communities as active participants in the conservation process, rather than passive recipients of external solutions, we can cultivate a deeper sense of stewardship that empowers them to protect their natural resources.

The Role of Civil Society Organizations (CSOs) in Coastal Blue Governance:

Civil society organizations (CSOs) have emerged as pivotal actors in bridging the gap between state institutions, market forces, and local communities in the governance of coastal ecosystems. Operating at the nexus of policy implementation, community engagement, and environmental sustainability, CSOs play a dual role as facilitators and advocates, ensuring that governance systems are inclusive and attuned to local realities.

CSOs are uniquely positioned to navigate the complexities of coastal governance. By building trust with local communities, they act as intermediaries that translate top-down policies into actionable, community-driven initiatives while also amplifying grassroots voices to influence state and market actors. Their interventions not only empower marginalized groups, particularly women, but also integrate ecological sustainability with economic viability, ensuring long-term impact.

The role of CSOs in fostering sustainability, social inclusion and resilience is exemplified through two case studies presented as illustrative boxes: Save Vikas in Gujarat and Nature Environment and Wildlife Society (NEWS) in the Sundarbans. These cases demonstrate how CSOs bring communities to the forefront of decision-making, transforming them into active custodians of their ecosystems.

Save Vikas has effectively integrated community-led governance with economic development. By establishing bioshield committees, it has ensured that mangrove regeneration is not merely a conservation effort but a livelihood-enhancing initiative. Its BIOSHIELD program, which incorporates multi-species, multi-layered plantations, showcases how CSOs can align ecological restoration with market opportunities such as carbon finance, ensuring sustainability beyond the intervention phase.

Similarly, NEWS has revolutionized mangrove restoration in the Sundarbans by shifting from monoculture plantations to holistic afforestation models that incorporate risk mapping, community participation, and monitoring. The organization's work with women-led self-help groups exemplifies how CSOs can foster gender equity while addressing ecological challenges. NEWS's efforts to create economic opportunities through mangrove value chains—including honey, fish, and eco-tourism—highlight the potential for market integration in community-driven governance models.

CSOs also play a critical role in institutionalizing sustainability by bridging the often-fragmented relationships between governments, markets, and local stakeholders. They enable communities to access resources, technical expertise, and markets while advocating for policy reforms that reflect grassroots realities. This intermediary role strengthens governance systems by fostering accountability and inclusivity. For instance, Save Vikas's engagement with industries to secure carbon finance and NEWS's partnerships with local governance bodies to address risk factors illustrate how CSOs ensure that interventions are context-specific and sustainable.

CSOs ability to incorporate traditional knowledge with modern technologies enables them to design interventions that are both locally relevant and globally significant.

Restoration Spotlight:

Advancing Gender Equality and Social Inclusion: VIKAS CFD's Model for Inclusive Blue Governance

VIKAS Centre for Development (VIKAS CFD) exemplifies the critical role that Civil Society Organizations (CSOs) play in blue governance, particularly through their community-based and women-led approaches to mangrove restoration. Operating in the coastal regions of Gujarat, VIKAS CFD integrates environmental conservation with poverty alleviation, addressing the dual challenges of ecological degradation and socio-economic vulnerability. By establishing Bioshield Committees in villages, VIKAS CFD has institutionalized grassroots participation, with women comprising the majority of committee members. These committees are empowered to plan, implement, and manage mangrove restoration activities, ensuring community ownership from the outset. The organization's BIOSHIELD program, which combines mangrove regeneration with multi-species plantations, demonstrates how CSOs can innovate beyond conventional restoration approaches by linking ecological resilience with livelihoods. This has created opportunities in fisheries, honey production, and animal husbandry, directly benefiting marginalized groups such as small-scale farmers, salt producers, and charcoal makers.

Furthermore, VIKAS CFD has pioneered collaborative models for carbon finance, ensuring that 40-50% of revenue generated from blue carbon initiatives is reinvested into the community through the Local Initiative Fund for Enterprise and Environment (LIFE). Such efforts highlight the importance of CSOs in bridging governance gaps, particularly in areas where formal mechanisms may fall short. By fostering women's leadership and embedding economic incentives into environmental stewardship, VIKAS CFD underscores the transformative potential of bottom-up governance models in achieving sustainable and inclusive blue economy objectives. This case demonstrates that community ownership, driven by CSOs, is indispensable for long-term ecological and socio-economic resilience in coastal regions.

Restoration Spotlight:

Guardians of Resilience: Women and Mangroves in the Sundarbans

In the heart of the Sundarbans, women are rewriting the narrative of climate resilience through their unwavering commitment to mangrove restoration, supported by the Nature Environment and Wildlife Society (NEWS). Many households, repeatedly devastated by cyclones, have seen a transformation as women began planting mangroves along vulnerable embankments. Today, these trees stand as sentinels, protecting homes and farmlands from rising tides and storm surges.

The journey of these women is not just about planting trees but about reclaiming agency over their environment. NEWS has transformed mangrove restoration into a community driven effort by involving women in decision-making, risk mapping, and nurturing local nurseries. Women have cultivated a deep connection with the mangroves, referring to them as “brothers” who shield them from nature’s fury. By tying cultural practices, such as “Rakhi” ceremonies on mangroves, with restoration efforts, NEWS has embedded a sense of stewardship, ensuring community-led sustainability. Their work extends beyond environmental protection to economic empowerment, with women earning income from plantations, honey, crabs, and eco-tourism ventures.

The creation of the “Green Brigade,” a group of women identifiable by their green sarees, symbolizes their leadership in ecosystem management. What started as an initiative to restore degraded embankments has evolved into a movement of stewardship, where women take turns protecting saplings and monitoring growth. This collective effort was validated when embankments fortified with mangroves withstood the devastation of Cyclone Amphan and Yaas, showcasing the ecological and social value of this approach.

NEWS’s model exemplifies how inclusive conservation can address pressing environmental challenges while advancing gender equity. By turning vulnerable women into custodians of their fragile ecosystem, this initiative demonstrates the power of community-led governance in safeguarding the Sundarbans.

Restoration Spotlight:

A Community-Driven Model for Seagrass Conservation by OMCAR Foundation

OMCAR Foundation is leading **seagrass conservation in Palk Bay, Tamil Nadu**, through a unique blend of **scientific expertise, community participation, and policy advocacy**. Their **scalable and sustainable approach** ensures that **ecological restoration and local livelihoods go hand in hand**, transforming conservation from a restrictive policy into a **people-powered movement**.

1. Community-Led Seagrass Restoration

Unlike conventional top-down conservation models, OMCAR actively engages local fishers in **seagrass restoration** through:

- **Low-cost restoration methods –** using bamboo frames and coconut coir ropes to stabilize seagrass meadows.
- **Participatory planting techniques**, ensuring that local communities take ownership of conservation efforts.

2. Dugong Conservation as a Focal Strategy

OMCAR strategically integrates **seagrass conservation with dugong protection,** recognizing the species' dependence on healthy seagrass meadows. Their efforts have led to:

- **The establishment of India's first Dugong Conservation Reserve in Palk Bay.**
- **Awareness programs** aimed at reducing seagrass-damaging fishing practices, protecting both dugongs and their habitat.

3. Integrating Conservation with Livelihoods

To ensure conservation efforts benefit rather than burden local communities, OMCAR promotes alternative income sources:

- **Mangrove and seagrass-based aquaculture –** supporting crab and seabass farming.
- **Sustainable agriculture & livestock rearing** – reducing dependency on marine resources while enhancing economic resilience.

4. Data-Driven Policy Advocacy

OMCAR's conservation model is **grounded in research and real-time data collection**, ensuring policies are **evidence-based and impactful**:

- **Mapping seagrass meadows** to inform government policies and conservation planning.
- **Documenting marine mammal strandings** and advocating for stricter conservation regulations.

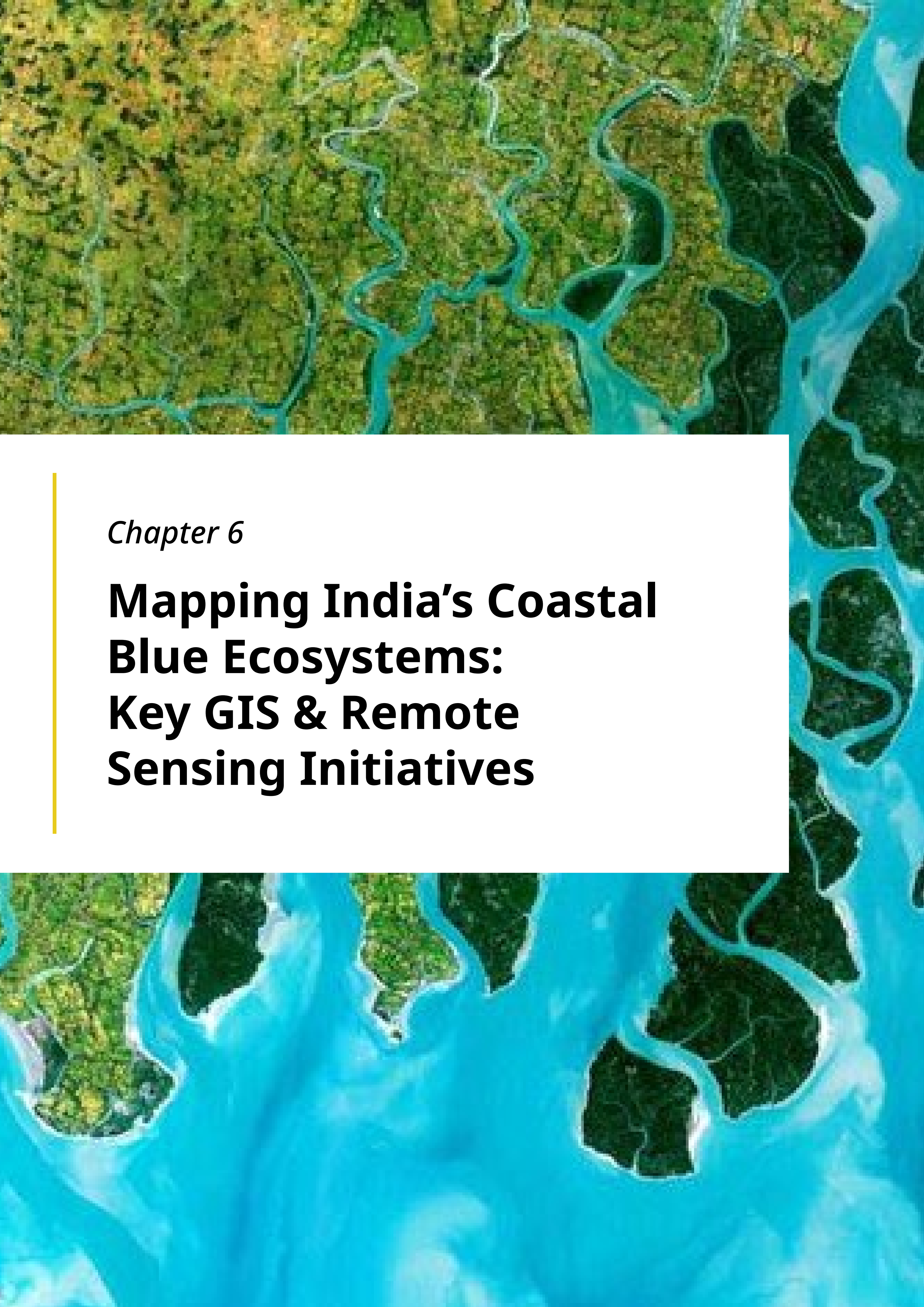
This model highlights the **critical role of CSOs** in bridging **scientific conservation efforts with community-driven action**, ensuring **long-term ecological sustainability and livelihood security**.

The role of Civil Society Organizations (CSOs) in coastal governance is transformative, but their models face several challenges. CSOs often struggle to align grassroots approaches with government policies and market interests, encountering bureaucratic delays, policy inconsistencies, and a lack of formal recognition, which hinders their ability to scale initiatives or secure long-term support. Many CSOs operate with limited budgets, relying on grants, donations, or sporadic funding from industries through Corporate Social Responsibility (CSR) initiatives, which lead to resource and funding constraints that limit their capacity to sustain long-term programs or invest in scaling successful models. Furthermore, while community participation is central to CSO success, maintaining consistent engagement can be difficult due to factors like migration, socio-economic instability, or a lack of immediate benefits, reducing commitment. Finally, the lack of standardization and replicability in CSO initiatives, often reliant on localized knowledge and conditions, makes it challenging to scale or replicate successful models across regions. Addressing these challenges requires stronger integration of CSOs into governance frameworks, sustained funding mechanisms, and collaborative efforts with government and market stakeholders to institutionalize and scale their models effectively.

Here is another important point to consider: While CSOs play a crucial role at the local level, a lack of capacity building and awareness of ecosystem processes can sometimes lead to unintended harm rather than benefits. For instance, well-intentioned mangrove plantation drives can inadvertently damage adjacent ecosystems such as salt marshes and seagrass meadows, disrupting ecological balance. To mitigate such risks, a standardized best practices manual in local languages is essential, ensuring that conservation efforts align with ecological principles. Additionally, capacity building for practitioners should be a key priority, equipping them with the necessary knowledge and skills to implement restoration and conservation initiatives effectively. Access to knowledge and continuous learning is fundamental to fostering good governance in coastal ecosystem management.

Chapter 6

Mapping India's Coastal Blue Ecosystems: Key GIS & Remote Sensing Initiatives



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Mapping India's Coastal Blue Vegetated Ecosystems:

Accurately mapping India's mangroves, salt marshes, and seagrasses is vital for carbon sequestration, coastal protection, and marine and terrestrial biodiversity. GIS and Remote Sensing (RS) provide real-time spatial data, enhancing conservation planning by integrating ecological and socio-economic insights.

Regular mapping helps detect vegetation shifts, species distribution changes, and human impacts, ensuring timely interventions. It enables data-driven conservation strategies, policy development, and targeted restoration efforts, safeguarding both ecosystem services and community livelihoods.

Some of the Key Mapping Initiatives by the Government of India:

- **Periodic Mangrove Survey by the Forest Survey of India (FSI):**

  The Forest Survey of India (FSI) has been assessing mangrove cover using remote sensing technology since 1987. The initial assessment was conducted at a scale of 1:1 million, providing a baseline for understanding the extent of mangrove ecosystems. From 1989 to 1999, assessments were performed regularly every two years at a scale of 1:250,000. Since 2001, these assessments have been carried out at a more detailed scale of 1:50,000, allowing for improved accuracy and insights into changes in mangrove ecosystems over time.

  The India State of Forest Report (ISFR) for the year 2023 provides comprehensive information on various aspects of forest ecology in India, including forest cover, tree cover, mangrove cover, growing stock, and carbon stock in the country's forests. It also includes data on forest fire monitoring, forest cover within tiger reserves, above-ground biomass estimates using Synthetic Aperture Radar (SAR) data and identifies climate change hotspots in Indian forests. Conducted ***periodically every two years***, this forest survey ensures that stakeholders have access to updated and reliable information for effective forest management and conservation efforts.

- **Coastal Regulation Zone Map & Portal by the National Centre for Sustainable Coastal Management (NCSCM) Edition 2021:**

  NCSCM has mapped ecologically sensitive zones that include coastal ecosystems as part of creating a Coastal Information System. This initiative includes the development of a Coastal Regulation Zone Map for the entire coastline, as well as a portal (Edition-June 2021) dedicated to the Coastal Zone Management Plans of 2011 and 2019. This mapping effort aims to enhance the management and conservation of coastal resources, supporting informed decision-making for sustainable coastal development.

- **Mapping of Ecologically Sensitive Areas (ESAs) and Critical Vulnerable Coastal Areas (CVCAs) along the Coast of India by NCSCM:**

  The mapping of coastal ecosystems, including mangroves, seagrasses, and salt marshes, was conducted under the World Bank-supported Integrated Coastal Zone Management (ICZM) Project (2010-2020). The objective of this project is to assist the Government of India (GoI) in building national capacity for the implementation of a comprehensive coastal management approach in the country.

The National Centre for Sustainable Coastal Management (NCSCM) has mapped a total area of 34,127.20 sq. km under Ecologically Sensitive Areas (ESAs) since 2011. Within this, 744 contiguous patches were identified, representing various biologically active ecosystems and important habitats:

- Mangroves – **5,590 sq. km**
- Coral reefs – **1,439 sq. km**
- Seagrass – **518 sq. km**
- Salt marsh – **600 sq. km**
- Sand dunes – **325 sq. km**
- Mudflats – **3,558 sq. km**
- Turtle nesting grounds – **179 sq. km**
- Horseshoe crab habitats – **70 sq. km**
- Nesting grounds of birds – **5,386 sq. km**
- Archaeological and heritage sites – **5.78 sq. km**
- National parks, marine parks, sanctuaries, reserve forests, wildlife habitats, and other protected areas – **16,455 sq. km**

(Source: https://ncscm.res.in/)

- **Development of the Spectral Library of Mangroves, Seagrass, and Seaweed by NCSCM:**

  This initiative aims to develop a spectral library of coastal vegetation and to implement a consistent method for collecting spectral data and associated metadata.

- **The National Wetland Atlas 2011**:

  This atlas is a comprehensive mapping initiative aimed at assessing and documenting the vast wetlands of India. Developed by the Space **Applications Centre (SAC)** in collaboration with various governmental and environmental agencies, the atlas serves as a foundational tool for understanding the distribution, extent, and ecological significance of wetlands across the country.

In addition to the key mapping initiatives undertaken by the Government of India, numerous remote sensing (RS) and geographic information system (GIS) studies have been conducted by various research institutes, universities, and individual researchers on a smaller scale. A review of the existing literature has revealed several important RS and GIS studies. Information regarding these studies has been compiled and is shared in the knowledge repository section. Private sector entities engaged in blue carbon trading are also actively involved in mapping blue carbon ecosystems to support their specific objectives and initiatives.

"It is important to note that, unlike the periodic and systematic GIS and remote sensing surveys conducted for mangroves in India by the Forest Survey of India, there is currently no established framework for the continuous monitoring of seagrasses and salt marshes. Mapping these ecosystems is largely dependent on project-based initiatives, which are often one-off efforts without provisions for ongoing surveys. This gap presents significant challenges for monitoring these vegetated ecosystems regularly, hindering effective conservation efforts and increasing the risk of their degradation."

Global Mangrove Watch:

The Global Mangrove Watch (GMW) is an online platform that offers remote sensing data for mangroves worldwide along with the necessary tools for monitoring them. It provides universal access to near real-time information regarding changes in mangrove ecosystems globally, and emphasizes their importance.

With high-resolution data on cover change, soil carbon, living biomass, canopy height, and other relevant parameters, Global Mangrove Watch equips coastal and park managers, conservationists, policymakers, and practitioners with the evidence required to combat illegal logging, identify the causes of local mangrove degradation, and monitor conservation efforts. This platform is instrumental in ensuring that mangroves are integral to climate mitigation, adaptation, and sustainable development strategies and policies.

Chapter 7

Conservation and Management of Coastal Blue Vegetated Ecosystems in India: Gaps, Strategic Pathways, and Action Plan

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India's coastal blue vegetated ecosystems—mangroves, seagrasses, and salt marshes—form a vital yet increasingly vulnerable nexus between terrestrial and marine environments. These ecosystems provide irreplaceable ecological and socio-economic services, including carbon sequestration, coastal defense, biodiversity conservation, and the sustenance of millions of livelihoods. Despite their fundamental role in both climate mitigation and adaptation, as well as broader ecological stability, they face complex and escalating threats, driven by anthropogenic pressures, governance fragmentation, and emerging environmental stressors.

Among these ecosystems, mangroves, though relatively well-documented, continue to experience severe degradation due to disruptions in freshwater inflows, urban encroachment, industrial expansion, and aquaculture intensification. Climate change further amplifies these stressors, altering hydrological regimes, increasing salinity intrusion, and intensifying storm surges. Seagrasses, critical for carbon sequestration and marine biodiversity, remain among the least studied coastal ecosystems, leaving significant gaps in understanding their vulnerability. They face escalating threats from habitat destruction, pollution, and emerging risks such as microplastic contamination and rising sea temperatures, which undermine their ecological integrity. Salt marshes, despite their essential role in sediment stabilization, salinity buffering, and coastal resilience, remain largely overlooked in conservation frameworks. Often misunderstood as wastelands, they suffer from neglect and poor documentation of species diversity and ecological functions, leading to their systematic undervaluation in policy and management strategies. India has made significant strides in coastal conservation, with the government and civil society organizations (CSOs) driving large-scale mangrove restoration, regulatory protections under the Coastal Regulation Zone (CRZ) framework, and community-led initiatives. However, despite these commendable efforts, fundamental gaps persist, undermining long-term conservation and sustainable management. The absence of standardized definitions and monitoring protocols results in inconsistencies in species classification and ecosystem assessments, making it difficult to track long-term changes. Emerging threats such as microplastic contamination, climate-induced stressors, and habitat degradation remain critically under-researched, leaving conservation efforts largely reactive rather than proactive.

At the same time, access to scientific data remains highly restricted, with high-resolution spatial datasets under the CRZ framework often inaccessible to researchers, conservation practitioners, and local communities—those who most need them for effective decision-making and management. Traditional ecological knowledge, despite its immense value in fostering local stewardship and ecosystem resilience, remains systematically overlooked, leading to missed opportunities for cost-effective, community-led conservation approaches.

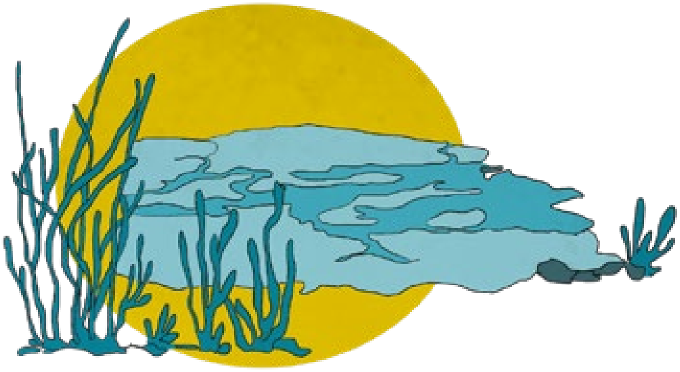
Fragmented governance structures and conflicting stakeholder interests further weaken conservation efforts, as multiple agencies struggle to align priorities and implement cohesive policies. This challenge is exacerbated by a lack of ecological literacy among policymakers, practitioners, and the broader public, limiting the effectiveness of conservation interventions and regulatory enforcement.

This study calls for a paradigm shift in coastal conservation and management, as India's coastal blue vegetated ecosystems stand at a critical crossroads. Their protection demands urgent, coordinated, and collective action to position them as keystones of climate resilience, mitigation, and sustainable development. This scoping study presents a strategic roadmap, integrating scientific innovation, traditional wisdom, and policy reform to safeguard and restore these vital ecosystems.

The following sections analyze key gaps, identify urgent priorities, and chart a participatory course of action, establishing these ecosystems as cornerstones of climate adaptation, biodiversity conservation, and sustainable coastal governance.

1.
Knowledge and Research Gaps

The scoping study revealed several critical gaps in knowledge and research that impede the effective conservation and management of India's coastal blue vegetated ecosystems. Despite their ecological significance, certain habitats—particularly seagrasses and salt marshes—remain among the least studied, resulting in significant blind spots in understanding their roles within broader coastal ecosystems. Key challenges include inconsistent definitions, insufficient recognition of ecosystem interdependencies, limited research on emerging threats, and a lack of appreciation and recognition for traditional knowledge. These gaps not only hinder informed decision-making for conservation and regular monitoring but also undermine the potential of these ecosystems to contribute to climate resilience and sustainable development.



1.1
Lack of Standardized Definitions and Data Consistency

A unified and scientifically agreed-upon definition for mangroves, seagrasses, and salt marshes is essential for consistent research and effective conservation efforts. However, significant discrepancies exist in species classification and geographic coverage, leading to inconsistencies in ecological assessments.
For instance, the reported number of true mangrove species in India varies widely, ranging from 34 to 69 species across different sources. This inconsistency arises due to differences in classification criteria, taxonomic methodologies, regional coverage, and evolving scientific assessments. Additionally, variations in species identification protocols, genetic analyses, and the inclusion or exclusion of hybrids and associated species further contribute to these discrepancies.
A similar lack of consensus exists for seagrasses, with Abhijith (2024) identifying 14 species, Seal et al. (2023) listing 15, and Thangaradjou and Bhatt (2018) reporting 16. Salt marshes face an even greater challenge, as there is no clear agreement on species diversity and distribution along India's coastline.

These taxonomic inconsistencies hinder comparative ecological studies and accurate biodiversity monitoring, making it difficult to track ecosystem changes and assess overall ecosystem health. Without standardized criteria for species inclusion, ecological roles, and geographic boundaries, conservation and restoration efforts will remain fragmented and less effective. (These discrepancies, highlighted with supporting evidence, are presented in Chapter 2).

1.2
Gaps in Documenting Traditional Knowledge

India's coastal communities have cultivated a wealth of traditional ecological knowledge over generations through sustainable interactions with their environments. This knowledge includes sustainable fishing practices, community-led restoration efforts, and the use of mangroves for storm protection and fisheries support. Evidence supporting these practices is discussed in Chapter 5.

However, a detailed literature survey of online resources indicates that very few studies have systematically documented this knowledge. The lack of proper documentation risks erasing this valuable cultural heritage and hindering its integration into modern conservation strategies. Moreover, without recognizing and preserving traditional knowledge, there is a missed opportunity to incorporate cost-effective, locally adaptable solutions into ecosystem management, which could significantly enhance restoration and conservation efforts.

1.4
Lack of Open-Access Data Repositories

The absence of centralized, open-access data repositories remains a significant barrier to effective conservation and decision-making. While basic mapping data is available, high-resolution data, which is crucial for detailed ecosystem monitoring and management, is not publicly accessible. Accessible data is vital for monitoring ecosystem health, identifying vulnerabilities, and supporting evidence-based strategies. For instance, detailed mapping of ecologically sensitive areas under the Coastal Regulation Zone (CRZ) has been conducted by various government departments, but high-resolution data is not readily available to the public. This lack of transparency and accessibility limits collaboration and hinders the effective use of critical information in conservation efforts.

1.3
Lack of Research on Emerging Threats

Emerging threats such as microplastics, invasive species, and climate-induced changes pose significant risks to coastal ecosystems, yet they remain critically under-researched, as evident from the knowledge repository (Annexure III). For instance, the effects of microplastics on seagrass habitats and the role of invasive species in altering ecosystem dynamics have not been adequately studied. These growing threats are increasingly compromising coastal ecosystem health, but without targeted research, conservation efforts will remain reactive rather than proactive. Advancing research on these emerging challenges is crucial for developing effective mitigation strategies and ensuring the long-term resilience of coastal habitats.

1.5
Interdisciplinary Research Gap:

There is a lack of interdisciplinary research that integrates ecological, economic, and social dimensions in the study of coastal ecosystems. The need for collaboration between ecologists, economists, and social scientists is crucial to fully understand the complexities of coastal ecosystem management, including the impacts of emerging threats like pollution and climate-induced changes.
To effectively address the existing gaps in coastal ecosystem management, it is crucial to implement solutions that bridge the divide between current knowledge limitations and the practical needs for sustainable conservation. The proposed solutions focus on standardizing data, integrating traditional knowledge, and addressing emerging threats, all of which are essential for enhancing our understanding and management of coastal ecosystems. By fostering interdisciplinary research and improving data accessibility, these solutions will not only fill knowledge gaps but also establish a more robust foundation for future ecosystem management strategies.

2
Missing Integrated and Holistic Ecosystem-Based Approach:

Effective conservation and management of coastal blue vegetated ecosystems require a shift from fragmented interventions to holistic, ecosystem-based strategies that account for ecological complexities, upstream-downstream linkages, and socio-economic interdependencies. Recognizing the interconnected nature of these ecosystems, addressing upstream drivers of degradation, and embedding equity into conservation efforts are essential for developing more resilient and inclusive management frameworks.

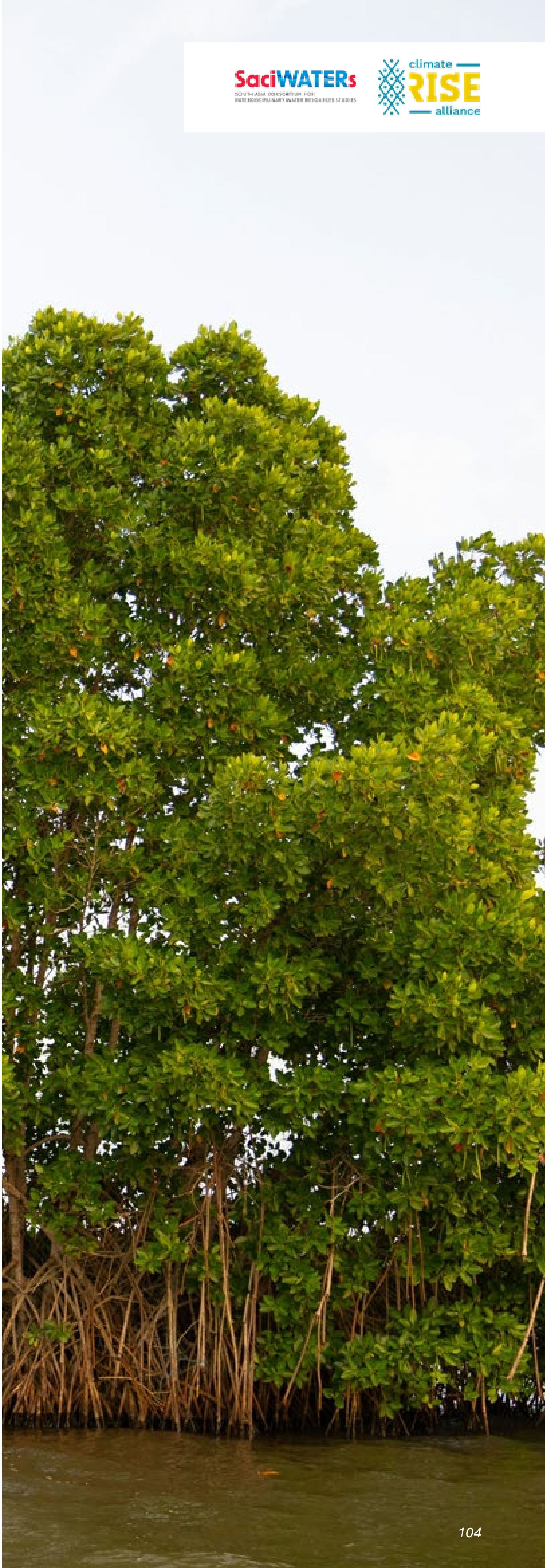
2.1
Lack of Recognition of Ecosystem Interconnectedness and Interdependency

In conservation planning, it is essential to acknowledge the intricate relationships among coastal ecosystems and their interdependencies with other habitats and species. Ecosystems do not function in isolation—a failure to recognize their natural linkages results in conservation strategies that are incomplete and less effective.

For instance, salt marshes play a critical role in supporting mangroves by stabilizing sediments, reducing erosion, and creating conditions conducive to mangrove growth. They buffer salinity fluctuations, facilitate nutrient exchange, and provide protection from storm surges, thereby enhancing the resilience of both ecosystems and contributing to overall coastal biodiversity. Additionally, salt marshes create protective microclimates for mangrove seedlings, aid in carbon sequestration, and foster complex ecological interactions that influence species establishment and ecosystem stability (Peterson & Bell, 2012).

Similarly, seagrass-mangrove interconnectivity plays a pivotal role in coastal biodiversity and resilience. Mishra & Farooq (2020) highlight that seagrass species, particularly Thalassia hemprichii, and mangroves exhibit an embedded ecological relationship that enhances population longevity and strengthens seagrass meadow traits. This natural connectivity fosters greater resilience against both natural and anthropogenic disturbances, making it a critical factor in the conservation and management of coastal biodiversity.

As discussed in Chapters 3 and 4, it is concerning that



“The rising ocean temperature is going to affect the physiology of mangroves—this will lead to large scale die-offs in mono-specific mangrove habitats, which are preferred for current coastal restoration activities. Ecological connectivity of mangroves with other ecosystems such as salt marshes, seagrasses, or coral reefs can provide the climate adaptation which can enhance mangrove restoration success.”

- Dr. Amrit Kumar Mishra, during expert consultation.

many large-scale mangrove plantation drives continue to overlook adjacent ecosystems, focusing solely on expanding mangrove cover without considering long-term ecological sustainability. The lack of scientific understanding in these well-intended initiatives often results in unintended ecological harm rather than lasting benefits, undermining the resilience of coastal ecosystems.

Furthermore, the narrow approach to ecosystem restoration, which prioritizes plantation expansion over ecological integrity, often relies on mono-species plantations, disregarding the natural diversity and ecological connectivity essential for long-term resilience. Successful restoration requires moving beyond monocultures and embracing the native ecological fabric of coastal habitats—a principle strongly emphasized by experts.

“When we limit our definition of what constitutes a blue ecosystem or blue forest, we overlook the interconnectedness of species that inhabit these areas. For instance, India hosts 33 species of marine mammals, including whales, dolphins, and porpoises, that reside within a mere 50 feet of depth along the shoreline. The Indian Ocean humpback dolphin has been observed hunting right up to the mangroves, yet these critical connections are often excluded from biodiversity assessments.”

- Ms. Puja Mitra during the expert consultation.

Failing to integrate these ecological interdependencies into conservation planning weakens long-term sustainability efforts. A holistic, ecosystem-based approach is essential to ensuring the stability, functionality, and adaptive capacity of coastal blue vegetated ecosystems in the face of climate change and human-induced pressures.

2.2
Lack of a Source-to-Sea (S2S) or River Basin Approach

To achieve effective ecosystem restoration and management, adopting a Source-to-Sea (S2S) or river basin approach is essential. This framework considers the full range of ecological interactions shaping coastal environments and ensures that restoration efforts address root causes rather than merely treating symptoms.

Upstream activities—including agriculture, urban expansion, industrial discharge, and water diversion—have profound effects on coastal ecosystem stability. Experts unanimously emphasized during the consultation that reduced freshwater flow from rivers is one of the most critical threats, leading to increased salinity, habitat degradation, and biodiversity loss. Freshwater inflows, vital for sustaining coastal ecosystems, are frequently disrupted by dam construction, excessive groundwater extraction, and unsustainable land-use practices. Additionally, pollution from upstream sources—such as agricultural runoff, untreated sewage, and industrial waste—introduces heavy metals, excess nutrients, and harmful chemicals into river systems, which accumulate in coastal waters, exacerbating eutrophication, habitat degradation, and biodiversity decline.

Restoration efforts must extend beyond coastal areas to include upstream interventions that safeguard natural hydrological and ecological processes. Implementing a river basin management approach is crucial for restoring freshwater connectivity and mitigating upstream pollution impacts on coastal zones.

"A River Basin approach could effectively address threats to coastal blue ecosystems by ensuring balanced freshwater and marine water flow essential for their survival."

– Mr. A. Sridhar, Wetlands International, during the expert consultation.

2.3
Lack of Integration Between Ecological and Socioeconomic Vulnerabilities:

As discussed in Chapters 3 and 5, conservation strategies often fail to address the intersection of ecological and socioeconomic vulnerabilities, particularly for marginalized communities. Coastal populations, especially those dependent on natural resources for their livelihoods, are directly impacted by ecosystem degradation. However, these communities—including women, low-income families, and marginalized ethnic groups—are often excluded from decision-making processes and conservation efforts. This exclusion perpetuates social inequities and weakens the resilience of both ecosystems and communities. Without integrating socioeconomic dimensions into conservation efforts, interventions risk reinforcing existing vulnerabilities rather than addressing them.


Image Credit: Jayati Chourey

3
Governance-Related Gaps

Effective governance is essential for the sustainable management of coastal ecosystems; however, persistent structural deficiencies hinder its efficacy. Policy fragmentation, regulatory insufficiencies, and the exclusion of local communities from decision-making processes contribute to disjointed and unsustainable conservation efforts. Despite their crucial role in enhancing ecological resilience, community-based conservation approaches and traditional knowledge systems remain underutilized, highlighting the urgent need for integrated and inclusive governance frameworks.

3.1
Fragmented Governance and Policy Frameworks

The governance of India's coastal blue vegetated ecosystems is characterized by policy fragmentation, institutional silos, and uncoordinated efforts across multiple governmental bodies and stakeholders. This lack of coherence results in regulatory overlaps, inefficiencies, and critical gaps in addressing ecological challenges. The absence of a well-defined, multi-tiered governance framework further constrains inter-agency collaboration, undermining effective conservation strategies and restricting meaningful engagement with local communities and key stakeholders.

3.2
Weak Regulatory Frameworks for Sustainable Blue Economy Management

The rapid expansion of carbon markets and the blue economy has outpaced the development of robust regulatory mechanisms necessary for their effective governance. The absence of stringent oversight frameworks creates vulnerabilities to unethical practices and ecological degradation, as market-driven interests increasingly take precedence over conservation imperatives. Additionally, the lack of equitable benefit-sharing mechanisms exacerbates socio-economic disparities, exposing local communities to exploitation and undermining their traditional livelihoods and social security.

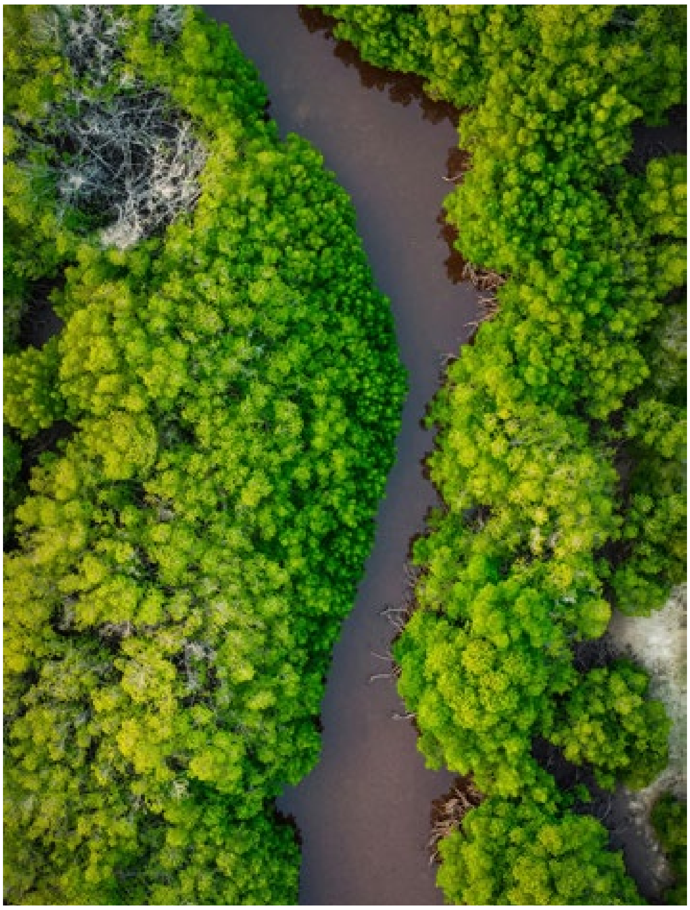
3.3
Limited Integration of Local Communities and Traditional Management Practices

Indigenous and local ecological knowledge and traditional management practices, honed over generations, remain largely overlooked in contemporary conservation and policy frameworks. Coastal communities hold invaluable insights into ecosystem dynamics, such as the role of mangrove ecosystems in sustaining fisheries and mitigating coastal erosion. However, these knowledge systems are rarely documented or systematically incorporated into formal governance structures. Furthermore, local communities are frequently relegated to passive beneficiaries rather than recognized as active stakeholders, restricting their agency in decision-making and undermining the long-term sustainability of coastal ecosystem management.

4
Monitoring Gaps in Coastal Ecosystem Management

Effective conservation depends on robust monitoring; however, coastal blue vegetated ecosystems face fragmented and inconsistent assessment efforts. While mangroves benefit from periodic GIS and remote sensing-based evaluations conducted by the Forest Survey of India, seagrass meadows and salt marshes lack comparable systematic oversight. The absence of a long-term ecological monitoring framework hampers the ability to track changes in ecosystem health, species distribution, and habitat integrity over time. Without continuous data collection, early signs of degradation often go undetected, delaying critical conservation interventions.

Moreover, the lack of a structured data-sharing mechanism limits accessibility to ecological insights, hindering collaborative conservation efforts. Enhancing the capacity of local communities and citizen scientists can facilitate regular ground-level data collection, fostering participatory monitoring. Establishing an open-access data portal for researchers, practitioners, and communities would enable transparent information exchange, promoting evidence-based decision-making and adaptive coastal ecosystem management.



5
Gap in Capacity Building for Sustainable Conservation and Restoration

A major challenge in coastal conservation and restoration is the widespread lack of capacity, awareness, and interdisciplinary understanding, leading to poorly designed initiatives that fail to deliver long-term ecological and socio-economic benefits. Many restoration efforts lack a foundation in scientific principles or integrated ecosystem approaches, resulting in fragmented and ineffective interventions. According to Wetlands International, nearly 80% of mangrove restoration projects fail globally, primarily due to inadequate planning, limited ecological understanding, and insufficient stakeholder capacity.

This gap exists at all levels of society—from policymakers and government agencies to CSOs, local practitioners, and communities. Limited ecological literacy and interdisciplinary awareness among decision-makers often lead to policies that overlook ecosystem complexities and socio-environmental interconnections. Practitioners and field agencies frequently lack access to scientific knowledge, technical skills, and best practices, weakening conservation outcomes. At the community level, insufficient environmental awareness and capacity-building opportunities further hinder meaningful participation in restoration and governance.

Closing this gap requires structured training, skill development, and targeted awareness programs designed for multiple stakeholders. Strengthening science-policy-community linkages through capacity-building initiatives is essential to advancing evidence-based, sustainable, and inclusive conservation and restoration strategies.

6
Lacking Sustainable Financing and Institutional Support:

Ensuring sustainable financing and institutional support is critical for the long-term viability of coastal blue vegetated ecosystems. However, existing financial mechanisms are inconsistent, fragmented, and insufficient to support large-scale, durable conservation efforts. Addressing this gap requires innovative and diversified funding approaches that provide consistent, scalable, and transformative investments in ecosystem protection and restoration.

6.1
Fragmented Funding Sources

While multiple funding streams—government allocations, philanthropic contributions, and international climate finance—exist, they often operate in isolation, lacking coordination and strategic alignment. This fragmentation leads to inefficiencies, missed opportunities for synergies, and persistent gaps in financing for ecosystem restoration projects.

6.2
Limited Private Sector Engagement

Despite growing recognition of the economic and resilience benefits of investing in ecosystem-based solutions, private sector participation remains limited. Many private entities lack awareness of the economic returns associated with ecosystem services or face insufficient incentives to engage in long-term, sustainable funding models. Strengthening policy incentives, market-based mechanisms, and public-private partnerships is essential to enhance private sector engagement.

6.3
Short-Term Funding Cycles

Many funding sources, particularly from corporate social responsibility (CSR) initiatives and philanthropic entities, operate on short-term cycles that do not align with the long-term nature of ecosystem restoration. This misalignment creates financial gaps, affecting the continuity and sustainability of conservation programs and limiting the effectiveness of ecosystem management strategies.

6.4
Insufficient Integration with Climate Finance Mechanisms

Despite the increasing global emphasis on nature-based solutions, coastal blue vegetated ecosystems remain underfunded within international climate adaptation and mitigation frameworks. The lack of direct alignment with established climate finance mechanisms restricts financial flows into critical ecosystem restoration and protection efforts. Strengthening the integration of coastal blue ecosystems into carbon markets, adaptation finance, and biodiversity credit systems is crucial to unlocking new financial opportunities.

6.5
Absence of Innovative Financing Models

Traditional financing models—grants, donations, and public funding—have historically supported conservation efforts but remain insufficient for large-scale restoration. The absence of blended finance models, which leverage public, private, and philanthropic capital, constrains the scalability and long-term sustainability of restoration initiatives. Expanding financial mechanisms to include impact investments, blue bonds, carbon finance, and payment for ecosystem services (PES) is essential to mobilize sustained, large-scale investments in conservation.

India's coastal blue vegetated ecosystems stand at a pivotal juncture—their conservation and restoration are no longer optional but imperative for national climate resilience, biodiversity preservation, and socio-economic stability. Despite policy advancements, scientific research, and community-driven efforts, these ecosystems remain highly vulnerable due to systemic governance failures, knowledge gaps, inadequate financing, fragmented conservation strategies, and unsustainable practices. The persistent gaps identified in this study underscore the urgent need for a paradigm shift—from isolated interventions to integrated, multi-stakeholder, and evidence-based conservation frameworks.

The Need for a Multi-Dimensional and Holistic Approach: The Path Forward

The identified challenges—from policy fragmentation and weak regulatory oversight to insufficient monitoring, capacity deficits, and financing constraints—are not isolated issues but interlinked structural deficiencies. Governance weaknesses exacerbate poor enforcement, while monitoring gaps obscure ecological trends, delaying timely interventions. Limited capacity and awareness among policymakers, practitioners, and communities further weaken conservation effectiveness. Simultaneously, inadequate financial mechanisms and short-term funding cycles constrain the scalability and sustainability of ecosystem restoration.

Addressing these challenges requires an integrated, systems-based approach that leverages scientific knowledge, traditional ecological wisdom, community participation, and cross-sectoral collaboration. Policy and governance must evolve beyond conventional regulatory structures to incorporate adaptive management frameworks that respond to dynamic ecological and socio-economic realities.

From Conservation to Transformation: A Call for Action

A business-as-usual approach will not suffice—coastal blue vegetated ecosystems must be repositioned as foundational pillars of India's climate mitigation and adaptation strategy, economic resilience, and disaster risk reduction framework. This necessitates:

- Strengthening governance structures to ensure policy coherence, institutional collaboration, regulatory enforcement, and community stewardship.
- Fostering interdisciplinary research and scientific consensus-building to bridge knowledge gaps, integrate emerging threats, and develop ecosystem-based conservation frameworks.
- Expanding long-term, sustainable financing by mainstreaming blue ecosystems into climate finance mechanisms, impact investments, and blended financing models.
- Enhancing ecological literacy and capacity-building among policymakers, practitioners, and communities to drive informed decision-making and locally led conservation.
- Embedding ecosystem monitoring and adaptive management through participatory, technology-driven frameworks to enable real-time decision-making and accountability.

Towards a Strategic Agenda for Immediate Action

The next section outlines a strategic and actionable roadmap to address these gaps through evidence-based policy reforms, inclusive governance mechanisms, robust financial models, and cross-sectoral partnerships. By implementing these strategies, India can not only secure the future of its coastal blue vegetated ecosystems but also harness their potential as powerful nature-based solutions for sustainable development, climate resilience, and biodiversity conservation.

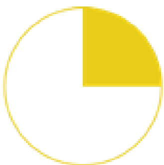
This is a defining moment—one that demands bold, decisive, and collective action to transition from incremental conservation efforts to a transformative agenda that safeguards these ecosystems for generations to come.

Stakeholder-Specific Actionable Agenda

Safeguarding coastal blue vegetated ecosystems requires coordinated, science-driven, and inclusive action. This moment represents a decisive crossroads—where the intellectual rigor of researchers, the foresight of policymakers, the action-oriented leadership of civil society, the stewardship of local communities, and the strategic vision of funders, philanthropists, and impact investors must converge in a unified effort. Recognizing the unique contributions of each stakeholder, this agenda provides targeted, time-bound actions to ensure a systematic, collaborative approach.

1. Research & Academic Institutions

Academic and research institutions play a critical role in generating scientific knowledge, standardizing monitoring frameworks, integrating traditional wisdom with modern conservation approaches, and building the capacity of key stakeholders to drive evidence-based conservation efforts.

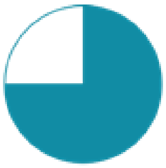


Short Term
1-2 Years

- Facilitating expert consultations and convening multi-stakeholder dialogues to build consensus on Standardized Definitions and Data Consistency for coastal blue vegetated ecosystems, including species classification, ecosystem boundaries, and ecological functions.
- Conducting comprehensive baseline assessments using remote sensing, GIS mapping, and field studies to identify degradation hotspots and priority restoration sites.
- Initiating research on emerging threats such as microplastics, invasive species, and climate change impacts on coastal ecosystems, with a specific focus on salt marshes and seagrasses, which are among the least studied ecosystems.
- Generating scientific evidence on the interconnectedness and interdependency of various marine and coastal ecosystems to inform integrated conservation strategies.
- Developing training modules, certification programs, and tailored capacity-building workshops focused on conservation science, ecosystem-based restoration, and inclusive approaches for policymakers, practitioners, researchers, and communities.
- Launching citizen science programs to engage local communities, create conservation leaders, and promote large-scale participation in ecosystem monitoring and conservation.
- Publishing policy briefs, best practice guidelines, and technical manuals to support science-driven conservation strategies and inform policy decisions.
- Initiating systematic documentation of traditional ecological knowledge using participatory approaches, ensuring its integration with scientific conservation frameworks.
- Launching youth fellowships and research grants to encourage early-career scientists to specialize in coastal ecosystem resilience, climate adaptation, and restoration science.

Medium Term
3-4 Years

- Establishing multi-disciplinary research consortia that integrate ecology, economics, climate science, and social inclusion (including Gender Equality and Social Inclusion - GESI) to guide evidence-based policymaking and collective action.
- Developing open-access, real-time biodiversity and ecosystem databases to facilitate knowledge sharing among researchers, practitioners, and citizen scientists.
- Systematically validating and integrating traditional ecological knowledge into restoration models, ensuring its role in adaptive ecosystem management.
- Mainstreaming Blue Ecosystem Science into Formal Education by introducing blue ecosystem-focused courses, degree programs, and online certifications at universities, technical institutes, and schools to build long-term expertise.



Long Term
5 Years

- Developing long-term ecosystem valuation frameworks to quantify the economic, social, and ecological benefits of blue ecosystems, ensuring their integration into national and international climate adaptation policies.
- Establishing AI-Powered Ecological Monitoring Systems: Developing AI-driven remote sensing models and automated species identification tools to track biodiversity trends, carbon sequestration rates, and ecosystem health in real-time.
- Creating Living Laboratories for Ecosystem Restoration: Establishing experimental restoration sites as “Living Labs” where researchers, students, and local communities co-design and test innovative restoration techniques before large-scale implementation.
- Developing Climate-Resilient Seed Banks & Bio-Repositories: Establishing seed banks for salt-tolerant, climate-resilient plant species to support restoration efforts in degraded coastal areas.
- Developing Carbon Market Tools & Blue Economy Innovation Hubs: Creating scientifically validated blue carbon credit methodologies to unlock sustainable financing for coastal ecosystem conservation and restoration.
- Establishing Blue Economy Innovation Hubs in collaboration with business schools, investors, and policymakers to promote eco-entrepreneurship, sustainable fisheries, and regenerative coastal businesses.

2. Civil Society Organizations (CSOs)

CSOs play a crucial role in bridging the gap between policy, science, and practice by mobilizing communities, fostering local leadership, piloting scalable restoration models, strengthening governance structures, and driving evidence-based advocacy. Their grassroots engagement ensures that conservation efforts are not only ecologically effective but also culturally relevant, while addressing socio-economic priorities. This approach guarantees that conservation initiatives are inclusive and rooted in local contexts, thereby enhancing their long-term sustainability.

Short Term
1-2 Years

- Launching Evidence-Based Restoration Pilots. Initiating community-led restoration projects that emphasize the restoration and conservation of vital coastal ecosystems, particularly seagrasses and salt marshes.
- Mobilizing Coastal Communities for Stewardship. Strengthening community-based organizations (CBOs) by empowering local groups with the knowledge and resources necessary to manage and protect coastal ecosystems.
- Training Community Champions and Women Leaders. Fostering leadership in ecosystem stewardship by providing specialized training for community champions and women leaders in restoration monitoring, biodiversity conservation, and sustainable livelihoods.
- Establishing Youth-Led Conservation Networks. Promoting youth engagement by establishing youth-driven networks aimed at enhancing local participation in blue ecosystem management and conservation activities.
- Collaborating with Research and Academic Institutions. Partnering with academic and research institutions to conduct technical training workshops and awareness programs for local government officials, CSOs, and fisher communities, focusing on ecosystem-based, participatory restoration techniques, biodiversity monitoring, climate resilience, and the formal recognition of seagrasses and salt marshes.
- Documenting Traditional Ecological Knowledge (TEK). Systematically recording TEK and initiating policy dialogues to integrate traditional practices into national and regional conservation frameworks, ensuring their value is recognized and incorporated into modern conservation efforts.
- Establishing Citizen Science-Based Monitoring Networks. Creating community-driven monitoring initiatives, where local communities and fisher groups are trained to use mobile applications and participatory tools for biodiversity monitoring and ecosystem management.
- Engaging in Policy Advocacy and Strengthening Local Governance. Actively participating in multi-stakeholder dialogues to integrate ecosystem-based adaptation strategies into coastal governance frameworks, ensuring that local knowledge and needs are represented in policy decisions.
- Building Partnerships with the Private Sector and Philanthropy. Forging strategic collaborations with private sector entities and philanthropic organizations to secure CSR funding and impact investments, ensuring a balanced focus on the conservation of mangroves, salt marshes, and seagrasses.
- Developing in-house capacity on emerging market finance mechanisms to enable CSOs to access and implement sustainable, ethical and sustainable financing models.

Medium Term
3-4 Years

- Expanding Nature-Based Livelihoods for Economic Resilience. Scaling up nature-based livelihoods, such as mangrove-based fisheries, seagrass-friendly aquaculture, and regenerative coastal farming, to enhance economic resilience in coastal communities.
- Supporting Community-Led Eco-Tourism. Promoting eco-tourism initiatives that are directly linked to conservation efforts, creating sustainable livelihoods for communities while fostering environmental awareness.
- Establishing Market Linkages for Nature-Based Products. Developing market access for sustainable, nature-based products to ensure the financial sustainability of restoration projects and local enterprises.
- Strengthening Regional and National Networks. Building state-level knowledge-sharing platforms to facilitate cross-community learning and the scaling of best practices in coastal ecosystem restoration.
- Leveraging Conservation Finance and Market-Based Mechanisms. Engaging with carbon finance mechanisms to establish ethical blue carbon credit projects, which will directly benefit local communities while contributing to climate mitigation goals.
- Strengthening Impact Investment Partnerships. Cultivating partnerships with impact investors to secure long-term financing for CSO-led restoration initiatives, ensuring financial sustainability for coastal ecosystem conservation.
- Technology Transfer to Communities. Empowering local communities with AI-based digital tools for tracking restoration efforts, monitoring biodiversity, and supporting conservation planning through training and capacity building.
- Influencing National and Global Conservation Policies. Enhancing CSO representation in international coastal conservation dialogues to exchange best practices and integrate science-driven policy recommendations into coastal governance frameworks.

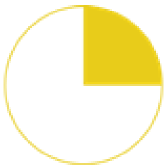
Long Term
5 Years

- Institutionalizing Governance and Securing Long-Term Conservation Finance. Establishing permanent governance structures for the co-management of coastal blue ecosystems by communities, ensuring their involvement in long-term decision-making processes.
- Advocating for Legal Recognition of Customary Practices. Advocating for the formal legal recognition of customary conservation practices within national policy frameworks, ensuring that traditional knowledge is preserved and respected.
- Embedding Community-Driven Conservation in National Strategies. Integrating community-led conservation models into national coastal management strategies, ensuring that these practices are institutionalized at the highest levels of governance.
- Developing Long-Term Financial Mechanisms for Conservation. Establishing community-managed conservation trusts and government-backed endowment funds dedicated to the protection of coastal ecosystems, ensuring sustainable financing for restoration efforts.
- Institutionalizing Blue Carbon Certification Frameworks. Creating blue carbon certification frameworks that ensure equitable benefit-sharing for coastal communities, fostering both ecological and economic sustainability.
- Positioning India as a Global Leader in Coastal Ecosystem Conservation. Strengthening India's role in global blue economy governance and climate adaptation frameworks, promoting international collaboration and sharing of best practices.

- Establishing Regional and International Alliances. Forming regional and international partnerships to promote knowledge exchange and policy integration, ensuring that coastal ecosystem conservation remains a priority in global environmental governance.

3. Policymakers & Government Bodies

Governments must be strengthening regulatory frameworks, integrating blue ecosystem conservation into development planning, and establishing sustainable financial mechanisms while ensuring that communities are playing a central role as active stewards. Recognizing and formalizing customary conservation practices and rights will be critical for ensuring inclusive and sustainable ecosystem management.



Short Term
1-2 Years

- Implementing and rigorously enforcing Coastal Regulation Zone (CRZ) notifications to prevent illegal encroachments and degradation of coastal ecosystems, ensuring compliance with environmental regulations.
- Allocating dedicated national and state budgets for the conservation and restoration of coastal blue ecosystems, such as mangroves, salt marshes, and seagrasses, ensuring targeted financial resources for their protection.
- Establishing dedicated task forces for blue ecosystems to improve coordination across ministries, ensuring a unified approach to coastal conservation and management.

Medium Term
3-4 Years

- Establishing multi-tiered governance frameworks that combine formal legal systems (laws and policies) with informal community-based conservation practices, ensuring broad-based participation, especially from local communities in decision-making processes.
- Formalizing communities’ role in stewardship by recognizing and formalizing communities’ roles as active stewards of coastal ecosystems, going beyond the traditional view of them as passive beneficiaries. This includes legally recognizing customary conservation practices and land rights, ensuring community-driven conservation approaches are supported within formal governance structures.
- Incorporating the valuation of ecosystem services into national development, economic planning, and environmental policies to acknowledge the significant economic contributions of blue ecosystems.
- Exploring and implementing innovative financial models, including blue bonds, carbon credits, and payments for ecosystem services (PES), to ensure sustainable funding for coastal ecosystem restoration and conservation.

Long Term
5 Years

- Positioning India as a Global Leader in Blue Ecosystem Governance by strengthening India's leadership role in global blue ecosystem governance by hosting international forums and creating platforms for knowledge-sharing and collaborative policymaking in coastal ecosystem management.
- Aligning Conservation Strategies with Global Commitments. Ensuring that national conservation strategies are aligned with global environmental commitments, such as the Sustainable Development Goals (SDGs) and the Paris Agreement, by prioritizing blue ecosystems in Nationally Determined Contributions (NDCs) and climate adaptation strategies.

4. Coastal Communities

Coastal communities are essential partners in ecosystem restoration and conservation efforts. Their active participation ensures that initiatives are rooted in local realities and are more sustainable in the long term. These communities must be empowered with the knowledge, tools, and resources needed to be effective stewards of blue ecosystems.

Short Term
1-2 Years

- Participating in workshops on leadership building, entrepreneurship training, sustainable practices, monitoring, and advocacy.
- Forming cooperatives to manage and benefit from restored ecosystems collectively.
- Engaging in mass awareness campaigns to understand the ecological and socio-economic importance of blue ecosystems.

Medium Term
3-4 Years

- Fostering community-driven, eco-based entrepreneurial ventures to enhance economic resilience and ensure long-term sustainability.
- Leveraging traditional ecological knowledge and cultural practices to adapt ecosystems to climate change impacts and build resilience.

Long Term
5 Years

- Securing co-management agreements with local governments for shared governance of ecosystems.
- Transitioning into decision-making roles in local and regional governance structures.

5. Philanthropy, Grantmakers, and CSR (Mobilizing Strategic, Long-Term Investments)

Philanthropic organizations, grantmakers, and CSR initiatives play a crucial role in providing sustained financial support for conservation, beyond short-term projects. Their engagement must shift from funding standalone interventions to supporting long-term, scalable, and community-driven solutions that ensure the resilience of coastal blue vegetated ecosystems.

Short Term
1-2 Years

- Funding integrated restoration pilot projects with equal emphasis on mangrove, seagrass, and salt marsh conservation alongside sustainable livelihoods.
- Facilitating interdisciplinary research partnerships between CSOs, academic institutions, and local communities to promote knowledge co-creation and participatory monitoring.
- Strengthening CSOs and communities in policy dialogues and advocacy to integrate blue ecosystems into national and regional conservation priorities.
- Supporting community-led documentation of traditional ecological knowledge (TEK) and its integration into conservation models.
- Financing citizen science networks for monitoring biodiversity, water quality, and ecosystem health.
- Investing in mass awareness and education campaigns targeting practitioners, policymakers, businesses, and the public.

Medium Term
3-4 Years

- Scaling up investments in nature-based solutions that integrate climate resilience, biodiversity conservation, and community well-being.
- Providing flexible, adaptive funding beyond infrastructure to support capacity-building and governance strengthening.
- Advancing policy advocacy efforts to ensure blue ecosystems are recognized in national and global climate strategies, including NDCs and SDGs.
- Ensuring multi-year funding commitments to sustain long-term conservation and community-driven initiatives.

Long Term
5 Years

- Establishing endowment funds to provide sustained financing for coastal ecosystem conservation, reducing reliance on short-term grants.
- Embedding blue ecosystem conservation into global development frameworks, corporate ESG policies, and international funding mechanisms.
- Developing blue carbon finance models to unlock investments in scientifically validated restoration projects.
- Enabling coastal communities to access global carbon markets and biodiversity credits, ensuring fair benefit-sharing mechanisms.

6. Markets (Impact Investments & Finance)

Sustainable financing mechanisms must shift from short-term grants to long-term investment models that ensure continuous support for ecosystem conservation. Leveraging innovative financial instruments and mobilizing private and philanthropic capital will be essential in scaling up blue ecosystem conservation efforts.

Short Term
1-2 Years

- Mobilizing private capital for ecosystem restoration through blue bonds, sustainability-linked loans, and carbon finance to restore and conserve coastal ecosystems.
- Creating investment frameworks to support nature-based enterprises, such as sustainable aquaculture, eco-tourism, and other blue carbon initiatives, ensuring that investments promote both environmental and economic benefits.

Medium Term
3-4 Years

- Establishing blended finance models that combine public, private, and philanthropic funds to support large-scale ecosystem-based conservation projects, ensuring comprehensive and sustained funding.
- Designing metrics to measure the return on investment (ROI) in ecosystem conservation, with a strong focus on biodiversity, carbon sequestration, and broader environmental impacts, ensuring that conservation efforts are economically viable.
- Markets should develop financial instruments that account for uncertainties and risks associated with climate change, dynamic ecological conditions, and shifting socio-economic factors. This includes creating risk absorption mechanisms such as resilience bonds, parametric insurance, and adaptive financing models that ensure long-term sustainability of conservation investments.

Long Term
5 Years

- Establishing dedicated impact funds for coastal ecosystem conservation, attracting global investors and supporting the scaling up of successful restoration models.
- Developing financial models that integrate conservation outcomes with socio-economic development goals, ensuring long-term sustainability of conservation efforts while fostering economic resilience for local communities.

Immediate Action Agenda for the Conservation of Coastal Blue Vegetated Ecosystems in India:

Establishing a Standardized Definition:

- Build consensus on the components of coastal blue vegetated ecosystems, including criteria for species inclusion and geographic coverage, by engaging scientists, citizen scientists, civil society organizations (CSOs), community representatives, and relevant policymakers.
- Develop and disseminate knowledge products to raise awareness among scientists, the public, and policymakers.

Mapping Coastal Blue Vegetated Ecosystems:

- Create an interactive website and dashboard for regular monitoring of mangroves, seagrasses, and salt marshes, serving as a one-stop solution for data access.

Popularizing Blue Ecosystem Science:

- Creating a digital knowledge hub on blue ecosystems.
- Establishing Young Scientist Fellowships: Create fellowships for young scientists to conduct research on under-studied components of blue ecosystems, such as seagrasses and salt marshes, encouraging innovative studies and fostering the next generation of researchers in this vital area.

Document Traditional Knowledge and Best Practices:

- Collaborate with local communities to document traditional ecological knowledge and advocate for its integration into conservation strategies, empowering these communities as decision-makers.

Capacity Building:

- Tailored capacity-building workshops focused on conservation science, ecosystem-based restoration, and inclusive approaches for policymakers, practitioners, researchers, and communities.

Building Capacity in Vulnerable Coastal Communities:

- Strengthen the capabilities of communities most affected by climate change and environmental degradation, enabling them to respond effectively.

Mass Awareness Campaigns:

- Implement campaigns to educate the public about coastal blue vegetated ecosystems, particularly lesser-known and often neglected areas such as salt marshes.
- Capacity building workshops for practitioners

Launch a Citizen Scientist Program:

- Engage local citizens in understanding, conserving, and monitoring coastal blue vegetated ecosystems through active participation.

Mainstreaming Coastal Blue Vegetated Ecosystems:

- Advocate for evidence-based policies to conserve coastal blue vegetated ecosystems that integrate ecosystem interconnectivity in planning; adopt a Source-to-Sea approach and implement essential reforms in blue ecosystem governance and regulatory frameworks to adapt to a changing world.

Fostering Partnerships and Collaboration:

- Build collectives to enhance synergies and maximize impact through collaborative efforts among various stakeholders.

Engage Donors and Investors:

- Actively seek to involve donors and investors to secure resources and financing with a long-term vision, ensuring sustainable funding for conservation efforts and initiatives related to coastal blue vegetated ecosystems.

Chapter 8 - Glossary of Technical Terms

A

Adaptive Management:
A structured, iterative process of robust decision-making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring.

B

Biodiversity:
The variety of life in the world or in a particular habitat or ecosystem. Biodiversity is a measure of the health of biological systems.

Blue Carbon:
Carbon captured and stored by the world's oceanic and coastal ecosystems, primarily by mangroves, seagrasses, and salt marshes.

Blue Carbon Ecosystems:
Coastal and marine ecosystems, including mangroves, seagrasses, and salt marshes, that play a significant role in capturing and storing atmospheric carbon dioxide.

Blue Economy:
The sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems.

Blue Ecosystems:
Broadly encompasses all marine and coastal ecosystems, including both vegetated (e.g., mangroves, seagrasses, salt marshes) and non-vegetated areas (e.g., coral reefs, open ocean).

Blue Forests:
Coastal and marine ecosystems, including mangrove forests, seagrass meadows, and salt marshes, which are crucial for protecting marine biodiversity and supporting coastal livelihoods. Blue forests are significant for their carbon storage capacity and ecological benefits.

Blue Governance:
A governance framework focused on the sustainable management of ocean and coastal resources, integrating ecological, economic, and social dimensions to ensure healthy and productive marine environments.

C

Carbon Credits:
Permits that allow a country or organization to emit a certain amount of carbon dioxide, with the ability to trade credits if emissions are reduced. Carbon credits can incentivize conservation and restoration of carbon-sequestering ecosystems like mangroves and seagrasses.

Carbon Sequestration:
The process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form, often by plants through photosynthesis.

Citizen Science:
The collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists. Climate Resilience: The ability of a system or community to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate.

Coastal Blue Carbon Ecosystems:
Coastal ecosystems such as mangroves, seagrasses, and salt marshes that are particularly effective at capturing and storing carbon, thus playing a critical role in mitigating climate change.

Coastal Blue Vegetated Ecosystems:
'Coastal Blue Vegetated Ecosystems' to encompass mangroves, seagrasses, and salt marshes, emphasizing their unique coastal habitats characterized by habitat-forming plant species and their proximity to the ocean.

Coastal Resilience:
The ability of coastal systems to resist, absorb, and recover from the effects of hazardous events such as sea-level rise, storms, and flooding.

E

Ecological Monitoring:
The systematic collection of data on the natural environment and its changes over time, used to understand and manage ecosystems.

Ecosystem-Based Approach:
A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way. It recognizes the complex interrelationships within ecosystems and addresses the connections between ecological, economic, and social factors.

Ecosystem Services:
The benefits people obtain from ecosystems, including provisioning services like food and water; regulating

services such as climate regulation and flood control; cultural services like recreational and spiritual benefits; and supporting services such as nutrient cycling.

G

Geographic Information Systems (GIS):
A framework for gathering, managing, and analyzing spatial and geographic data. GIS integrates many types of data and is used in environmental studies to map and analyze ecosystems.

I

Integrated Coastal Zone Management (ICZM):
A process for managing coastal areas to balance environmental, economic, social, cultural, and recreational objectives. ICZM promotes sustainable use of coastal resources and ecosystem-based management approaches.

M

Mangroves:
Mangrove forests are unique ecosystems located along coastlines, shallow waters, and intertidal areas in tropical and subtropical regions. The trees and shrubs within these forests are specifically adapted to survive in saline environments, growing from sea level up to the spring tide line, under harsh environmental conditions of salinity, temperature, tides, sedimentation, and muddy anaerobic soils.

Marine Protected Area (MPA):
Regions of seas and coasts where human activities are restricted to protect the natural environment and biodiversity.

N

Nationally Determined Contributions (NDCs):
NDCs are national climate action plans by each country under the Paris Agreement. A country's NDC outlines how it plans to reduce greenhouse gas emissions to help meet the global goal of limiting temperature rise to 1.5°C and adapt to the impacts of climate change. The Paris Agreement requires that NDCs are updated every five years with increasingly higher ambition, taking into consideration each country's capacity.

R

Remote Sensing:
The acquisition of information about an object or phenomenon without making physical contact, typically through satellite or aerial imagery, used to monitor environmental changes.

S

Salt Marshes:
Salt marshes are coastal wetlands located in the upper tidal zones, regularly experiencing tidal inundation at consistent or seasonal intervals. Salt marshes are communities of halophyte (salt-tolerant) plants that thrive at the interface of land and sea, where fresh and saline waters converge.

Seagrasses:
Seagrasses are flowering plants that thrive in marine environments and are present on every continent except Antarctica. These plants possess roots, stems, and leaves, and are capable of producing flowers and fruits. They are closely related to terrestrial plants, having likely evolved from land-based angiosperms (flowering plants) millions of years ago. In terms of land relatives, seagrasses share a connection with monocots, which include grasses, lilies, and palms.

Source-to-Sea (S2S) Approach:
A holistic method that considers the entire watershed, from inland areas to coastal zones, in managing ecosystems. This approach addresses the interconnectedness of water systems and the impacts of upstream activities on coastal and marine environments.

Sustainable Development Goals (SDGs):
A collection of 17 global goals set by the United Nations General Assembly in 2015, aimed at achieving a better and more sustainable future for all by addressing global challenges, including those related to poverty, inequality, climate, environmental degradation, and peace and justice.

T

Traditional Ecological Knowledge (TEK):
Indigenous and local knowledge systems developed over generations through direct contact with the environment. TEK is valuable for the sustainable management and conservation of natural resources.

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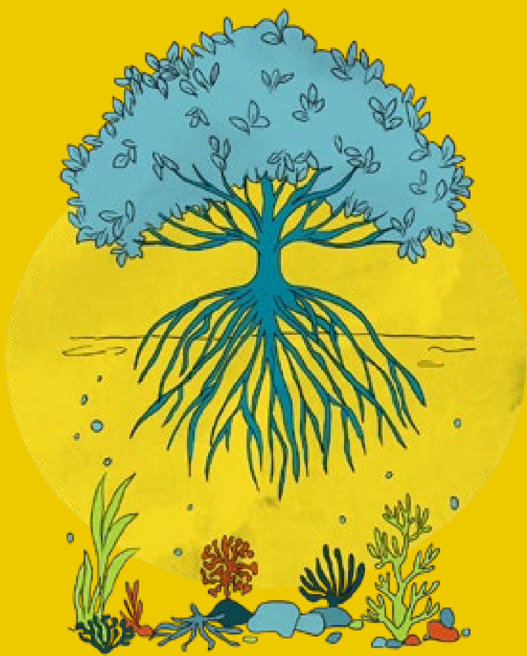
Chapter 10

Annexures

Scan me!

- Annexure-I: List of Species
- Annexure-II: Expert Consultation Report
- Annexure-III: Knowledge Repository
- Annexure-IV Blue Ecosystem Organizations Directory

Click here to view Annexures



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