International Symposium on
Building Resilience of Communities in Sundarbans
Narendrapur, Kolkata

12-14 February 2025

Proceedings

Organised by

School of Environment and Disaster Management
Ramakrishna Mission Vivekananda Educational and Research Institute

In collaboration with
Centre for Oceanographic Studies, Jadavpur University
Department of Sundarban Affairs, Government of West Bengal

With support from
Indian Council for Social Science Research

International Symposium on
Building Resilience of Communities in Sundarbans
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Edited by

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With Foreword by

Swami Atmapriyananda
Pro-Chancellor

Ramakrishna Mission Vivekananda Educational and Research Institute
(Deemed to be University)
Narendrapur Campus
April 2025

Preface

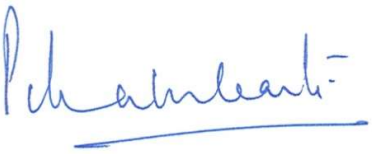
The School of Environment and Disaster Management of Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI) – a deemed to be university – organized an International Symposium on Building Resilience of Communities in Sundarbans on 12-14 February at the Narendrapur campus of the university.

The Symposium was organized in collaboration with the Department of Sundarban Affairs of Government of West Bengal and the School of Oceanographic Studies of Jadavpur University Kolkata. The Indian Council of Social Science Research New Delhi provided a grant to support the organization of the symposium.

More than fifty invited experts across social, environmental, earth, agricultural and engineering sciences and technology from various parts of the country and abroad presented their research and field work on the physiographic, climatic and socio-economic challenges faced by the people living in Sundarban delta and on innovative, community based, technology driven, cost effective and sustainable solutions to these challenges.

Based on these deliberations on the challenges, opportunities and the strategic approach for building resilience of communities, an outcome document was drafted which was discussed in the closing session of the symposium and further kept open for comments from all concerned. Based on these comments the draft outcome document was revised and finalized as the *Strategic Framework and Road Map for Building Resilience of Communities in Sundarbans2025-2050.*

This document provides a summary of the proceedings of the symposium. The contribution of the PhD scholars and faculty members of the School of Environment and Disaster Management in compiling the proceedings of the symposium is appreciated.



Dr P G Dhar Chakrabarti

Convenor

Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI)
(Deemed-to-be University declared by Govt. of India under section 3 of UGC Act 1956)
(Formerly known as "Ramakrishna Mission Vivekananda University")
Head Quarter: Belur Math, Howrah, West Bengal: 711 202
(Accredited by NAAC A++ Grade)

Swami Atmapriyananda
Pro-Chancellor
RKMVERI

Foreword

The Sundarbans, literally meaning the "beautiful forests", have a number of global superlatives to its credit - the largest river delta, the largest contiguous mangroves forest, the most densely populated delta, the delta with the richest bio-diversity, the only mangroves with tigers, spotted deer, masked finfoot and brown-wined kingfisher, and so on. This unique ecosystem, rightly recognized as a UNESCO world natural heritage, is sadly facing an existential crisis due to the combined onslaughts of natural and anthropogenic processes. The natural geomorphic process of land subsidence and river sedimentation, have been compounded by the large-scale felling of trees over the past for human settlement and agriculture, and now further compounded by the climate change and the associated risks of extreme climatic events like cyclonic storms and breach of embankments and slow onset events like sea level rise, coastal erosion and

salinization. A few islands of the delta have vanished and a few more are in the process of imminent dangers of getting sunk into sea and estuarine rivers.

A powerful school of technocrats led by the World Bank has advocated shifting of 2.5 million population from the critical areas of the delta, to be countered by equally vociferous school of social scientists and community leaders who have pointed out the colossal humanitarian tragedies in social and economic rehabilitation of such a large number of poor people from their habitats.

In this context it is heartening that the 'School of Environment and Disaster Management' of our University has taken the initiative to organize a three-day International Symposium during 12-14 February 2025 on 'Building Resilience of Communities in Sundarbans' in which scientists, scholars, practitioners and policy-makers and enlightened public concerned about Sundarbans participated enthusiastically and an amazing large number of more than 50 speakers contributed through their enlightening presentations.

We congratulate the EDM (Environment and Disaster Management) team of our University, under the able and dynamic leadership of Dr PG Dhar Chakrabarti, the Head of the EDM Dept. and 'Swami Vivekananda Chair Professor in EDM' instituted in our University by the Govt. of West Bengal, on his great effort in meticulously organizing this symposium. He has painstakingly compiled the proceedings of the three-day conference and carefully edited them to produce this comprehensive volume that will, we are sure, serve as a unique resource document for scientists and laymen alike who are concerned and deeply interested in the conservation and the preservation of the valuable 'UNESCO World Natual Heritage'—the Sundarbans Ecosystem. We are happy to place this volume, prepared in a remarkably short time thanks particularly to Dr PG Dhar Chakrabarti's untiring efforts with the help of his committed team of faculty and research scholars before you, the reader.

It is a matter of gratification that this three-day symposium could come up with a 'Strategic Framework' and a 'Road Map' for building resilience of communities in the delta. This is the thoughtful contribution of the Department of Environment and Disaster Management—the subject experts, faculty and scholars—that is now being offered in humility for the careful consideration of the State and Central Governments as well as other Agencies involved in and concerned about the Sunderbans ecosystem. We hope that the suggestions and recommendations, contributions and thoughts embodied in this volume—this 'Outcome Document'—prepared after serious 'brainstorming' as well as 'heartstorming' by persons possessing not only vast knowledge of the subject, but whose hearts are deeply moved by their concern about the Sundarbans saga, will be duly honored and the proposals/suggestions herein given thoughtful consideration.

It is high time that we earnestly heard the 'wakeup call of Nature' and the cries of poor and hapless Sundarbans population. If the specific programmes suggested in the present document for saving the lives and livelihoods of the Sundarbans people in a time bound manner resonate with and awaken the consciousness of the 'powers that be' and all of us, thus rousing us to concrete action, we will consider our efforts worthwhile. We invite feedback from the readers of this volume to assist and reinforce our collective endeavor in serving the 'beautiful' (*sundar*) Sundarbans.

Belur Main Campus of RKMVERI
Date: 14 April 2025

Swami Atmapriyananda
Pro-Chancellor, RKMVERI

C O N T E N T S

Introduction

The Sundarban region - an expansive delta formed on the confluence of the Ganga, Meghna, and Brahmaputra rivers with the Bay of Bengal spanning across India and Bangladesh - is facing a multifaceted existential crisis due to environmental degradation, rising sea levels, and extreme weather events exacerbated by climate change.

The region, home to the world's largest contiguous mangrove forest with rich biodiversity, has seen its landmass shrinking significantly over the last two centuries. The population, primarily living in isolated island blocks, is heavily dependent on subsistence farming, fishing, and minor forest products, with nearly half of the population living below the poverty line.

Despite various government and non-government initiatives to address these challenges, the region remains one of the most critical hotspots in the world, with layers of vulnerabilities exposed to multiple hazards of nature, creating complex of risks of disasters, affecting lives and livelihoods of nearly 12 million people in the two South Asian countries, many of them pushed by circumstances to migrate as climate refugees.

In the recent years there have been a rise of research on Sundarbans across various disciplines and sectors, analysing the problems of the region and trying to find solutions, through innovative programmes with varying results, but most of such initiatives have taken place in silos, without any comprehensive multi-sectoral strategic approach for building resilience of the local communities.

In this backdrop the *International Symposium on Building Resilience in Sundarbans* brought together scientists, researchers, policy makers and practitioners across various disciplines and sectors in a common platform to

a) Discuss various physiographic, climatic, social, economic and environmental changes of Sundarbans that are driving the existential crisis of the deltaic islands;
b) Deliberate on eco-system based, scientific, sustainable, cost effective, community driven, gender sensitive and inclusive measures that can be adopted for reducing the risks of disasters, adapting with the changing climate, enhancing livelihood opportunities, eradicating poverty and stopping distressed migration; and
c) Develop a road map for building resilience in Sundarbans and recommend a set of programmes, projects and activities that can be adopted on short, medium and long terms for building resilience in Sundarban.

The Symposium was structured in ten different sessions, including the inaugural session flagged the contexts and issues for discussion and concluding session discussed on a draft Strategic Framework and Road Map on Building Resilience of Communities in Sundarbans, based on the discussion held on eight thematic sessions on the following themes:

1) Physiographic Changes in Sundarbans: Sedimentation, Erosion and Subsidence
2) Living with Risks: Natural Hazards and Human Vulnerabilities
3) Living on the Edge: Impact of Climate Change on Life and Economy of Sundarbans
4) Existential Crisis in Sundarbans: Poverty, Livelihood and Migration
5) Reducing Risks of Disasters: Structural and Non-Structural Solutions
6) Adapting to Climate Change: Innovative Technology and Practices
7) Nature Based Solutions
8) Strategic Approach for Building Resilience

Each theme was further divided in five sub-themes, with a keynote speaker on the session theme and one speaker on each of the five sub themes. Each keynote speaker and other speakers was chosen for their extensive research on the theme and sub-theme and valuable contribution to the expanding knowledge and understanding of the subject.

The programme schedule of the symposium with details of themes, sub-themes, keynote and other speakers and the summary proceedings of all these ten sessions are presented in the following pages.

International Symposium on
Building Resilience of Communities in Sundarbans

S C H E D U L E

DAY-1: 12 FEBRUARY 2025

Session-1:
Inaugural Session: Setting the Contexts and Flagging the Issues
(11 AM to 1 PM)

Welcome Address
Dr. P G Dhar Chakrabarti
Swami Vivekananda Chair Professor on Environment and Disaster Management, RKMVERI

Opening Remarks
Swami Shastrajnananda
Secretary Ramakrishna Mission, Narendrapur

Address of
Prof. Amitava Datta
Pro-Vice Chancellor
Jadavpur University Kolkata

Video Address of Guest of Honour
Dr. Amitav Ghosh
Author, Jnanpith Awad Winner

Address of Chief Guest
Shri Atri Bhattacharya
Additional Chief Secretary
Sundarban Affairs Department
Government of West Bengal

Presidential Address
Swami Atmapriyananda
Pro Chancellor
Ramakrishna Mission Vivekananda Educational and Research Institute

Vote of Thanks
Prof. Tuhin Ghosh
Director, School of Oceanography, Jadavpur University

Session-2:
Physiographic Changes in Sundarbans:
Sedimentation, Salinisation, Erosion and Subsidence

(2 PM to 4:30 PM)

Session Chair:
Prof. Tuhin Ghosh
Professor & Director, School of Oceanographic Studies, Jadavpur University
Keynote Address:
Dr. Kalyan Rudra
Chairman West Bengal State Pollution Control Board

Speakers:

1. **Alteration in Estuarine Processes: Tidal Asymmetry and In-channel Sedimentation**
   Prof. Ramkrishna Maiti, Professor, Department of Geography and Environment Management, Vidyasagar University, Midnapore

2. **Island Area Change: Patterns, Trends, and Processes**
   Prof. Sunando Bandyopadhyay, Professor, Department of Geography, University of Calcutta, Kolkata

3. **Land subsidence - contributing factors and remedial measures**
   Prof. Ashis Kumar Paul, Professor (retd), Department of Geography, Vidyasagar University, Midnapore

4. **Changing expanse, depth and quality of mangroves of Sundarbans**
   Prof. Abhijit Mitra, Director Research, Techno India University, Kolkata

5. **Reviving mangroves in Habited Islands of Sundarbans**
   Dr. Debajit Datta, Associate Professor, Department of Geography, Jadavpur University Kolkata

Session-3:
Living with Risks: Natural Hazards and Human Vulnerabilities

(4:30 PM to 6:30 PM)

Session Chair:
Dr. P G Dhar Chakrabarti
Swami Vivekananda Chair Professor on Environment and Disaster Management, RKMVERI
Keynote Address:
Prof. Tuhin Ghosh
Director School of Oceanography, Jadavpur University, Kolkata

Speakers:

1. **Patterns and trends of cyclones, floods and other natural hazards**
   Dr. Sourav Pal, Director, Estuarine and Coastal Studies Foundation, Howrah

2. **Damage and loss of tangible and intangible assets in Sundarbans**
   Dr. Ranit Chatterjee, Co-Founder, Resilience Innovation Knowledge Academy (RIKA-India), Delhi

3. **Social and economic vulnerabilities of Sundarban islands**
   Dr. Jenia Mukherjee, Associate Professor, Humanities and Social Sciences, Indian Institute of Technology, Kharagpur

DAY-2: 13 FEBRUARY 2025

Session-4:
Living on the Edge:
Impact of Climate Change on the Life and Economy of Sundarbans

(9 AM to 11 AM)

Session Chair:
Dr. P G Dhar Chakrabarti
Swami Vivekananda Chair Professor on Environment and Disaster Management, RKMVERI

Keynote Address:
Sea Level Rise: Trends, Projections and Impacts
Prof. Sugata Hazra
Former Director, School of Oceanography, Jadavpur University, Kolkata

Speakers:

1. **Salinization of soil, sub-soil and river in Sundarbans**
   Dr. Dhiman Burman, Head and Principal Scientists, Regional Research Station, Central Soil Salinity Research Institute, Canning

2. **Impact of climate change on agriculture in Sundarbans**
   Dr. Sumanta Kundu, Scientist, Central Research Institute for Dryland Agriculture, Indian Council of Agricultural Research, Hyderabad

3. **Impact of climate change on life and economy in Sundarbans**
   Dr. Somnath Hazra, Climate Change Adviser, Indus Value Consulting

4. **Impact of climate change on fisheries in Sundarbans**

   Dr. Swagat Ghosh, Head (In-Charge) & Subject Matter Specialist (Fisheries), SSKVK, Sonarpur

Session-5:
Existential Crisis in Sundarbans: Poverty, Livelihood and Migration

(11:30 AM to 1:30 PM)

Session Chair and Keynote address:
Dr. Rupak Goswami
Associate Professor, School of Agriculture & Rural Development, RKMVERI, Narendrapur

Speakers:

1. **Livelihood in Sundarbans – Challenges and opportunities**
   Dr. Debojyoti Das, Lecturer, School of Oriental and African Studies, University of London, UK

2. **Climate refugees of Sundarbans**
   Dr. Upasona Ghosh, Associate Professor, Indian Institute of Public Health Bhubaneswar

3. **Migration and feminisation of agriculture: Unequal burden of work of women**
   Dr. Srija Basu, Independent Researcher and Consultant

4. **Multi-Dimensional Poverty in Sundarbans**
   Dr. Megnaa Mehtta, Lecturer in Social Anthropology, Institute of Risk and Disaster Reduction, University College of London, UK

Session-6:
Reducing Risks of Disasters: Structural and Non-Structural Solutions

(2:30 PM to 4:30 PM)

Session Chair:
Dr. P G Dhar Chakrabarti
Swami Vivekananda Chair Professor on Environment and Disaster Management, RKMVERI

Keynote Address:
Dr. Indrajit Pal
Associate Professor and Chair Disaster Preparedness, Mitigation and Management Program, Asian Institute of Technology, Bangkok

Speakers:

1. **Protecting embankments from storm surges and sea level rise**
   Prof. Chandan Ghosh, Former Professor, National Institute of Disaster Management

2. **Disaster and climate safe houses and infrastructure**
   Prof. Souvanic Roy, Professor, Department of Architecture & Planning, Indian Institute of Engineering Science & Technology (IIEST), Shibpur.

3. **Cyclone shelters of Sundarbans**
   Prof. Gupinath Bhandari, Professor, Civil Engineering, Coordinator, Centre for Disaster Preparedness & Management, Jadavpur University, Kolkata

4. **Community Based Disaster Risk Management**
   Md. Shamsuddoha, Chief Executive, Centre for Participatory Research and Development, Dhaka, Bangladesh

Session-7:
Adapting to Climate Change: Innovative Technology and Practices

(5 PM to 7 PM)

Session Chair:
Prof. Tapash Dasgupta
Dean, RKMVERI, Narendrapur, Narendrapur campus
Keynote Address:
Dr. Sanjay Srivastava
Chief Disaster Risk Reduction, UNESCAP, Bangkok

Speakers:

1. **Climate resilient agriculture in Sundarbans**
   Dr. Prabir Kumar Garain, SMS (Plant Protection), Ramakrishna Mission Ashram KVK, Nimpith, South 24 Paraganas

2. **Untapped potentials of inland fisheries in Sundarbans**
   Dr. Parthapratim Chakrabarti, Former Principal Scientist and Scientist-in- charge, Regional Research Centre, Rahara and Kalyani, ICAR-CIFA

3. **Indigenous coping mechanisms and traditional wisdom for survival**
   Mr. Anshuman Das, Senior Programme Manager, Welthungerhilfe- India, Kolkata

4. **River, estuarine and marine fisheries: Challenges and opportunities**
   Dr. Tapas Kumar Ghoshal, Principal Scientist & Head ICAR- Central Institute of Fisheries Education, Kolkata Centre

DAY-3: 14 FEBRUARY 2025

Session-8:
Nature Based Solutions

(9 AM to 11 AM)

Session Chair:
Dr Manas Ghosh
Director
West Bengal State Agricultural Management and Extension Training Institute, Narendrapur
Keynote Address:
Dr. Debal Ray
Principal Chief Conservator of Forests, Government of West Bengal

Speakers:

1. **Conserving bio-diversities for sustainable development**
   Dr. Asok Sanyal, Former Chairman, West Bengal State Biodiversity Board

2. **Enhancing nature based livelihood opportunities**
   Dr. S. K. Sarangi, Head, Division of Agricultural Technologies for Women, ICAR-Central Institute for Women in Agriculture, Odisha

3. **Restoring ponds for rainwater harvesting**

Dr. Abhra Chandra, Assistant Professor, School of Oceanographic Studies, Jadavpur University Kolkata

4. **Eco-tourism in Sundarbans – Problems and prospects**
   Dr. Chandrima Sinha, Programme Manager (Planning and Monitoring), Nature Environment and Wildlife Society, Kolkata

Session-9:
Strategic Approach for Building Resilience

(11:30 AM to 1:30 PM)

Session Chair:
Prof. Jayanta Bandyopadhyay
Distinguished Fellow, Observer Research Foundation, Kolkata

Keynote Address:
Shri Prabhat Kumar Mishra
Additional Chief Secretary, Finance Department, Government of West Bengal

Speakers:

1. **Development plans in Indian Sundarbans: Achievements and shortcomings**
   Mohd. Abdul Goni, Former Special Secretary, Department of Sundarban Affairs, Government of West Bengal

2. **Strategic Interventions for Building Resilience to Climate Change and Disasters**
   Dr. Rajarshi Dasgupta, Assistant Professor, School of Public Policy, IIT, Delhi

3. **Planned adaptation or managed retreat**
   Dr. Anamitra Anurag Danda, Director, Sundarban Programme, WWF-India, Senior Visiting Fellow, Energy and Climate Change Programme, ORF, Kolkata

4. **Conservation and conflict - Hopes and despair for the future**
   Prof. Amites Mukhopadhaya, Professor, Department of Sociology, Jadavpur University, Kolkata

Session-10:
Concluding Session: Sundarbans - Road Map to Resilience

(3 PM to 5 PM)

Session Chair:
Shri Prabhat Kumar Mishra
Additional Chief Secretary, Finance Department, Government of West Bengal

Presentation of Draft Framework and Road Map
Dr. P G Dhar Chakrabarti IAS (retd)
Swami Vivekananda Chair Professor on Environment and Disaster Management, RKMVERI

Panel Discussion on Strategic Framework and Road Map

Panelists

Prof. Andy Large
Director, Living Deltas Hub
School of Geography, Politics and Sociology
Newcastle University, UK

Shri Rajendra Ratnoo IAS
Executive Director
National Institute of Disaster Management
Government of India

Shri Atri Bhattacharya IAS
Additional Chief Secretary, Sundarban Affairs Department
Government of West Bengal

Dr. Kalyan Rudra
Chairman, West Bengal State Pollution Control Board

Dr. Jayanta Basu
Environment Documentation and Communication Expert,
Visiting Faculty, Calcutta University

Prof. Sugata Hazra
Former Director, School of Oceanography
Jadavpur University

Shri Subhas Acharya
Member
Sundarban Development Board

Inaugural Session:
Setting the Contexts and Flagging the Issues

The inaugural session of the International Symposium on Building Resilience of Communities in Sundarbans was presided over by Swami Atmapriyananda Pro-Chancellor of Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI). Other

dignitaries on the dais included Shri Atri Bhattacharya Additional Chief Secretary Department of Sundarban Affairs Government of West Bengal, Professor Amitava Datta Pro-Vice Chancellor of Jadavpur University, Swami Shastrajnananda Secretary Ramakrishna Mission Narendrapur and Administrative Head of the Narendrapur Campus of RKMVERI, Professor Tuhin Ghosh Dean Faculty of Interdisciplinary Studies Law and Management and Director School of Oceanographic Studies, Jadavpur University, and Professor Tapas Dasgupta Dean Narendrapur Campus of RKMVERI. The Chief Guest Shri Bankim Chandra Hazra Hon'ble Minister for Sundarban Affairs

could not attend due to the budget session of West Bengal Assembly. Guest of Honour Jnanpith Awardee Padma Bhushan Amitav Ghosh could not attend in person and sent his video address,

The session commenced with an invocation by the students of the University, followed by the lighting of the ceremonial lamp and welcoming of the dignitaries on dais with bouquet of flowers.

Welcoming the dignitaries on the dais, the speakers, the participants and the online viewers, ***Dr P G Dhar Chakrabarti*** Swami Vivekananda Chair Professor and Head of the School of Environment and Disaster Management, RKMVERI explained the contexts, objectives, uniqueness and expected outcome of the international symposium. More than 2.5 million

people living in 9 isolated island blocks of Indian Sundarbans are facing an unprecedented existential crisis due to the combination of a number of physiographic, climatic and socio-economic challenges. The physiographic challenges of land subsistence, river sedimentation and coastal erosion are compounded by increasing frequencies and intensities of extreme climatic events like cyclonic storms and floods and slow onset events like seal level rise and salinization. Agriculture and fisheries that are the mainstays of the livelihood of the local communities are deeply affected by saline water ingress into the islands due to repeated breaches in embankments. Adult male members of many distressed families are forced to migrate to cities in search of livelihood leaving women behind to take care of the young and the old, besides animals and the dwindling farming and fisheries. This is sharply increasing the burden of work of women with adverse impact on their physical and mental health, while the menfolk are struggling with increasing cost of living in cities to save from their meagre earnings to support families in villages. The result is rising levels of poverty and malnutrition and sharp deterioration in the social and economic wellbeing of the people. The worsening situation of the deltaic islands had prompted WWF-India and the World Bank to recommend that these 2.5 million should be shifted to safer places in the

hinterland, where there are hardly any surplus land for their rehabilitation and opportunities for their livelihood.

In this backdrop this International Symposium on Sundarbans has been convened with three main objectives. First, it brings together in the same platform, probably for the first time, scientists and researchers from multiple disciplines, including social science, environmental science, bio-sciences, geography, oceanography, engineering, and agricultural and veterinary sciences, who have worked and written on Sundarbans and have contributed to our expanding knowledge and understanding on the subject, to interact with each other and find solutions to the existential crises in Sundarbans. Secondly, the symposium further brings practitioners and policy-makers, including retired and serving top technocrats, bureaucrats and representatives from NGOs in the same platform for interaction and discussion. There will be a total of 55 speakers in ten sessions of the symposium over three days. The proceedings of the symposium as well as the selected papers shall be published in two separate volumes through reputed publishers. Third, and the most important, the symposium will not merely be an academic exercise; it will come up with a strategic framework and road map for building resilience of the local communities to tide over the existential crises. A draft framework and road map shall be presented in the closing session and finalised after obtaining comments from the participants and speakers. The final Strategic Framework and Road Map for Building Resilience of Communities in Sundarbans 2025-2050 shall be submitted to Central and State Government for necessary follow up action.

***Swami Shastrajnanandaji*,** Secretary Ramakrishna Mission Ashrama, Narendrapur extended his respectful greetings to the dignitaries and highlighted the extensive involvement of the Ramakrrishna Mission in relief, rehabilitation and development activities in the Sundarbans, mentioning the work done through the joint forest management project and the Jan Shikshan project. *Swamiji* shared his firsthand experiences of visiting vulnerable islands such as G plot, Mousuni, Bali, Gosaba, and Satjelia, emphasising the immense crisis faced by the local population. *Swamiji* expressed his strong belief that

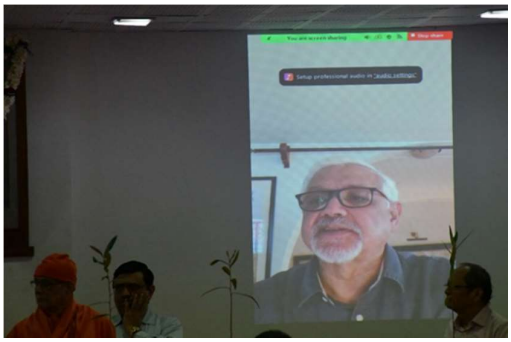
such an international symposium would be instrumental in identifying sustainable solutions and roadmaps to improve the living conditions of the marginalized communities in the Sundarbans. He acknowledged the region's challenges, including its geographic isolation, economic struggles, and cultural vulnerabilities. He pointed out the existing gap between academic research and practical realities, and hoped that the symposium would create a platform for academicians, practitioners, and activists to engage in meaningful discussions, share experiences, and bridge the divide between theoretical research and on-the-ground application. In conclusion, *Swamiji* conveyed his optimism that the discussions and interactions at the symposium would shed new light on sustainable development strategies, ultimately leading to improved living conditions for the Sundarbans' vulnerable communities. He concluded his speech with warm regards and best wishes for the success of the symposium.

Professor Amitava Datta**,** the Pro-Vice Chancellor of the Jadavpur University Kolkata, highlighted the multifaceted challenges faced by the Sundarbans and their communities a*nd* emphasised the importance of interdisciplinary approach in addressing the complex issues of the Sundarbans. He made a mention about Jadavpur University's long-standing commitment to interdisciplinary research, tracing back to the 1980s when the institution established various interdisciplinary schools. Today, the university houses 21 such schools under the Faculty of Interdisciplinary Studies, actively engaging in diverse research domains, including oceanographic studies with a strong focus on the Sundarbans. *Professor Datta* also spoke on the significance of the Sundarbans, the world's largest mangrove forest, situated at the confluence of the Ganga, Brahmaputra, and Meghna rivers, playing a critical role in ecological balance. *Professor Datta* pointed out that the mangroves act as a significant carbon sink, mitigating environmental degradation. However, the fragile ecosystem and the 2.5 million people residing in the region face mounting challenges due to climate change and human activities. In his speech, *Professor Datta* distinguished between

growth and development, underscoring that true development should always be positive. Historically, development was measured through economic indicators, but modern approaches incorporate human development indices, including education and health. The focus has now shifted towards sustainable development, ensuring that economic progress does not come at the cost of environmental degradation and that future generations can thrive in harmony with nature.

Professor Datta elaborated on climate change and its impact by highlighting the severe effects of industrial development over the past two centuries, particularly its contribution to climate change. He highlighted alarming trends, such as the last decade being the warmest on record and global temperatures dangerously close to the 1.5°C threshold set by the Paris Agreement of 2015. Rising sea levels, frequent tropical cyclones, and other climate-induced adversities have made the Sundarbans one of the most vulnerable regions globally. Concerning the need for policy interventions and research, *Professor Datta* stressed the necessity for rigorous research and well-formulated policies to mitigate the challenges faced by the Sundarbans. He called for collaborative efforts among researchers, policymakers, and NGOs to develop resilient strategies for the affected communities. The symposium's interdisciplinary nature, bringing together 55 speakers over three days, was recognized as a crucial step toward formulating a roadmap for sustainable development in the region. In his concluding remarks, *Professor Datta* expressed confidence that the symposium would foster meaningful discussions and generate actionable insights for enhancing the resilience of the Sundarbans communities. He extended his best wishes for the success of the event and hoped that participants would derive valuable takeaways from the deliberations.

Dr. Amitav Ghosh*,* a renowned author and recipient of the prestigious Jnanpith Award, delivered a compelling video address at the International Symposium on the Sundarbans. He underscored the ecological significance of the Sundarbans and the urgent need to address the pressing environmental and socio-economic challenges facing the region. *Dr Ghosh* highlighted that the Sundarbans, located at the confluence of the Ganga, Brahmaputra, and Meghna rivers with the Bay of Bengal, is the



world's largest contiguous mangrove forest. The region serves as a crucial ecological buffer, sustaining both biodiversity and human settlements. However, it is now on the brink of an existential crisis due to environmental degradation, rising sea levels, and extreme weather events exacerbated by climate change. *Dr Ghosh* emphasized that over the past two centuries, the Sundarbans has witnessed significant land loss, with communities reliant on subsistence farming, fishing, and forest products struggling against poverty, displacement, and the increasing risks of climate-induced migration. Despite numerous efforts by governments and organizations, these challenges persist, often due to fragmented approaches that lack a comprehensive, multi-sectoral strategy.

He lauded the objectives of the symposium to bridge these gaps by facilitating discussions on the physiographic, climatic, social, economic, and environmental transformations impacting the Sundarbans. *Dr. Ghosh* stressed the importance of ecosystem-based, scientific, and community-driven solutions that are sustainable, cost-effective, and inclusive. A key highlight of *Dr. Ghosh's* address was the emphasis on integrating indigenous knowledge with modern technological innovations. He mentioned that the local communities of the Sundarbans have long adapted to nature's rhythms, developing invaluable traditional wisdom and coping mechanisms that could play a significant role in climate adaptation and resilience-building efforts. *Dr Ghosh* called for the development of a comprehensive roadmap aimed at reducing disaster risks, adapting to climate change, enhancing livelihoods, and eradicating poverty. He insisted that this strategy must be gender-sensitive, inclusive, and actionable across short, medium, and long-term horizons. In closing, *Dr Ghosh* expressed his hope that the Symposium would foster collaboration, dismantle existing silos, and co-create innovative solutions that honour both the ecological uniqueness of the Sundarbans and the resilience of its people. His address served as a clarion call for urgent and coordinated action to safeguard this critical region and its communities for future generations.

In his thought provoking address, Chief Guest, **Shri Atri Bhattacharya, Additional Chief Secretary, Sundarban Affairs Department, Government of West Bengal** highlighted the complexities of balancing environmental sustainability with human development in the Sundarbans and emphasized the need for a collaborative approach to address the region's pressing challenges.

He acknowledged that, as a bureaucrat, he did not claim to be an expert on the subject but greatly valued the interdisciplinary discussions and perspectives brought together by the symposium. He expressed his appreciation for the efforts of the organizers for curating an event that comprehensively covered the key issues affecting the Sundarbans. He said that the primary challenge facing the region is the conflict between human activity and nature, when humans tried to dominate over the nature and is now facing the backlash from the nature. He referenced a 2014 World Bank report that proposed evacuation of vulnerable blocks in the Sundarbans due to rising sea levels and climate change-induced disasters, such as frequent cyclones. However, he recalled that human habitation in the region dates back to at least the 4th century AD, and now nearly five million people live Indian Sundarbans, making it impractical to consider a complete withdrawal of human presence from the area. *Shri Atri Bhattacharya* emphasized that the Sundarbans issue is not just a local or national concern but an international one, given that the region spans two countries — India and Bangladesh. He acknowledged the complexities of international relations that impact cooperative conservation efforts, referencing the geopolitical tensions and trade dynamics between the two nations. He stressed that without collaboration, sustainable solutions for the Sundarbans would be difficult to achieve. *Shri Atri Bhattacharya* pointed out the alarming reduction in mangrove forest cover, which raises critical questions about the balance between nature and human encroachment. He posed an important question: Can the Sundarbans serve as a pilot case for global studies on balancing ecological preservation with human development?

While discussing development projects in the region, he cautioned against large-scale infrastructural interventions, particularly concrete bridges, which could disrupt the hydrology of tidal rivers. He emphasized the need for alternative solutions such as floating pontoons and roll-on/roll-off vessels, preferably powered by electric propulsion, to minimize environmental impacts. He acknowledged that the region's economic disparities contribute to environmental degradation. While most residents of the Sundarbans are impoverished, a small, affluent segment exploits the region's resources for commercial gain. He stressed that governance

must focus on regulating greed-driven exploitation while supporting developmental needs that benefit the broader community. He also highlighted the risks faced by local communities, particularly those dependent on forest resources. He shared a tragic example of a woman who lost her son to a tiger attack, underscoring the challenges of human-wildlife coexistence in the region. With the Sundarbans tiger population increasing despite various threats, he questioned how the region should approach habitat management while ensuring community safety.

Shri Atri Bhattacharya voiced his opposition to mass tourism in the Sundarbans, citing concerns about pollution and ecological degradation caused by excessive human activity. Instead, he advocated for high-end, controlled tourism models that generate revenue while minimizing environmental harm. Concluding his address, *Shri Atri Bhattacharya* expressed his eagerness to see actionable solutions emerge from the symposium. He stressed that research papers and discussions should lead to concrete policy recommendations and implementation strategies. He reaffirmed his commitment to attending the closing session and hoped that the event would produce a roadmap for sustainable development and resilience in the Sundarbans.

Swami Atmapriyanandaji, Pro-chancellor of Ramakrishna Mission Vivekananda Educational and Research Institute delivered the presidential address at the symposium, emphasizing the need for peace, environmental harmony, and the integration of knowledge across disciplines. His speech touched upon the philosophical foundations of learning, the balance between nature and humanity, and the vision behind the establishment of educational institutions inspired by Swami Vivekananda. The address began with the recitation of the Shanti Mantra, invoking peace across the universe. *Swamiji* highlighted the interconnectedness of all elements in nature and the necessity of maintaining harmony for sustainable living. He emphasized that ancient Indian traditions viewed knowledge as indivisible and holistic, an approach that remains relevant today. *Swamiji* elaborated on the modern academic trend of interdisciplinary research, pointing out that ancient Indian philosophy inherently followed a holistic approach to knowledge. He advocated for a systems-based perspective, where knowledge should not be fragmented into isolated disciplines but seen as interconnected and interdependent.

A core theme of the address of Swami Atmaprityananda was the conflict between human

development and nature. *Swamiji* criticized the tendency of humanity to consider itself superior to nature, leading to environmental degradation. Using the COVID-19 pandemic as an example, he explained how nature has its ways of teaching humility to mankind. He also cited Alfred Hitchcock's film *The Birds* as an allegory for nature striking back when humans fail to respect it. *Swamiji* emphasized the importance of gratitude towards nature, urging people to respect trees, rivers, and other natural elements. He warned that continued environmental neglect would lead to severe consequences, describing nature as a force that, if disrespected, would retaliate forcefully. He called for proactive cooperation with nature rather than a reactive approach after disasters occur. Drawing from scientific theories and historical anecdotes, *Swamiji* discussed the importance of both theoretical and practical knowledge. He referenced Albert Einstein's theory of relativity, the emergence of probability theory, and the debates between deterministic and probabilistic models in physics. He linked these scientific advancements to Indian philosophical concepts, reinforcing the idea that knowledge is a dynamic and evolving entity. *Swamiji* addressed the increasing role of artificial intelligence and its impact on education, discussing concerns about reliance on AI-generated content. He noted that while technology brings advancements, it should not replace fundamental human intelligence and critical thinking. *Swamiji* also recounted Swami Vivekananda's vision for education, emphasizing its purpose in empowering the underprivileged and addressing 'gap areas' often overlooked by conventional universities. He outlined five key thrust areas of this university which are Indian heritage and cultural studies, Mathematical and physical sciences, agricultural, rural, and tribal development, environmental and disaster management, and emerging fields such as artificial intelligence and medical biotechnology. He underscored the need for translational research, ensuring that academic findings directly benefit society. *Swamiji Maharaj* appealed for sustained financial and administrative support for research in environmental and disaster management. He urged government and institutional leaders to recognize the importance of these disciplines and invest in their long-term sustainability. Swami Atmapriyananda concluded his address with a call to embrace purity, patience, perseverance, and love in all

endeavours. His speech served as a profound reflection on the interconnectedness of knowledge, the responsibilities of humanity towards nature, and the role of education in shaping a sustainable and ethical future.

Prof. Tuhin Ghosh**,** Dean, Faculty of Interdisciplinary Studies, Law and Management and Director, School of Oceanographic Studies, Jadavpur University delivered the vote of thanks, acknowledging the invaluable contributions of various stakeholders who played a crucial role in making the event successful. His speech reflected gratitude towards the dignitaries, organizers, participants, and support staff. *Prof. Tuhin Ghosh* began by expressing deep appreciation to the Indian Council of Social Science Research (ICSSR), the Government of India, and the Sundarban Affairs Department of the Government of West Bengal for their support. He extended sincere thanks to all keynote and other speakers for their valuable time, effort, and insightful contributions. Their presence and expertise greatly enriched the discussions. He also recognized the faculty members of Ramakrishna Mission Vivekananda Educational and Research Institute for their tireless efforts in ensuring the event's success and alignment with its objectives. *Prof. Tuhin Ghosh* expressed admiration for the discipline and sincerity of the student volunteers, stating that their hard work was commendable. He also appreciated the enthusiasm of registered participants who joined despite limited promotional outreach, demonstrating their keen interest in the subject matter. Special acknowledgement was given to the support staff, including those managing the logistics, hall arrangements, canteen, and other essential services. Their dedication ensured smooth operations throughout the symposium. *Prof. Tuhin Ghosh* concluded by thanking everyone for their active participation and announced a lunch break before the next session scheduled at 2 PM. His vote of thanks served as a heartfelt recognition of collective efforts in making the symposium a meaningful and impactful event.

Compiled by
Sujan Mandal, PhD Scholar
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Session-2:

Physiographic Challenges in Sundarbans: Sedimentation, Erosion and Subsidence

The session was chaired by Dr. Tuhin Ghosh Dean, Faculty of Interdisciplinary Studies, Law and Management and Director, School of Oceanographic Studies, Jadavpur University. He briefly introduced the theme of the session – the triple physiographic challenges of sedimentation, erosion and subsidence - and further introduced the Keynote and other speakers of the session.

The Keynote Address was delivered by **Dr. Kalyan Rudra, Chairman of the West Bengal Pollution Control Board.** A well-known authority on river and water management and author of the celebrated publication, Rivers of Ganga Brahmaputra Meghna Delta: A Fluvial Account of Bengal, Dr. Rudra explained the marine process by which the GBM delta witnessed significant reduction in flow of water and sediments, leading to erosion of deltaic islands. Eleven estuaries of the delta are 'beheaded' as flow of water from the upper to the lower delta have been badly affected by various upstream projects. Hence there is an urgent need to address these critical issues and augment the flow of water into the estuaries to save the delta. He carried an in-depth discussion on mitigation strategies for restoration of the delta, focusing specifically on the issues of strengthening of the embankments and sea dykes.

Strengthening the Embankment or Lifeline:

It is observed that 90% stretches of embankment in Sundarban, are low-height earthen structures having crest width around 2.5 m. to 3.5 m. and elevation of 2.5 to 3 m. above existing ground level. Though constructed within intertidal space, these embankments can sustain the impact of normal tides but face overtopping in case of high waves during severe

cyclones. Such overtopping causes washing out of the upper part of embankments, ultimately leading to breaches and total collapse. The collapse of embankments due to under-scouring along the concave banks is also common. The impact of waves is more dominant along concave banks where there is no mangrove on inter-tidal spaces, which could at least absorb a part of the kinetic energy of the rolling waves. On the other hand, about 364km long armoured embankments have crest width around 3.5 m. to 4.5 m. and a height of about 4.5 m. to 5.0 m. above existing ground level. The embankment is built up by the earth but has a bigger base width and quite flat riverside slope (at 18º or even less). The slope is protected /armoured by concrete or brick block pitching to resist the impact of the breaking waves. Quite often the frontal *char* is protected or widened by deflectors and other anti-erosion devices, mostly bamboo cubicles with protrusions, known as porcupines, filled up with bricks to add weight. These types of embankments have successfully resisted overtopping and failure during "Amphan" as well as "Yaas" in the entire area across Sundarban. However, these are quite cost prohibitive (around Rs 14 crore per km. for river embankment) and require at least 20m -25m of additional private land in the countryside. The irrigation and Waterways department has identified 378 stretches of different rivers having a total length of 559 km. as vulnerable, of which 207 stretches having a total length of 324 km. as extremely vulnerable. These are mostly east-facing concave banks which should be taken care of as top priority.

Sea-facing Dykes:

In the 30km.long sea front of four inhabited islands (Sagar, Moushuni, Bakkhali-Namkhana and G-plot), reinforcement of the existing embankments with concrete and their protection with thoughtfully planned vegetative buffers should work well to prevent overtopping of storm surges. It is also important to put two parallel dykes with cross-embankments put at regular intervals between them to prevent widespread flooding of the interiors in the event of beaching or wave-overtopping of the outer embankments. If the frontal old embankment is located along the High Tide Line (HTL), the buffer area between the old and new dykes may ideally be 200 m.. It should be declared as 'no construction zone' in compliance with the Coastal Zone Regulation (2019).

In this context the proposal of IIT-Madras for constructing reef barriers off the southern front of the islands may be reviewed. It may be placed 150-200 m. away from the LTL at a depth of 2.30 m. expected to act as wave breaker and reduce intensity of erosion. This may be

proposed as a pilot project along the southern front of Sagar island and if found to work well, it would be replicated elsewhere.

Mitigation Strategies:

Strengthening of embankments could be a way forward to mitigate this damage and deal with the overtopping. The concrete reinforced embankments with vegetative buffers were recommended to safeguard the region. In addition, construction of two-parallel dykes with cross-embankments might reduce the chances of flood occurrence. To comply with the regulations, establishment of a "no construction zone" of 200 meters between the old and new embankments was recommended. A pilot project on establishment of reef barriers to minimize erosion was proposed by IIT-Madras on the southern front of Sagar Island. Based on the effectiveness, the approach might be guiding to safeguard other parts of areas.

The second speaker of the session was **Dr. Ramkrishna Maiti, Professor, Dept. of Geography, Vidyasagar University, Midnapore**, He spoke on the theme Alteration of Estuarine Processes: Tidal Asymmetry and In-channel Sedimentation.

Dr. Maiti, highlighted on historical to present time intertidal mangrove reclamation in Sundarban. This indicated that the process of reclamation has influenced natural tidal systems, increasing river sedimentation, decaying of drainage, and flood vulnerability. He

further narrated that this process has heightened the coastal erosion, along the mangrove occupied islands, caused by sediment reduction. The Dam construction has impacted reduction in sediment supply from Hooghly River and its tributaries, sea level change, and subsidence. Hence, the reduction of sediment could potentially disturb the stability of Ganga-Brahmaputra delta in near future.

Colonial rulers started mass-scale reclamation of intertidal areas of mangroves, although there is evidence of early history of human habitation in Sundarbans since ancient period. Mr. Claude Russel, Collector General and Tilman Henckell, the then Judge and Magistrate of Murli (Jessore) took initiatives for massive reclamation and granting lease to the zamindars

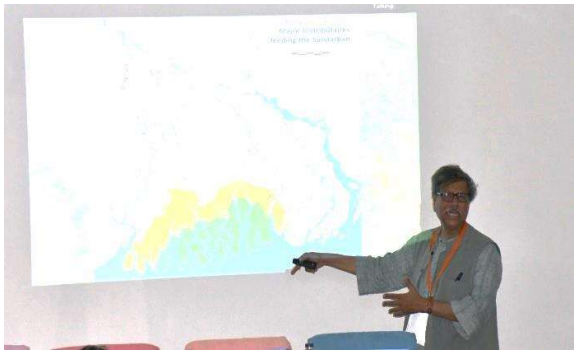
during 1770-1793 and 1783-1784 respectively. The process continued till the 1970s, although pace of reclamation varied. Intertidal lands are reclaimed by construction of embankments along tidal creeks and clearance of mangrove from the enclosed area. No central regulations or instructions are followed in construction and maintenance of embankments as grantee zamindars performed these according to their own convenience.

Under the natural system, before reclamation, flood tide used to engulf the intertidal areas covered with dense mangrove that might have retarded the tide propagation velocity due to high shearing resistance. Ebb tide became swifter and powerful as water drained downslope following gravity. Ebb-dominated estuarine processes prevailed, where tidal channels remained hydrologically fit and free from sedimentation.

By reclamation, tidal creeks are excluded from their large intertidal areas and are walled within the embankments, constructed along both the sides. Both water and sediment concentrate along the channel. Depth of water within the channel increases which results in higher and swifter flood tide. Absence of shearing resistance from the mangrove of intertidal area also contributes in swifter flood tide. This ultimately leads to tidal asymmetry characterized by swifter and shorter flood tide and longer as well as slower ebb tide. Earlier ebb-dominated estuarine system is altered to the flood dominated one, contributing to in-channel sedimentation and drainage decay. Intensity of tidal asymmetry increases towards the interior part of Indian Sundarbans (Chatterjee et al. 2013). Gradual decay of the interior tidal creeks prompts local people to occupy them for fisheries and crop cultivation. Thus, most of them are excluded from the estuarine system. Exclusion of large numbers of interior creeks and huge parcel of intertidal land (tidal spill area) ultimately reduces the water-holding capacity of the entire estuarine system which enhances the vulnerability to overtopping and saline flood. Spatial distribution of the erosion-accretion in the Indian Sundarbans shows a consistent trend of accretion in the interior (northern) portion, and prominent propensity of erosion along seaward margin of islands. Surprisingly, rate of erosion is high along the islands that are under thick mangrove cover (Bera and Maiti, 2019, 2021). Bandyopadhyay et al. (2023) found that rate of erosion in the islands of Indian Sundarbans is 2.55 times more than the eastern islands of Bangladesh. Bera (2021) found that suspended sediment at the Hooghly estuary is remarkably low at the southern front but high in the interior section between Nayachar and Sagar islands. Suspended sediments are pushed inside the channel due

to stronger flood tide. Even sediment supply from the Chhota Nagpur plateau by the right-hand tributaries of Hooghly is reduced as sediment and water are trapped in the numbers of large dams constructed for flood management and irrigation. Hooghly river and its tributaries cannot supply the sediment required to compensate for the sea level rise and land subsidence and so this sediment deficiency along the southern front leads to severe erosion in the islands of Indian Sundarbans. A recent work by Raff et al. in 2023 shows that at present Ganga-Brahmaputra delta receives 1100 Mt of sediment per year which may rise to 1624 Mt/yr by 2100 due to intensification of monsoon. If all the proposed structural intervention like large dams and river linking projects of upper riparian countries are complete, this supply may reduce to only 85 Mt/yr. For maintenance of the delta and to compensate projected sea level rise (8.5 mm/yr) and subsidence (3 mm/yr) total requirement of sediment may rise to 2363 Mt/yr; resulting in a net deficit of 2278 Mt/yr. This huge amount of sediment deficiency might be a serious threat for the sustenance of Ganga delta in near future.

Dr. Sunando Bandyopadhyay, Professor, Department of Geography, University of Calcutta, Kolkata spoke on the theme 'Island Area Change: Patterns, Trends, and Processes'.



Dr. Bandyopadhyay's extensive research on the dynamics of the Sundarban delta over the years is clearly directed towards the need for developing management possibilities thorough observation and understanding. He stated that about 5.5 million people, annually growing by 1.8% (2024 estimate based on Census of India data), reside in 19 Community Development Blocks of the Sundarban Biosphere Reserve. This population faces diverse types of natural hazards — sea level rise, storm inundation, saline intrusion, channel sedimentation, and coastal erosion — which stand to aggravate with global warming. Addressing these problems in the coming decades is a challenge to the authorities and organisations working in the Indian Sundarban.

He made an elaborate presentation on the geomorphic problems of the Indian Sundarban and the possible management approaches for addressing the problems, which is presented the

table below. Many of these issues are beyond prevention, which need to be adequately recognised and incorporated into future planning for the region.

Geomorphology-related Problems of Sundarbans and Management Possibilities

Observations	Management possibilities
All mid-delta distributaries of the Ganga flowing between the Bhagirathi–Hugli and the Baleswar are degenerated (delta abandonment), cutting off sediment supply to the Sundarban	Cannot be prevented unless large-scale resuscitation akin to the Farakka Barrage Project is undertaken – highly unlikely
All southern islands on the western Sundarban seaface are eroding laterally – up to 40 m/yr – a trend that continued from the 19th century. REASON: Delta abandonment and diversion of the westward transportation of the Meghna sediments by the Swatch of No Ground Submarine Canyon + relative sea level rise (includes subsidence).	Cannot be prevented and does not depend on reclamation / deforestation. Mangrove regeneration cannot prevent coastal or bank erosion and cannot be undertaken in eroding stretches of the coast. Their value lies in ecological services and as storm buffers.
Rates of relative mean sea level trends along the estuaries range between 1.2 and 6.3 mm/yr with an absolute rate of 3.9 mm/yr in the off-shore. Rates of high water level (called effective sea level) rise are up to 15 mm/yr in some sections.	Somewhat preventable through tidal river management
In the interior (often reclaimed) portions of the coastal delta, creeks are getting silted. REASON: Flood-dominated asymmetry in tidal currents: High northward speed but noticeably slower southward speed.	Creek sedimentation is partly reversible through tidal river management.
Surface accretion is occurring at rates up to 10 mm/yr (up to 180 mm/yr in sediment-	Vertical accretion is welcome and yields long-term dividends, preventing relative

starved reclaimed regions).	mean sea level rise — a case for tidal river management.
Tropical storms are likely to get more intense in future.	Controlled retreat from island edges may be considered.

In India and Bangladesh, Sundarban mangrove wetlands are exposed to multiple natural threats that include sea level rise, storm surges, saline intrusion, sediment build-up, and coastal erosion. These could be adversely impacted due to global warming. Appropriate management planning is required to minimize these impacts of the hazards. This could be formulated based on observed trends on geomorphic change and in the region. In addition, human induced changes should be taken into consideration to maintain harmony between the needs of humans and nature. Also, the human induced ecosystem changes and balancing the natural environment with its people would aid the future planning in this region.

Future planning for the Sundarban region must acknowledge the human-driven changes to the ecosystem and find a way to balance the needs of nature with those of its people. While relocating the most vulnerable populations to safer, interior areas or high-rise buildings may be feasible for certain parts of the reclaimed Sundarban, it is not a viable solution for larger regions. A phased approach to tidal river management, along with strategies like controlled retreat for mangrove buffer creation and adaptive farming practices, will be crucial in enhancing resilience to challenges. Joint forest management has proven successful in protecting the Sundarban mangroves by generating income for local residents. Similarly, the success of measures to combat global warming-related challenges can be increased if they include incentive-based approaches. However, in contrast to coastal Bangladesh and Odisha, people in the Indian Sundarban are often hesitant to leave hazard-prone areas due to the government support they receive while staying despite the risks. The ability to cope with natural hazards often depends on economic strength and development. It is anticipated that population pressure in the Sundarban will ease in the coming decades as the region develops and the population growth rate declines.

The plausible *long-term* solution to the hazards probably lies in a balanced socio-economic development of the Sundarban region — this alone can provide a sustainable possibility by cutting birth rate, elevating standard of living, and rationalising resource allocation.

Dr Ashis Kumar Paul, Professor (retd), Department of Geography, Vidyasagar University, Midnapore spoke on the theme 'Land subsidence - contributing factors and remedial measures'. Dr. Paul elucidated that both natural and manmade factors are contributing to the increasing land subsidence in Sundarbans. Sea level rise is further compounding the subsidence threatening the settlements in the region. This could influence relocation of the people from this region in near future. Hence, Dr. Paul suggested the probable measures such as; groundwater recharge, tidal river management, mangrove protection, and climate-resilient infrastructure development.

Today the delta dynamics of the lower Ganga plains are impacted by interactions and interplaying between energy drivers, processes, material supply, human controlled river discharges, and the effects of premature land reclamations in the Sundarbans. The System of ocean dynamics, shoreline morphodynamics, tidal hydrodynamics, estuarine morphodynamics, fluvial marine dynamics, and fluvial dynamics are not only interacting and interplaying between them but also influenced by sea-level rise threats, climate change induced coastal hazards, changing wave climate regimes, and human impacts in the forms of reduction in sediment supplies and reduction in tidal spill grounds of the deltaic region. As a result of such above controlled factors the lower Ganga delta and Sundarbans have become the complex system of sedimentary depositional environment in which the spatio-temporal changes of sedimentation rates, erosion rates, and land subsidence rates are represented.

The land subsidence rates are varying in the physiographic regions of i) the inner delta plains, ii) the reclaimed Sundarbans, iii) the open tide lands of the mangrove swamps, iv) the estuaries and large tidal rivers, and v) the subaqueous parts of the delta using satellite derived data (Sentinel-1 A SAR C band data) of 2014 and 2022, considering the multiphase components at two different time phases with application of algorithms, and spatial modelling techniques the land subsidence rates are estimated for the south west Sundarbans in the present work. The contours of land subsidence rates are varying in 2014 and 2022 at different physiographic regions of the Sundarbans depicted by the study. The rates are ranging from 2.63 mm/yr to 6.9mm/yr and shifting from place to place over the time. As the

sea-level rise rates are varying from 3.47mm to 4.37 mm per year in the northern Bay of Bengal, and the land subsidence rates are added with them the relative sea-level rise rates will be increased from 6mm to 11mm per year.

Topographic surface depressions are generated due to land subsidence rates in the reclaimed tracts of the Indian Sundarbans (Sagar, Namkhana, Kakdweep, Pathar Pratima, Basanti, Gosaba, Sandesshkhali, Hingalganj, Hasnabad blocks) which are assessed by considering the SOI Toposheet BenchMarks (1969-72) and comparing with the inundation zones of post cyclonic phases (2009, 2019, 2020, 2021) of the coastal administrative blocks (Sentinel-1A SAR). The sedimentation rates are measured in the sections of Hugli estuary (1972-2011) in open tide lands (1985-2020), and also in the sub aqueous parts of delta (1972-2013). Results of the study showed that land subsidence rates are compensated by the high rates of sedimentation only in the subaqueous parts of the delta, estuarine beds, and open tide lands of the Sundarbans. As the spill grounds of tides are protected by the embankments and the sedimentation is well managed in the polderized islands by the defence structures and sluice gates since initial phase of land reclamation history (1810-1863) in the northern fringe and southwestern fringe of the Indian Sundabans, the land subsidence rates are reflected in the topographic expressions. Such topographic lows were inundated by the coastal floods after the landfalls of previous cyclones (2009, 2019, 2020, 2021) and associated tidal surges,
The contributing factors of such land subsidence rates are categorized into natural and human controlled factors in the region assessed by the study. Automatic compaction of sediment layers below the surface, impacts of seismo tectonic activities between the hinge line and thrust belt tectonics of the Bengal basin, isostatic adjustment between the erosional unloading, and depositional loading processes in the delta, and variation in bulk density of the sediment layers as per the texture and organic matter content within the sediments are considered as natural factors of land subsidence rates. However, human factors like over extraction of the ground waters from the aquifers, land reclamation process over a time in the premature sedimentary depositional land surfaces, and the results of landuse land cover changes in the reclaimed tracts. The land subsidence rates of 18 places by the model study using satellite derived data are correlated with other studies by geologists, archaeologists, chronology research of the Sundarbans for validation of the present study.

Further, considering the relative sealevel rise rates (RSLR) of the region, and the RCP phase 4.5 (predicted by the IPCC) of 1m sea level rise rate the total numbers of displaced people are estimated by the study. About 28,000 people will be displaced from the shore fringe settlements of Sagar, Namkhana, Kakdweep, and Pathar pratima blocks by the year 2050 in the Sundarbans.

The subsidence induced slumping scars are well developed across the mangrove dominated islands, and (Bullchery, Dhulibasanti, Halleyday, Gobardhanpur) as a result of the concentration of hydraulic energy into the slumping scars during surge tides and storm surge conditions the chunks of lands are getting submerged and eroded at a faster rates in the region of shore fringed and estuary fringed-mangrove dominated islands.

The solutions are recommended to reduce the risks of land subsidence rates in the Sundarbans:

i) Developing awareness among the people to reduce the drawdown activities from the groundwater aquifers for irrigating winter rice paddy lands;

ii) Uses of abandoned wells and injecting wells for recharging ground water in the monsoon months;

iii) Rainwater harvesting practices in the abandoned river beds, village ponds, other topographic depressions.

iv) Tidal rivers management (TRM) in the inner deltaic islands by constructing underheight embankments to allow the tide waters enter for accepting sedimentation rates;

v) Mangrove plantation mission to be introduced in the open tidelands with monitoring survivability rates and attracting community participation in this purpose by promoting NGOs activities.

vi) The 25 years of vision plan is to be formulated in consideration with the sources of funding, incentives to the villagers for their direct participation, environmental right of the landscapes, promoting micro economy and related activities, finding the higher grounds for future rehabilitation of displaced people, carbon trading by large scale mangrove plantation in the open tide lands, increasing supply of fresh water sources into the mangrove ecosystem, storm proof housing structures, climate resilient embankment structures around the estuaries and the shore fringe areas; introduction of salt resistant crops, livelihood security of the marginal

people in disasters affected areas, development of ecological buffers at coastal blocks etc

Dr. Debajit Datta, Department of Geography, Jadavpur University, Kolkata spoke on the theme Reviving the Mangroves in the Inhabited Islands of Indian Sundarbans. Dr. Datta presented his extensive research on Sundarban mangrove to convey that there is an urgent need to restore village-fringe mangrove. He highlighted the requirement for ecological rehabilitation, sustainable resource management, and economic incentives like eco-tourism. He further stressed on collaborative initiatives involving local communities, government bodies, and environmental organizations for building long-term resilience for safeguarding ecosystems and people.

Decades of unsustainable resource utilization practices and alterations in hydro-geomorphic conditions have made the village-fringe mangroves of Indian Sundarbans ecologically fragile. This is further accelerated by augmented conversion and expansion of agricultural as well as aquacultural plots, beside storm surge-induced wash-outs and fragmentation owing to unregulated extraction of mangrove wood. Moreover, the rising sea levels initiated by climate change have led to salinity intrusion, thereby modifying habitat conditions and threatening the ecosystem's flora and fauna. This eventually has degraded the structure and composition of village-fringe mangroves, which often act as crucial bio-shields against tsunami waves, coastal storms, and tidal surges. In addition, mangroves have been recognized for improving water quality by filtering pollutants and trapping sediments. Nevertheless, such services have been gravely affected by continuous diversion of mangroves leaving the villages vulnerable to coastal erosion and storm surges. This, in turn, calls for an urgent need for revival of these ecotonal interfaces.

In this context, priority should be given to the ecological restorations whereby achieving structural complexity in the newly planted or restored mangrove sites having multi-species stands. Consequently, site-specific introduction of suitable seedlings may be executed to regulate the protective, habitat, and economic functioning of these village-fringe mangroves. These can be conducted in addition to the existing plantations of native mangrove species like

Rhizophora varieities, *Bruguiera gymnorhiza*, and *Avicennia* varieties, which are well-adapted to local conditions. Besides, a participatory approach that engages local communities in the restoration process may also be incorporated to ensure sustainable management and stewardship of these ecosystems, thus enhancing the overall success of revival efforts. Identification of actual causes of mangrove degradation at a site, selection of appropriate rehabilitation sites, arrangement of suitable seedlings and timely planting, regular monitoring of the outcomes and continuous protection, restricting small-scale logging and thinning until completion of gestation period and regeneration of characteristic biodiversity, prohibition of the ecologically harmful activity of prawn seed collection in mudflats would be some of the prime requisites for sustaining the plantations.

Furthermore, the multi-faceted economic benefits of mangrove plantations should be strengthened, especially in terms of Non-Timber Forest Products (NTFPs) and eco-tourism opportunities. The most marginalized sections of the rural communities in the Sundarbans still rely substantially on mangrove resources for their livelihoods, including harvesting fish, honey, small-log, and other NTFPs; legally or illegally. The revival of mangroves would enhance these resources, providing more sustainable income streams. Facilities of river cruising and canopy walks amidst mangroves can also be initiated. Additionally, coastal trekking can be promoted as an emerging form of eco-tourism that offer new opportunities for the local economy while simultaneously fostering awareness about the importance of mangrove conservation.

Besides, effective mangrove restoration requires collaboration between local communities, government bodies, and environmental organizations. Traditional knowledge of the local people, coupled with scientific expertise, can lead to the development of tailored restoration strategies. Institutional support is necessary for monitoring and enforcing protection regulations, ensuring the sustainable use of resources, and providing financial incentives for conservation. Furthermore, local community involvement in decision-making processes ensures that revival efforts align with their needs and priorities, increasing the likelihood of long-term success. In this regard, it is important to note that the initial euphoria among local communities often wither away after withdrawn of external assistance or funding. Many times, community institutions fail to keep themselves active amidst resurfaced intra- and inter-community conflicts. Hence, keeping provisions in regeneration project proposals for monitoring and intervention even after the completion of assistance/ aiding periods would be

a judicial strategy to tackle these issues. In addition, protection of customary and ethical rights of local communities regarding access to mangrove resources is also of paramount importance.

Hence, revival of mangroves in the inhabited islands of the Indian Sundarbans requires a customized, multi-dimensional approach. There is no single solution or panacea to address the complex ecological, economic, and social challenges involved. A combination of ecological restoration, economic incentives, and institutional support, alongside active participation from local communities, will ensure the success of these restoration efforts. By tailoring solutions to the unique conditions of each island and community, mangrove ecosystems can be revived to support both environmental and human resilience.

Dr Abhijit Mitra former Professor and Head of Marine Science Department of Calcutta University and Director Research of Techno-India University Kolkata could not be physically present to speak on the theme of 'Changing expanse, depth and quality of mangroves of Sundarbans'.

The five presentations were followed by an interactive session among the speakers and with the audience. It was noted that many of the physiographic changes in the Sundarbans are beyond redemption, but it is possible to take remedial measures through an appropriate mix

of hard and soft engineering and management measures to facilitate nature to reclaim some of its losses. In this context the following

- There is an urgent need for developing strategic thinking for policy development with practical implementable solutions
- Management of intertidal space of the rivers for effective dispersal of sediment and building of embankments along the low tide line are the key strategic solutions.
- Upper and lower delta should be connected to increase the flow of water and sediments into the Sundarban estuary.
- Surplus water from Bangladesh Sundarban can be transferred to Indian Sundarbans to simultaneously address the problems of flooding in Bangladesh and salinity and sedimentation in India
- The subsidence rates can be partly offset by enhancing the siltation rate by better management of intertidal zones.
- Sediments can be trapped through various innovative techniques and management measures
- Multi-pronged strategies should be adopted for strengthening embankments and sea dykes through the combination of structural and non-structural measures including bio-engineering solutions
- Forest Department, Irrigation Department. Sundarban Development Board, Disaster Management Department, Public Health Engineering Department, Environment Department, Inland Navigation, and Panchayat should work together under a central authority to save the Sundarban.
- There is a requirement for adaptive measures for the people to adjust with the changing situations. The issues regarding the housing structure, livelihood characteristics, and man-environment harmony need to be addressed
- Also there is need to locate higher grounds where displaced people will be required to be rehabilitated in near or distant future

Compiled by
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Session-3:
Living with Risks: Natural Hazards and Human Vulnerabilities

The session was Chaired by Dr P G Dhar Chakrabarti Swami Vivekananda Chair Professor and Head of the School of Environment of Ramakrishna Mission Vivekananda Educational and Research Institute. He introduced the theme of the session by giving an overview of the layers of hazards, vulnerabilities and exposures of Sundarbans that are compounded by the climate change to create complex risks of disasters. He introduced the Keynote and other speakers of the session and mentioned that Dr. Jenia Mukherjee, Associate Professor, Humanities and Social Sciences, Indian Institute of Technology, Kharagpur who was supposed to speak on Social and economic vulnerabilities of Sundarban islands could not be present due to bereavement in the family.

The Keynote address was delivered by **Dr. Tuhin Ghosh Dean, Faculty of Interdisciplinary Studies, Law and Management and Director, School of Oceanographic Studies, Jadavpur University.** He spoke on the theme 'Lessons for the future from recent cyclones in the Indian Sundarbans delta'.

The Keynote speaker discussed the challenges faced by the communities of Sundarbans due to human vulnerabilities and natural hazards. He discussed the impacts of cyclones, floods, and climate change on the ecosystem of Sundarbans and their livelihoods. He emphasized the need for developing adaptation strategies for building the resilience of the community against the disaster. The Indian Sundarban Biosphere comprises an area of 9629 sq. km of which 4264 sq. km is reserved forest. The area is densely populated by more than 5 million people. Despite the natural hazards and human vulnerabilities, the population is growing at a faster rate than the state and the twin districts of North and South 24 Parganas.

Cyclone Bulbul was hit with a maximum wind speed of 137 mph and significant rainfall on November 11, 2019, in Sundarbans. On May 20, 2020, the cyclone Amphan was hit on May 20, 2020, in West Bengal, India's South 24 Parganas District, with winds between 155 and 165Kmph. Cyclone Yaas made landfall in Odisha on May 26, 2021. But it still had an impact on West Bengal, with gusts of up to 155 mph and wind speeds of 130 to 140 kmph. Cyclone Aila (2009) continues to be a significant occurrence that has played a key role in altering the delta.

People of Sundarbans talking about most devastating extreme events is Cyclone Aila in 2009. The path of Aila is straight south to north. The effect of cyclone was not found only Sundarbans but also far Northern part of West Bengal in Darjeeling where 1 person was died and 3 person in Sikkim also.

According to the Department of Disaster Management, Govt. of West Bengal, Due to cyclone AILA, there are 1.22 million people and 2282 villages were affected in South 24 Parganas district. The damage and loss of S 24 Paragans district are about 0.13 million houses, loss of life 40 and livestock loss 80045, crops are damaged 125260 hectares, crops damaged in value 245.7 million INR and in infrastructure damage and loss is about road 304 km., boat 1126, tube wells 7020, school 200, jetty 24. Like S 24 Parganas district, N 24 Parganas district is also highly affected. The damage and loss in N 24 Parganas is about the loss of life 95, livestock loss 103949, crops are damaged 85830 hectares, and crops lost in values 3121.7 million INR. In addition, 1.33 million people were affected.

There are 63 to 64 gram panchayat were inundated by cyclone AILA, the most effected villages were Gosaba, Patharpratima, Hingalganj, Kunatali etc. However, the cyclone AILA is more dangerous but according to Media, the cyclone AMPHAN is more dangerous than the AILA. There are 6 to 7 Gram Panchayet Inundate by cyclone AMPHAN. There are 50 Gram panchayat were inundated by cyclone YAAS.

Issues and Drivers:

The sea level rise, rapid land riverbank erosion, land subsidence, cyclonic storm surge, saline water intrusions, lack of fresh water and sediment supply in the river, breaching and water stagnation, absence of need-based adaptations policy, lack of alternate skill development among the people of Sundarbans, etc are the key issues and drivers of Sundarbans. The speaker shared his own experiences at post cyclone difficulties of people like lack of food and water, though some hyperactive NGOs were working on this matter.

Impact of natural hazards:

There are three-fold impacts of natural hazards in Sundarbans.

1. Ecosystem services: natural hazard affects the land, water, biomass, and air.
2. Cause damage to: damage the sectors like agriculture, population (gender and age-specific), and to property.
3. Negatively impact: negatively affect the activities of poverty alleviation, economy, education, infrastructure, health, employment.

After any kind of disaster, government release fund for emergency basis to save the disaster victim people but the fund is coming from the development fund, so development process is slowing down and make less resilient society. The problem is the next natural Hazard will create Havoc more than the earlier one, because the society is less resilient.

Floods, cyclones, erosion, and salinization all this are impacted resilient society, resilient housing, or something like that. Climate change is contributing a little bit more and where the impacts are in the social sector, infrastructure & Services, productive sector, and in the environmental sector. One AILA Cyclone affected, we can assess 4 sectors and 15 Subs sectors maybe less or more.

Natural hazards and disasters affect on environment, human life, and livelihood. Natural hazards affect on standard of living like the loss of electricity, loss of drinking water, restricted sanitization access, and general well-being. Effects on health like increased mortality, increased morbidity, and access to health services became difficult due to damaged infrastructure and roadways. Effect on food security like the saline water affected the crops

and stock food grain, vegetables, and fish. Effect on infrastructure impact like the Housing damage (tin roof and asbestos damage, mud wall collapse) and sinking embankments that resulted in flooding Access to essential and emergency services is hampered by flooded roads. Jetties that collapsed, Damaged mobile towers and electrical poles. Effect on livelihoods like loss of access to a source of income, assets used for livelihood (livestock, fishing nets and gear, fishing boats, and tourist boats) were lost, negatively impacted agriculture, causing harm to stand crops and agricultural farms, cultivable lands become unsuitable for cultivation.

Impact on the long run:

A major concern in the long run impact that its consequence will be some kind of soil salinization and it will create a problem with food security. Consequences may changes in river water salinity, loss of productive land, susceptibility to inundation and stagnation, indigenous adaptation failure, health and sanitization issues, and failure of strategic interventions. The management, the fund, and skill development play a crucial role in adaptation in this matter. The knowledge from a developed country like Japan is not sufficient for adaptation purposes; we need to learn from developing countries and local level like Orrisa. Copy and paste knowledge is not sufficient for adaptation strategy; there are need to investigate the best adaptation process.

Flood Affected Area in Sundarbans:

Bsanti, Gosaba, Kultali, Pathar Pratima, and Hingalganj are the most flood-prone areas in the Sundarbans.

Cyclone Affected Area in Sundarbans:

Hingalganj, Sandeshkhali-II, Basanti, Gosaba, Jyanagar-II, Mathurapur-I & II, Patharpratima, Kakdwip, Namkhana, Sagar are the most cyclone prominent area.

Coastal Erosion: Maximum coastal erosion is found in Sagar, Namkhana, and Gosaba.

Risk-prone areas: Gosaba, Sandeshkhali- II, Pathar Pratima, Hingalganj, Sagar, and Basanti are the most risk-prone areas in the Sundarbans area.

Past exposure and determined future preparedness actions:

Cyclone Amphan damaged a huge number of mangrove trees, from this lesson Govt., NGOs took action about the plantation of mangroves, and they think need for it. The Cyclone AILA teaches the importance of relief work. At the time of AILA Govt. and NGOs did good work of relief. The cyclone damages the Kutcha houses. The Govt. constructed a multipurpose

cyclone shelter. The Gitanjali prokolpo helps people to make a good house, but the people of Sundarbans even make a normal house. The previous cyclones taught us the need for an early warning system, the IMD is doing good, they warn us at least 5 to 6 days before.

The peoples Sundarbans secure their roofs with fishing and nylon rope, they learn how to immediately secure the roof.

Recommendation:

There some recommendations are- planting mangroves and monitoring in Sundarbans, consciously need to provide relief among the needy people of Sundarbans, need of arranging community kitchen, Need of Embankment locally name as AILA bandh, Elderly people, women, and children need to send earlier to cyclone shelter.

Title: Patterns and trends of cyclones, floods, and other natural hazards

Speaker: Dr. Sourav Pal (Director, Estuarine and Coastal Studies Foundation, Howrah)

Dr. Sourav Pal discussed natural hazards like cyclones and floods, emphasizing their effects on communities and ecosystems. His background in ecology provided a deeper understanding of these environmental challenges.

Dr. Sourav Pal works on a micro level, he worked in Sagar Island. During the time of the cyclone, everyone was desperate people of Sundarbans maintained their lives, with their vulnerability without any gender biases, or age bias. Common phenomena of Sundarbans are Destruction and damage due to cyclones and less resilient human society. There are more than 100 of year's history of cyclones in the Indian peninsula and now our country is not in a very fortunate condition because the country is already economically losing a lot.

Cyclonic storms and severe cyclones in decades:

From the Govt., data of 120 years shows that the number of cyclones are decreasing in Bay of Bengal and increasing in Arabian seas. The Arabian Sea's Sea Surface temperature (SST) increasing from colder one. Severity Of cyclones increase both the Bay of Bengal and Arabian Sea. It is projected that cyclonic severity will be more in future.

Generally people think cyclones comes more in hotter month like April to May but in reality it is shows that highest cyclones found in Monsoon time, (the month June to September), then second highest in post monsoon time (the month November to December). The winter cyclone is more intense rather than the summer cyclone. If we believe in climate change and Hazard preparedness, then we have need to prepare more for winter cyclone.

Progress of cyclone research in India:

The study of the cyclone was developing in India from the 1980s. After facing the Orissa supercyclone, the study of cyclones came too seriously among the researchers. Another big cyclone AILA is destroying a lot, a cause of thinking about the cyclone very seriously among researchers, academicians, and administrators. After COVID-19 and along with the cyclone severity came into more thinking process, thinking about the subject matter and adding more literature in this time in India. According to Web of Science and Scopus data, the research on cyclones in India continuously increasing trend. The research on cyclones in India is in Physics, Social Science and remote sensing is more than the other subject.

Cyclone Ecology Research in Indian Sundarbans:

The study of cyclone ecology in Indian Sundarbans are very limited. There are need of, pre-cyclone and post-cyclone study and need of river estuary study with cyclonic effectiveness on plankton. Plankton are the 65% to 70% world oxygen source, though the plankton are very important today, often the research on it in Sundarbans is undervalued.

At the time of the cyclone, though the plankton were kicked out or swept away from their homes by the velocity they came back within 10 to 15 days, at least 50% of their number. Cyclone means does not mean always negatively impacted. If the resilient community is present in any area, they will not affected by any cyclone. Therefore, preparedness or adaptability is the key to success in surviving an extreme event in Sundarbans. Bastiolina plankton in Sundarbans are more resilient to other communities of plankton. The bastiolina plankton is never affected by cyclones, they always come back again in their niche.

Mangrove as a shield against cyclones:

According to Government data, the mangrove area is increasing rather than decreasing. In 1987 there was 276 sq km. of mangrove and after AILA in 2009 it was 2152 sq km. and also after 2 years of AILA in 2021, it was 2155 sq. km. However At the time of COVID-19, there was so many cyclones were found, like Amphan, Bulbul, fenny and there was mobility

restriction, no mangrove was planted, but the mangrove land was 3 sq km. Increases. The area of mangroves increases but mangrove health and diversity decrease day by day.

Strategic road map for mangrove conservation and management:

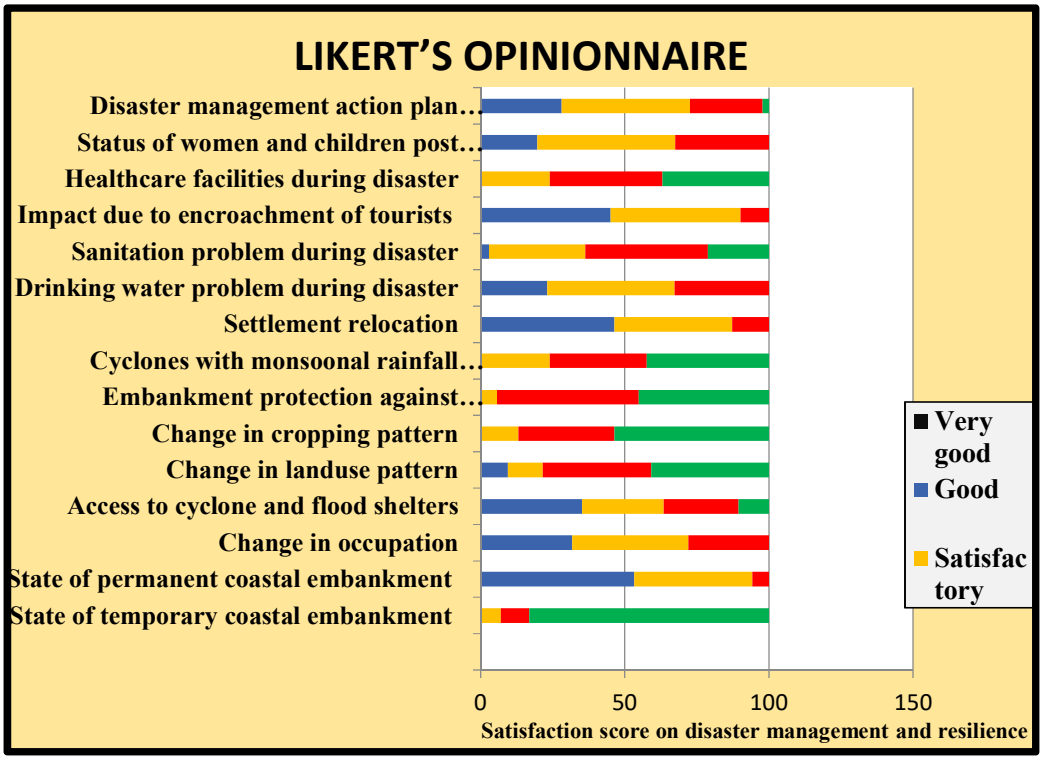
The government already created a road map for the conservation and management of mangroves. The govt. of Maharashtra already started its plan implementation. The government of India also started its plan to implement with the help of the Ministry of Earth Sciences. Bellow shows the road map of Govt.

Vulnerability/ Resilience:

Houses submerged, settlements and agriculture lost, salt water inundation following the cyclone Aila (May 2009) in Indian Sundarbans but the region is now, slowly bounced back. Salt tolerant seed and some engineering may partially reclaimed land can be more resilient in agricultural sector. Embankment may help to protect from inundation.

Local's perception of disaster management and resilience at Mousuni Island:

Many people of Mousumi Island reside at the edge of the river or coast. The people who lived in edge, they need to mentally and physically prepare for adaptation on this area. The need of cyclone shelter for this people is too much but the cyclone shelter is too much faraway from this people, who lived in edge. However, there are cyclone shelter in far but the basic facility is very poor. Bellow table shows local people's perception of disaster management and resilience at Mousuni Island.



Disaster management action plan:

There are need for together work of Govt. as well as non-governmental platforms on disaster management. There need to educate people make them aware, and provide necessary resources. There is more involvement needed from college and university students that can act as champions. There need for the right policy and their smooth implementation. There are need for more discussion, and conferences at the national level and international level. Youth involvement is very important they may crucial role in disaster management.

Title: Damage and loss of tangible and intangible assets in Sundarbans

Speaker: Dr. Ranit Chatterjee (Co-founder and CEO of RIKA India)

Dr. Ranit Chatterjee discusses his experiences from various countries, focusing on environmental management and adaptation strategies. His international perspective will help in understanding how different regions cope with similar risks.

Introduction:

Damage and loss are defined as simple the term damage is something, that we can repair, and we can reverse. Loss is something, which we cannot reverse it. A long-term non-reversible process is in Sundarbans. Sundarbans is a world heritage site. Two criteria make Sundarbans Not only appealing to us but also appealing to the world.

Criteria (ix): The Sundarbans show the process of delta creation and the resulting immigration of the newly formed deltaic islands and related mangrove communities, they offer an important illustration of ongoing ecological processes. Monsoon rains, flooding, delta creation, tidal effect, and plant colonization are some processes. Part of the largest delta in the world, which covers the Bengal Basin and was created by the sediments left behind by the Ganges, Brahmaputra, and Meghna, the land has been shaped by tidal action, giving it a unique physiology.

Damage and loss of Tangible vs Intangible Heritage:

Tangible

Tangible is what we can capture and see after a disaster event or any Hazard event where we do a rapid need assessment this is generally the process like. To construct a recovery plan for us, the government would first do a fast needs assessment, then move on to a post-disaster needs assessment of the economic value of lost. After that, they would look at the next plans for 3 years, 5 years, 7 years, 10 years focus on recovery programs, and then it can enter that cycle of development.

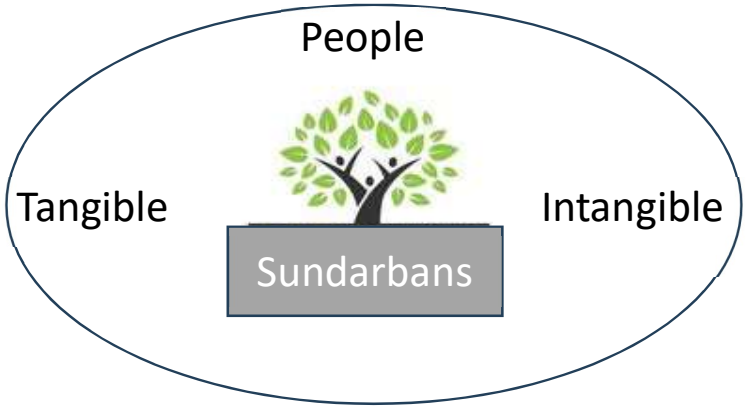
Intangible

The issue is that nobody investigates such kinds of plans, which ignore this portion, which may include 99 percent of the submerged area and is challenging to capture.

Short time, which is what, may require long-term longitudinal, interdisciplinary involvement, as well as community ownership and driven initiatives, because this is essentially the main point of the discussion.

Sundarbans as a System of Tangible and Intangible Heritage:

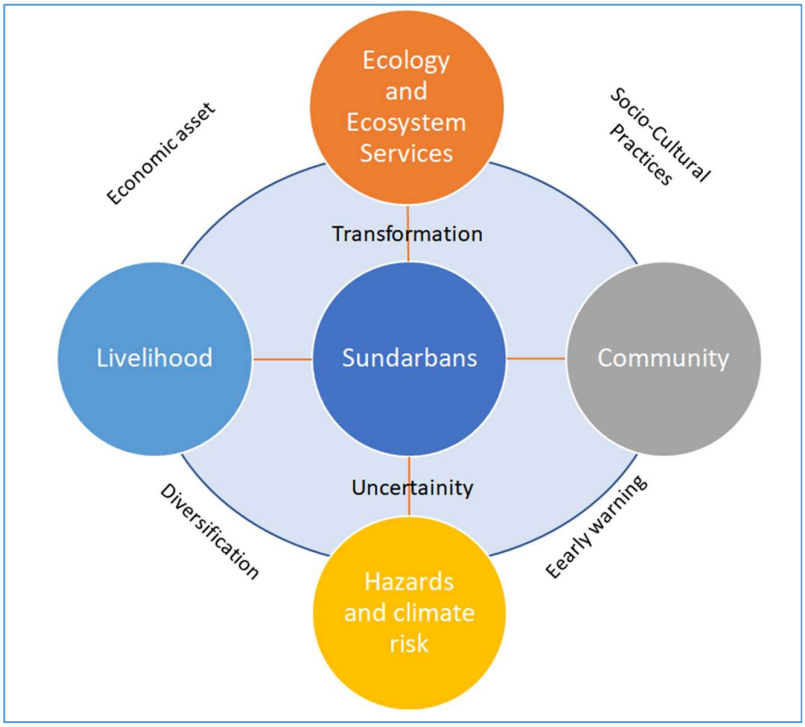
Oral traditions, performing arts, social customs, rituals, celebrations, knowledge and practices about the natural world and the cosmos, or the ability to make traditional crafts are examples of living expressions that have been passed down from our ancestors to our descendants and are included in UNESCO's Cultural Heritage.



The problem here is that people take ecosystem services for granted, believing that they are free, so we should take advantage of them as much as possible without returning them. This is the problem with Sundarbans, and it's not just the problem with Sundarbans; it's a system of interwoven tangible and intangible heritage that makes it interesting to the world and all of us. With people and ecosystem services at its core.

According to UNESCO's approach, intangible heritage examines all of these oral traditions, performing arts, social practices, and rituals that are a part of our everyday lives.

The linked landscape of Sundarbans:



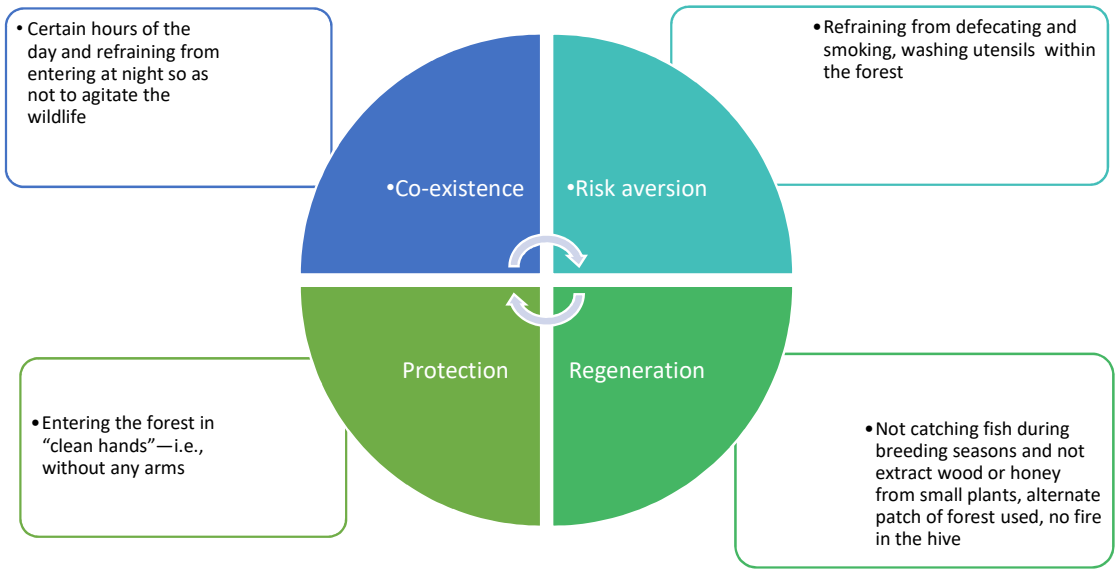
Include it in these four categories: economic assets, diversity, early warning systems, and social and cultural activities. All of these can be grouped under the four ecosystem services that we enjoy, and they are all being affected by either the transformation that is occurring as a result of the development process or the uncertainty that is coming from changes in the intensity, severity, or whatever you want to call the various natural events that are occurring there.

Non-economic damage and Loss due to intangible heritage are beyond IPCC's Mobility, mortality, and Mental Well-being:

Not only does non-economic harm and loss affect the sense of place, but it also affects mobility, morals, and mental health. The IPCCC's recommendations and the current Santiago framework networks' discussions of non-economic damage and loss are increasingly focused on those topics. Skill sets that are related to livelihoods, it has to do with the traditions, the market, and the traits that go along with it. The safety nets. There are obvious health consequences.

Bonbibi's customary regulations:

For instance, if we wanted to include the Bonbibis customer regulations, we could include them under this protection provisioning regulation and cultural services, then examine it closely. We will discover that it has a positive effect on the ecosystem as a whole, which helps us maintain our livelihood and realize social aspects. This may be something that has existed for a long time, and it is already a sort of tried-and-true solution; the only problem is that when we create policies, we may negate them and create conflicts where we put the government in a position of power.



Source: Adopted from Sen and Mukherjee (2020) "Bonbibi"

On top of this, policies are being undermined. The rate of erosion increases during any such disaster event and this is further explored by migrations, displacements, displacements caused by disasters, and many other variables.

Panel Discussion:

• Creating a dashboard that maps tangible and intangible heritage and the hazards associated with it

• Creating synergies between customary regulatory mechanisms and policies

• The creation of methods for evaluating intangible assets based on examples from other similar locations across the globe.

• Supporting transboundary, longitudinal, multidisciplinary research on intangible asset losses in the Sundarbans.

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SESSION-4
LIVING ON THE EDGE:
IMPACT OF CLIMATE CHANGE ON THE LIFE AND ECONOMY OF SUNDARBANS

The Sundarbans, the world's largest mangrove ecosystem, is at the frontline of climate change. Rising sea levels, increasing salinity, extreme weather events, and shifting ecological patterns threaten the region's environment, livelihoods, and economic sustainability. Communities that have lived in harmony with nature for generations now find themselves in a constant battle against changing climatic conditions that erode their traditional ways of life.

Session 4, ***"Living on the Edge: Impact of Climate Change on the Life and Economy of Sundarbans,"*** aims to explore the far-reaching consequences of climate change on this fragile region. Led by **Dr. P G Dhar Chakrabarti**, the session will begin with a keynote address by **Prof. Sugata Hazra**, who will provide crucial insights into sea level rise, its current trends, future projections, and the implications for both the physical landscape and human settlements.

Dr. P.G. Dhar Chakrabarti chaired the session, setting the stage with a thought-provoking introduction on the existential challenges of climate change in the Sundarbans. He emphasized that the region, home to millions, faces an escalating crisis due to rising sea levels, increasing soil salinity, and the degradation of natural resources. His address underscored the urgency of proactive intervention through scientific research, policy reform,

and community engagement. Highlighting key climate threats, Dr. Chakrabarti noted that the Sundarbans is experiencing one of the fastest rates of sea level rise globally, exacerbating land loss, displacement, and economic instability. He linked these phenomena to broader climate change patterns, stressing the need for interdisciplinary solutions that integrate environmental science, sustainable development, and disaster risk reduction.

Keynote Address by **Prof. Sugata Hazra, Former Director, School of Oceanography, Jadavpur University, Kolkata spoke on the theme "Sea Level Rise: Trends, Projections and Impacts".** *Prof. Sugata Hazra* delivered an insightful presentation on sea level rise and its impact on the Sundarbans Delta. He highlighted that climate change had exacerbated sea level rise, but other factors, including land subsidence, also contributed significantly. He elaborated on the historical governance challenges associated with acknowledging rising sea levels in West Bengal, recounting how, until 2019, official narratives had downplayed the phenomenon. However, data from Diamond Harbour confirmed that the region experienced the highest sea level rise rate in India at 5.2 mm per year. Prof. Hazra presented critical insights into the variation in sea level rise across different parts of the Sundarbans. He noted that measuring relative sea level rise was complex, as land movement influenced these observations. He also detailed the methodologies used for sea level measurement, from traditional bamboo stick methods in Sagar Island to modern automatic tide gauges and satellite altimetry.

Discussing the socio-economic ramifications, Prof. Hazra pointed out that over 50,000 people had already been displaced due to rising sea levels and island erosion. He cited satellite data confirming the submergence of two Sundarbans islands, previously inhabited by communities forced to migrate. Despite scepticism from international observers, he stressed that these were among the first climate refugees in India. Prof. Hazra emphasized that mangrove restoration, while beneficial for biodiversity and carbon sequestration, could not single-handedly prevent sea level rise. He presented predictive models showing that by 2050, 30% of mangrove

forests could be lost under the current rate of sea level rise. By 2100, under high-emission scenarios (RCP 8.5), more than 50% of mangroves could disappear. However, with effective sedimentation and managed realignment strategies, mangrove retreat could be slowed or even stabilized. He outlined four possible adaptation strategies: 1. **Protection with embankments** – Strengthening infrastructure to shield human settlements. 2. **Managed realignment** – Allowing mangroves to migrate northward. 3. **Nature-based solutions** – Promoting assisted sedimentation to enhance natural land accretion. 4. **Hydrological interventions** – Restoring freshwater flow to counteract salinity intrusion.

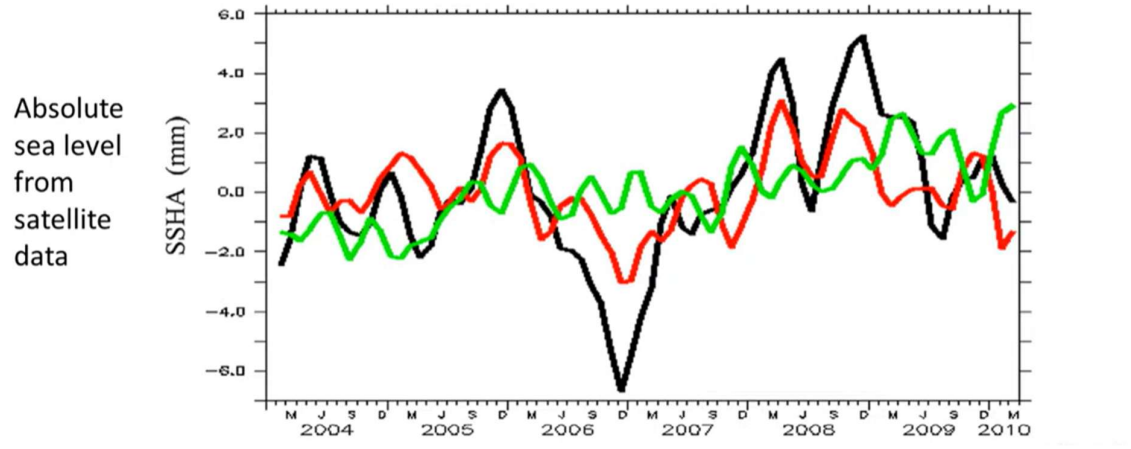


Figure: Seal level rise from satellite data

Prof. Hazra detailed the significance of monitoring techniques such as satellite altimetry and tide gauge data collection. He explained that sea level trends were not uniform worldwide, and regional variations, particularly along India's east coast, were influenced by oceanic circulation patterns and land movements. He noted that the impact of sea level rise on estuarine systems in the Sundarbans required more extensive research to understand the interaction between tidal behavior, sedimentation, and land subsidence. He elaborated on how climate change had intensified extreme weather events, leading to increased erosion of mangrove islands. He highlighted findings from satellite imagery showing that some Sundarbans islands had shrunk by over 30% in the past three decades. He stressed the importance of incorporating community-driven solutions alongside technological interventions, as local populations had firsthand knowledge of environmental changes affecting their livelihoods.

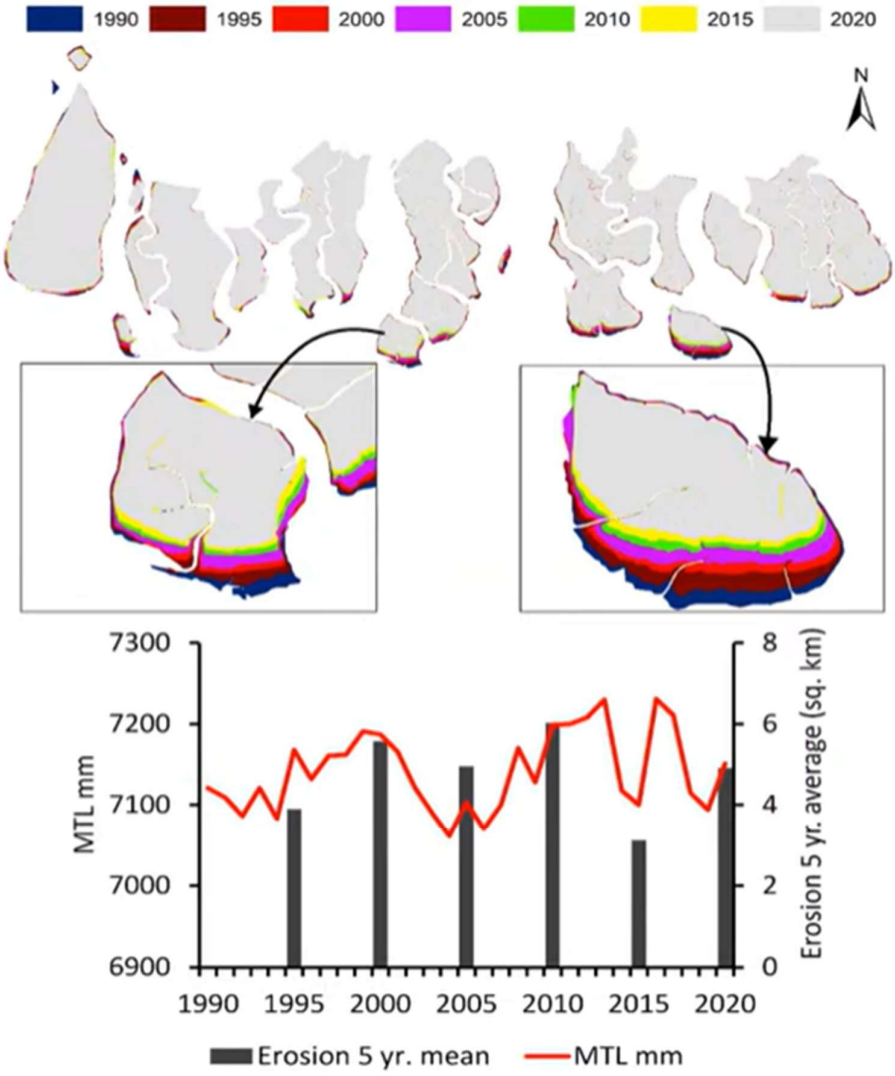


Figure: Sea level rise and erosion of Mangrove Island

Prof. Hazra also discussed the socio-political challenges of addressing climate migration. He pointed out that displacement due to sea level rise was a long-term issue that required proactive planning, yet governments had been slow to implement large-scale resettlement strategies. He cited case studies where displaced communities struggled to secure land and resources, exacerbating their vulnerabilities. He emphasized the need for policies that recognized climate migrants and provided them with sustainable livelihood opportunities. Furthermore, he addressed the hydrological challenges faced by the Sundarbans, particularly the impact of reduced freshwater inflow due to upstream water diversions. He explained how

declining river discharge had led to increased salinity in both soil and water, further degrading agricultural land and threatening biodiversity. He called for cross-border cooperation between India and Bangladesh to ensure better water resource management and mitigate the adverse effects of reduced freshwater supply.

Prof. Hazra concluded his presentation by stressing the urgency of integrated climate adaptation strategies. He urged policymakers, researchers, and local communities to collaborate on solutions that combined scientific advancements with traditional knowledge. He warned that without immediate intervention, the Sundarbans would continue to experience accelerated environmental degradation, leading to irreversible socio-economic consequences. His presentation served as a wake-up call, reinforcing the need for decisive action to protect one of the world's most climate-vulnerable regions.

Second speaker of this session was **Dr. Dhiman Burman, Head and Principal Scientists, Regional Research Station, Central Soil Salinity Research Institute, Canning spoke the theme on "Salinization of soil, sub-soil and river in Sundarbans".** *Dr. Burman* presented a comprehensive analysis of the challenges posed by soil, sub-soil, and river salinization in the Sundarbans. He began by outlining the unique environmental and socio-economic conditions of the region, emphasizing that the Sundarbans, home to approximately 4.5 million people, is an ecologically fragile, tidally influenced deltaic ecosystem where nearly 43% of the population lives below the poverty line. Given the overwhelming dependence on agriculture, with 90% of farming households being smallholders, salinization poses a severe threat to food security and livelihoods.

Dr. Burman explained that the region's soils, predominantly saline alluvial in nature, have been subjected to increasing salinity intrusion over the years. He presented satellite-derived salinity maps showing that the salt-affected area had expanded significantly, from 73.2% of the region in 1973 to 85.4% in 2023. He identified major causes of soil salinization, including capillary rise of saline groundwater, evaporation, embankment breaches, and river water seepage. Seasonal fluctuations in soil and water salinity were another critical challenge, with high salinity during the dry season due to

freshwater scarcity and waterlogging issues during the wet season exacerbated by tidal activities. The presentation further delved into the impacts of salinization on agricultural productivity. He highlighted that the region's soil fertility had deteriorated over time, with low nitrogen and phosphorus availability, making it difficult for farmers to maintain consistent yields. Using data from DUALEM-based surveys, he demonstrated that soil salinity varied significantly across different depths, affecting root zone health and plant growth. His research indicated that while some crops had adapted to the saline conditions, the overall productivity remained low compared to non-saline agricultural regions.

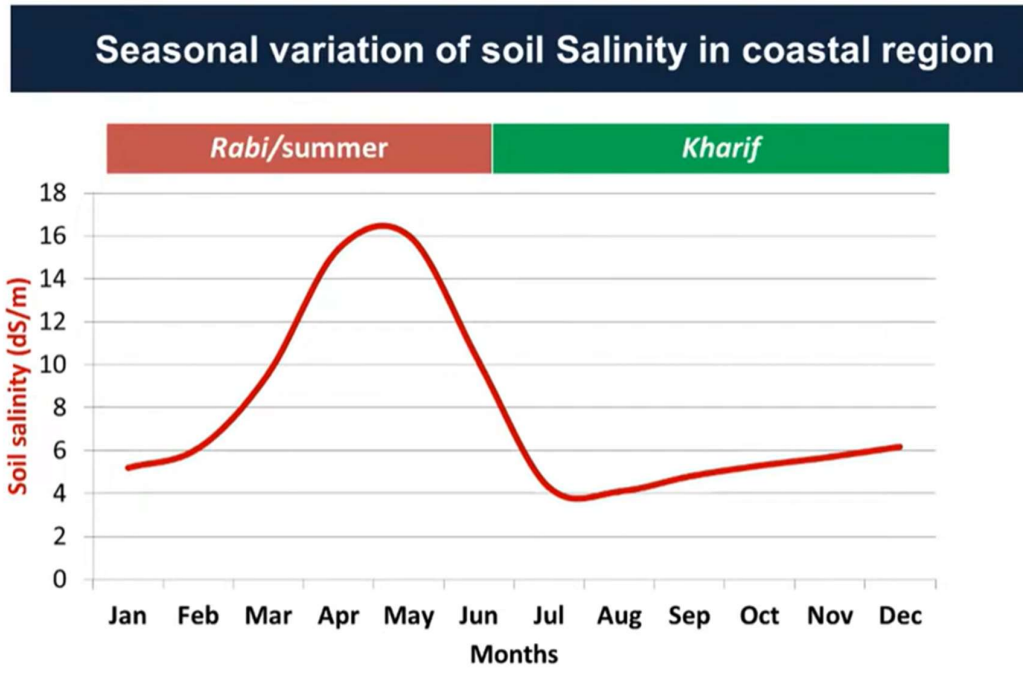


Figure: Soil salinity change

Dr. Burman also provided a broader perspective on coastal salinity dynamics in West Bengal, explaining that South 24 Parganas was the most affected district, followed by East Midnapore, North 24 Parganas, and Howrah. He demonstrated how Landsat 8 OLI imagery had been used to delineate salinity hotspots and track seasonal variations in soil conductivity. The findings indicated that water salinity levels ranged from 2.34 to 13.60 dS/m, with an average of 6.09 dS/m, highlighting significant spatial variability across different areas of the Sundarbans. The hydrological impact of salinization was another crucial topic of discussion. Dr. Burman explained that estuarine water quality had been deteriorating, with rising salinity levels influencing nutrient concentration and freshwater availability. Seasonal variations

indicated that estuarine water salinity was highest during the dry season and gradually reduced with monsoon-driven freshwater inflows. He noted that increasing tidal dominance had further exacerbated the salinity crisis, as diminished freshwater flows from upstream regions resulted in an encroachment of saline water into agricultural lands and drinking water sources. In the latter part of his presentation, Dr. Burman discussed the alarming impact of sea level rise on salinity intrusion. Citing data from the Permanent Service for Mean Sea Level (PSMSL), he explained that the rate of sea level change in the Sundarbans ranged from 3.24 mm to 7.48 mm per year, with Diamond Harbour witnessing a rise of 4.85 mm per year. He warned that under the RCP 8.5 scenario, which projected an 80 cm sea level rise by 2070, combined with an additional 50 cm rise due to ice sheet melting, approximately 1305.9 square kilometers of land in the Sundarbans would be inundated. This, he stressed, would have devastating consequences for local communities, leading to widespread displacement and loss of arable land.

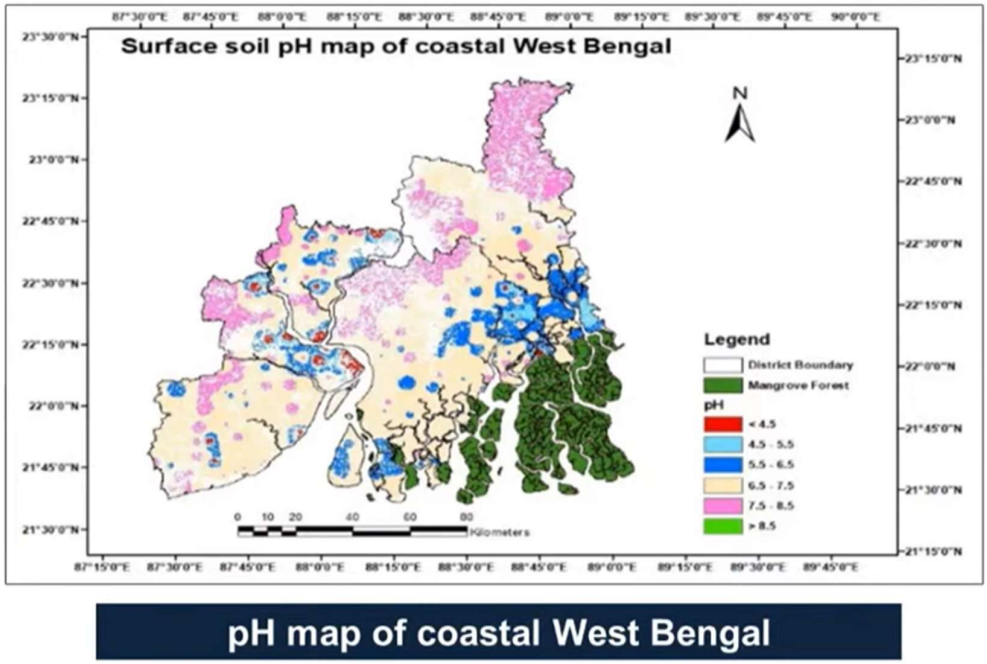


Figure: Soil pH map of Sundarbans

The discussion then moved to salinity management strategies and possible solutions. Dr. Burman proposed a range of approaches, including soil and water management techniques, salinity-tolerant crop varieties, and sustainable land use practices. He emphasized the importance of integrated nutrient management, acid sulphate soil remediation, and

sequestration of soil organic carbon to mitigate salinity buildup. He also advocated for improved water management through rainwater harvesting, conjunctive use of saline and freshwater resources, and community-driven drainage system maintenance. Another crucial aspect of his presentation was the impact of anthropogenic activities on soil degradation. He highlighted that the conversion of croplands into brackish water aquaculture (BWA) had contributed significantly to increasing soil salinity. Comparing land use patterns from 1975 and 2015, he demonstrated that aquaculture areas had expanded while fallow lands had also increased, indicating a decline in agricultural sustainability. The long-term effects of this shift, he argued, required urgent attention from policymakers to balance economic benefits with ecological preservation.

Dr. Burman also discussed successful adaptation practices, including zero-tillage potato cultivation with paddy straw mulch, which had proven to reduce salinity buildup while enhancing productivity. He presented promising results from resource conservation technologies that optimized soil moisture retention and reduced salt accumulation, helping farmers improve yields even in saline-prone areas. Additionally, he emphasized the potential of agroforestry and conservation agriculture in ensuring long-term soil stability and ecological balance. Concluding his presentation, Dr. Burman underscored the necessity of climate-resilient planning for the Sundarbans. He called for immediate policy interventions, increased investment in salinity management research, and greater collaboration between scientists, farmers, and policymakers. He urged the need for transboundary water resource management between India and Bangladesh to ensure equitable freshwater availability and mitigate the risks of further salinity intrusion. Without proactive measures, he warned, the Sundarbans would face an existential crisis, threatening both its rich biodiversity and the livelihoods of millions of inhabitants.

Third speaker of this session was **Dr. Anindya Nayak, Scientist, Krishi Vigyan Kendras, 24 Parganas (North) spoke on "Impact of climate change on agriculture in Sundarbans".** The presentation on the impact of climate change on agriculture in the Sundarbans, delivered by Anindya Nayak on behalf of Dr Sumanta Kundu, provided an in-depth analysis of the threats posed by climate change to the agricultural sector. The speaker began by emphasizing that global climate change had already been extensively discussed, highlighting temperature rise, increasing sea levels, and extreme weather events. He noted

that 2024 had been the warmest year since record-keeping began in 1850, and previous heat waves, particularly in 2022, had drastically affected key wheat-producing regions in northwest and central India, leading to a 4.5% decline in wheat production.

Dr. Nayak presented climate change projections and their expected effects on agricultural yields in India. According to modelling approaches, rainfed rice yields were projected to decrease by 20% by 2050 and 47% by 2080, while irrigated rice production was expected to decline by 3.5% in 2050 and 5% in 2080. Similarly, wheat yields would drop by 19.3% in 2050 and 40% in 2080, and Kharif maize yields were projected to decline by 18-23% in the same period. Turning to the Sundarbans, the speaker presented a climatic vulnerability map that classified different regions based on risk levels. The red-coloured zones represented high-risk areas, while the faded red zones indicated moderate risk and low-risk areas were marked accordingly. The mangrove forests were also distinctly highlighted. The speaker emphasized that the Sundarbans were already witnessing significant sea level rise, leading to land submergence, soil salinity increase, and the subsequent loss of agricultural land and freshwater sources. The intrusion of saltwater into farmlands had further reduced soil fertility, adversely affecting crops.

The impact of extreme weather events on agriculture was another crucial topic of discussion. The speaker listed major cyclones, including Aila and Bulbul, which had led to widespread damage, particularly through embankment breaches that facilitated saltwater intrusion. He explained that erratic rainfall patterns and drought conditions had exacerbated agricultural losses. Heavy rainfall events had resulted in water stagnation, delayed sowing, crop losses, and the escape of fish from ponds, while prolonged dry spells had led to seedling transplantation delays, stunted flowering, and increased pest infestations. Furthermore, rising temperatures were adversely impacting crop productivity, livestock health, and breeding cycles. A significant shift in agricultural patterns was noted between 2002 and 2009, as the total agricultural land in the Sundarbans decreased by approximately 4,558 square kilometres. This decline, documented in the West Bengal State Action Plan on Climate Change, was attributed to a combination of land subsidence and

increasing salinity. Farmers had responded to these challenges by adopting monoculture practices, primarily cultivating a single crop during the Kharif season, leading to low cropping intensity. While the cropping intensity in the Sundarbans was recorded at 128%, other regions, such as northern Odisha, had achieved a higher intensity of 222%.

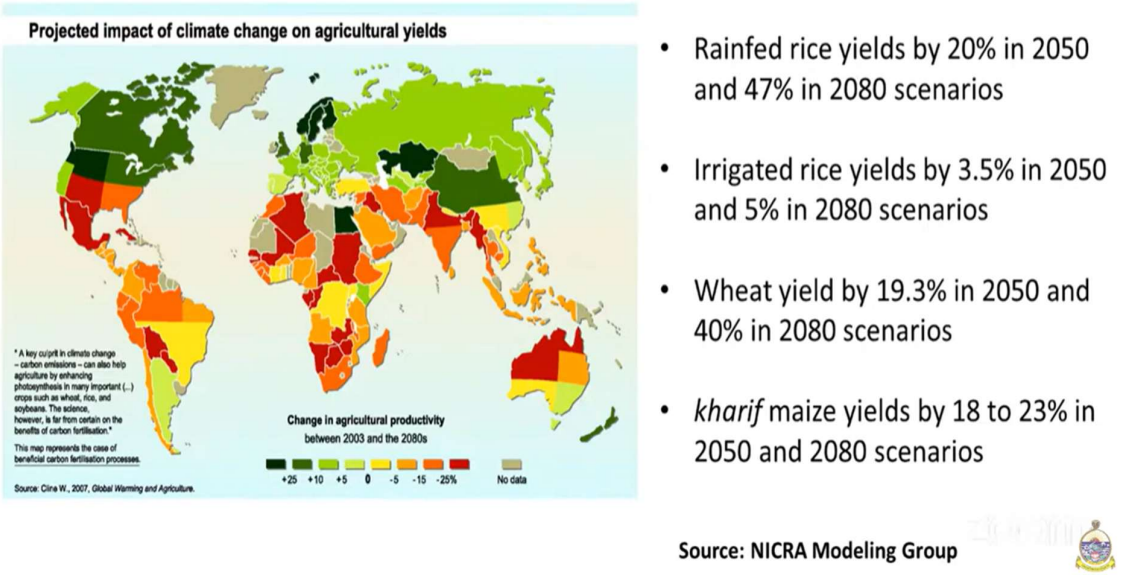


Figure: climate change projection and likely reduction in the yield of major crops

Limited irrigation was another major constraint, as only 12% of cultivated crops in the Sundarbans benefitted from irrigation, mainly through rainwater harvesting structures like ponds, tanks, and canals. However, these freshwater sources were vulnerable to saltwater intrusion due to the destruction of sluice gates, further exacerbating water scarcity. The speaker warned that these factors collectively posed a severe threat to food security in the region. The impact of climate change on agriculture was categorized into three areas: crops, livestock, and fisheries. The effects on crops included declining yields due to increased salinity and erratic rainfall, which had reduced the production of rice, mustard, and vegetables. Cyclones and heavy flooding had caused extensive crop losses, while farmers had been forced to adopt salt-tolerant crop varieties and rainwater harvesting techniques to sustain agriculture. Additionally, the capillary movement of saline groundwater had increased soil salinity, rendering large portions of land infertile.

For livestock, the challenges were equally severe. Water scarcity and increased salinity had led to fodder shortages, affecting the availability of grazing areas. Heat stress and waterborne diseases had caused higher livestock mortality rates, while cyclone-related damage to cattle

sheds had resulted in financial losses for farmers. The fisheries sector had also suffered from climate-induced changes. The speaker highlighted declining fish stocks due to the degradation of breeding grounds and damage to fishing boats and nets caused by cyclones. The destruction of fish farms had further impacted livelihoods. In response, many fish farmers had shifted to brackish water aquaculture, particularly shrimp farming, but this practice had raised ecological concerns, including the long-term salinization of soil and water bodies. Pollution was identified as another contributing factor to agricultural decline. The reduced freshwater flow from the Ganges River due to heavy siltation and industrial discharge had led to deteriorating water quality in the Sundarbans. Heavy metal contamination and pesticide residues had further exacerbated the problem, ultimately affecting biodiversity and ecosystem health.

Figure: Climate vulnerable zonation map of Sundarbans

To address these issues, the Government of India, through the Ministry of Farmers' Welfare and the Indian Council of Agricultural Research (ICAR), had initiated the National Innovations in Climate Resilient Agriculture (NICRA) program in 2011. This program focused on strategic and applied research, as well as on-ground demonstration projects to enhance climate resilience. A total of 73 research stations had been established under NICRA, with 51 Krishi Vigyan Kendras (KVKs) implementing technology demonstrations in 448 villages across India. As part of the NICRA initiative, several adaptation strategies had been developed, including water conservation efforts and sustainable land management

practices. The speaker discussed the implementation of rainwater harvesting through pond desiltation rather than constructing new ponds, which could disrupt the ecological balance. The desiltation process involved removing accumulated silt from pond bottoms to improve water retention capacity. A key challenge was the presence of acid sulfate soils, which required careful soil management to prevent exposure to air. By strategically layering desilted soil, ponds could be reclaimed for fish cultivation, while embankments could support vegetable farming and livestock irrigation.

Additionally, diversified horticulture practices had been introduced through land embankment cultivation. Given the low-lying nature of the Sundarbans, trenches had been excavated to create raised land areas suitable for vegetable and rice cultivation. These raised areas were designed to withstand flooding, providing a more stable agricultural base. Farmers had also adopted integrated farming models that combined rice, fish, and duck rearing to optimize land use and enhance food security. A novel intervention introduced in the region was floating rice bed seed cultivation. This technique, piloted on 0.065 hectares of land, involved constructing bamboo-supported floating seedbeds lined with polythene and filled with compost and soil. Initially used for aromatic rice cultivation, this method had been scaled up through community-based seedbed preparation efforts, reducing farmers' reliance on external seed sources.

Another innovative adaptation was the introduction of floating duck houses, designed to withstand flooding events. These structures allowed farmers to maintain poultry farming despite recurrent inundations. Additionally, pilot programs for freshwater prawn breeding have been implemented to enhance fishery resilience. The speaker concluded by presenting a climate-resilient integrated farming system model, which had been successfully adopted by the West Bengal State Government. This model incorporated multiple adaptation strategies, including pond desolation, embankment raising, floating seedbeds, and integrated agriculture-aquaculture systems. The government had allocated ₹1.34 crore to implement pilot demonstrations across six coastal blocks in North 24 Parganas, with 120 demonstration sites established under the initiative. The presentation underscored the urgent need for continued investment in climate resilience and adaptive agricultural practices in the Sundarbans. By integrating scientific research with traditional knowledge, stakeholders could develop sustainable solutions to mitigate the adverse effects of climate change on agriculture and food security.

Fourth speaker of this session was **Dr. Somnath Hazra, Climate Change Adviser, Indus Value Consulting and the mentor at Climate Change Loss and Damage Research, IIED, London spoke on "Impact of climate change on life and economy in Sundarbans"**

Dr. Hazra delivered an in-depth presentation on the impact of climate change on the life and economy of the Sundarbans. He began by describing the Sundarbans as one of the most vulnerable deltaic regions, facing severe consequences due to climate change. His presentation examined economic losses, human displacement, and adaptation strategies, drawing from scientific literature and publicly available data.

Dr. Hazra provided an overview of the Indian Sundarbans, covering approximately 10,000 square kilometers, with 4,200 square kilometers in India. He highlighted the region's rich biodiversity, estuarine systems, and mangrove forests, which were highly exposed to sea-level rise, erosion, and extreme weather events. He emphasized that temperature and rainfall variability, increasing cyclonic activity, and saltwater intrusion had contributed to significant environmental and socio-economic challenges. He elaborated on the projected sea-level rise of 1.2 to 1.48 meters by 2100, citing research indicating that large portions of land could submerge. He also noted that cyclonic activity had increased in frequency and intensity, resulting in higher storm surges, embankment failures, and coastal flooding. He pointed out that saltwater intrusion was affecting freshwater sources and agriculture, thereby threatening livelihoods.

Dr. Hazra emphasized that climate change, extreme weather, and rising sea levels threatened approximately 4.5 million people in the Sundarbans. He reported that nearly 800 kilometers of embankments were at risk of breaching, based on recent studies. Citing past cyclones such as Aila (2009), Amphan (2020), and Yaas (2021), he discussed the displacement of thousands of people and the severe saltwater intrusion that had rendered agricultural lands infertile. He stated that over one million people could be displaced by 2050 due to sea-level rise and that

cyclones struck the region twice a year on average. Addressing livelihood losses, he explained that 51% of the Sundarbans population depended on farming, yet rice yields had decreased by 15.6% in recent years. He noted that 40% of Hilsa fishermen had abandoned their profession due to declining fish stocks, leading to an increase in illegal crab hunting and wood collection. Additionally, he highlighted health issues, stating that 40% of children were underweight, 51% suffered from stunted growth, and 64% of women were anemic, largely due to food insecurity and poor sanitation.

Dr. Hazra discussed the significant economic consequences of climate change in the Sundarbans. He warned that infrastructure damages from cyclones, flooding, and embankment failures could lead to a 7% loss in GDP per capita by 2050. He projected a 12% decline in GDP due to climate-induced shocks, with agricultural output potentially dropping by 17%. The fisheries industry was also shrinking, contributing less than 1% to GDP, which directly affected local livelihoods. He elaborated on the decline in the agricultural sector, explaining that saltwater intrusion and erratic monsoons had reduced crop yields. According to the Indian Council of Agricultural Research (ICAR), soil salinity in some areas had increased by 15-20% over the past 15 years, causing a 25-30% decline in rice yields. The loss of agricultural jobs had led to rising poverty levels, with nearly 27% of households shifting away from farming. The fisheries sector had also been adversely impacted, with Hilsa fish populations declining due to rising salinity and temperature shifts. The contribution of fisheries to GDP had shrunk, affecting thousands of livelihoods. Furthermore, trade and port infrastructure were under threat due to rising sea levels and storm surges, disrupting supply chains and reducing economic efficiency.

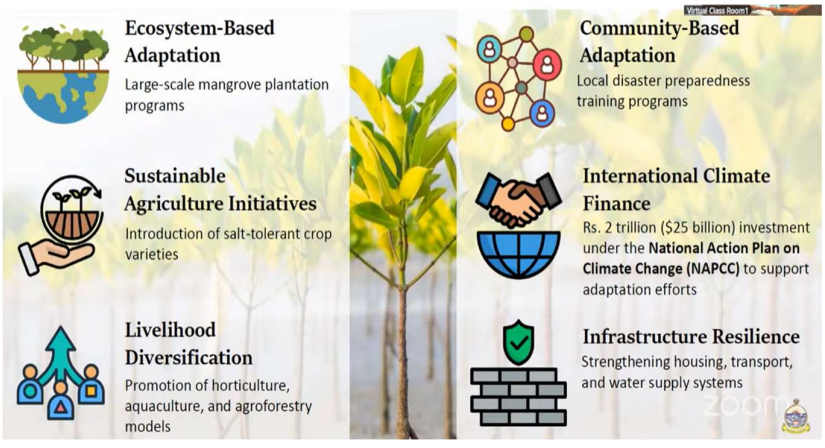


Figure: Climate adaptation strategies

Dr. Hazra detailed the infrastructure damages caused by past cyclones. Cyclone Amphan (2020) had resulted in economic losses of ₹1.02 lakh crore, affecting over two million people, while Cyclone Aila (2009) had caused ₹150 crore in damages. Cyclone Bulbul (2019) had led to ₹23,811 crore in losses, damaging over 500,000 households. He noted that frequent storms and tidal surges continued to erode embankments, destroy homes, and disrupt public utilities.
Dr. Hazra outlined various adaptation strategies to counter climate risks. He emphasized the need for ecosystem-based adaptation measures, such as large-scale mangrove plantation programs, sustainable agriculture initiatives, and improved disaster preparedness. He advocated for the introduction of salt-tolerant crop varieties, promotion of agroforestry, and the development of climate-resilient housing and infrastructure. He highlighted community-based adaptation initiatives, including local disaster preparedness training and sustainable farming practices. He stressed that international climate finance was crucial for supporting these efforts. He pointed out that while India had initiated a ₹2 trillion investment under the National Action Plan on Climate Change (NAPCC), gaps in funding still existed. Strengthening embankments, improving cyclone shelters, and enhancing early warning systems were among the key disaster risk reduction measures he recommended.
Dr. Hazra discussed sustainable agriculture solutions, emphasizing the importance of efficient irrigation, paddy-cum-fish farming, and brackish water aquaculture. He noted that salt-resistant rice varieties such as Matla, Lunishree, and Gobindobhog had been successfully cultivated in high-salinity areas. He also underscored the significance of mangrove conservation, describing mangroves as natural buffers against cyclones and storm surges. He explained that 85% of India's mangrove forests were in the Sundarbans, serving as a critical carbon sink. However, rising salinity and deforestation were threatening mangrove biodiversity, necessitating large-scale restoration efforts.
Dr. Hazra stressed the importance of community engagement in climate resilience. He highlighted initiatives such as women-led mangrove stewardship programs, community-mapped vulnerable zones, and climate-resilient farming cooperatives. He urged local councils to advocate for stronger climate policies and disaster funding while collaborating with NGOs and researchers. He concluded his presentation with policy recommendations, calling for investments in climate-resilient infrastructure, diversification of the local economy through eco-tourism and sustainable fisheries, and improvements in disaster response mechanisms.

He emphasized the necessity of securing international climate funding to support long-term adaptation efforts in the Sundarbans.

Figure: Disaster risk reduction measures

Dr. Hazra concluded by warning that without urgent action, 15-20% of the Sundarbans could be underwater by 2050, with annual GDP losses of 2-3%. He urged policymakers, private sector stakeholders, and local communities to collaborate in building a climate-resilient Sundarbans, stressing that stronger protection and proactive strategies were imperative for ensuring the region's sustainability. His presentation served as a call to action, emphasizing the need for immediate and coordinated efforts to mitigate the impacts of climate change on the Sundarbans.

Last speaker of this session was **Dr. Swagat Ghosh, Head (In-Charge) & Subject Matter Specialist (Fisheries), SSKVK, RKMVERI, Sonarpur spoke on "Impact of climate change on fisheries in Sundarbans".** *Dr Swagat Ghosh* presented an in-depth analysis of the impact of climate change on fisheries in the Sundarbans, West Bengal. He began by emphasizing that climate change had become a major global threat, affecting species survival and the integrity of ecosystems. He cited IPCC data indicating that the global mean surface temperature for the decade 2006-2015 had risen by 0.87°C, six times higher than the average recorded during the 1850-1900 period. He explained that climate change had affected fisheries through multiple channels, including shifts in species distribution, breeding behavior, growth rates, and habitat quality. The speaker highlighted that increased water temperatures, saltwater intrusion, and extreme weather events had negatively impacted fish

populations and aquaculture activities in the Sundarbans. He warned that the region's freshwater and brackish water ecosystems were particularly vulnerable to climate-driven changes, leading to disruptions in fish migration patterns and spawning cycles.

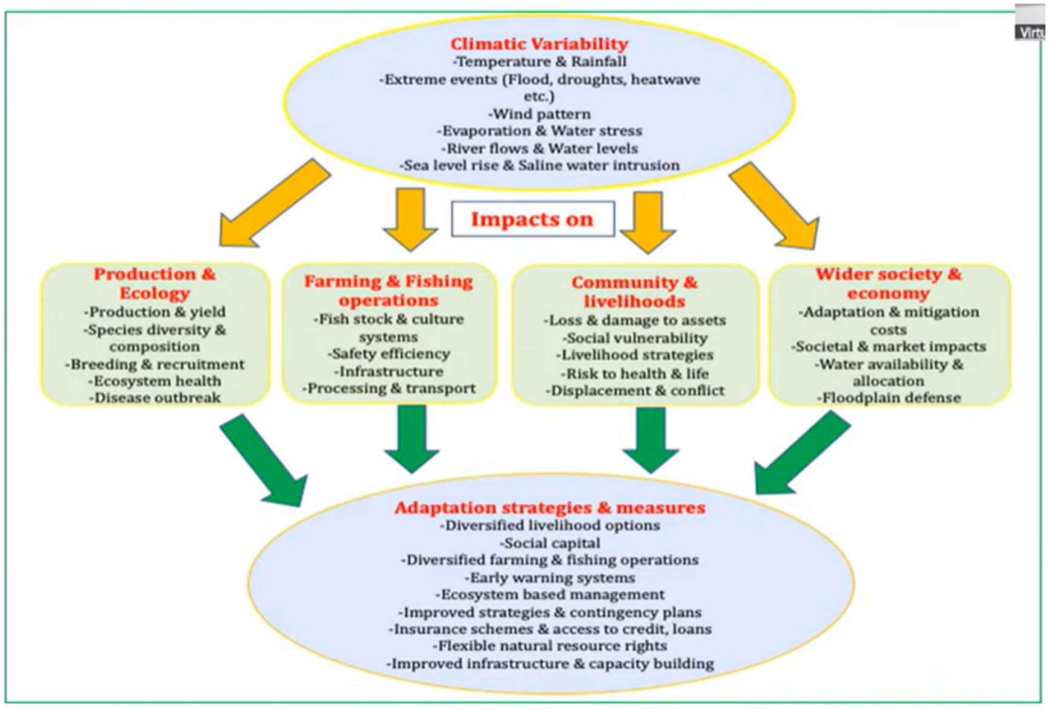
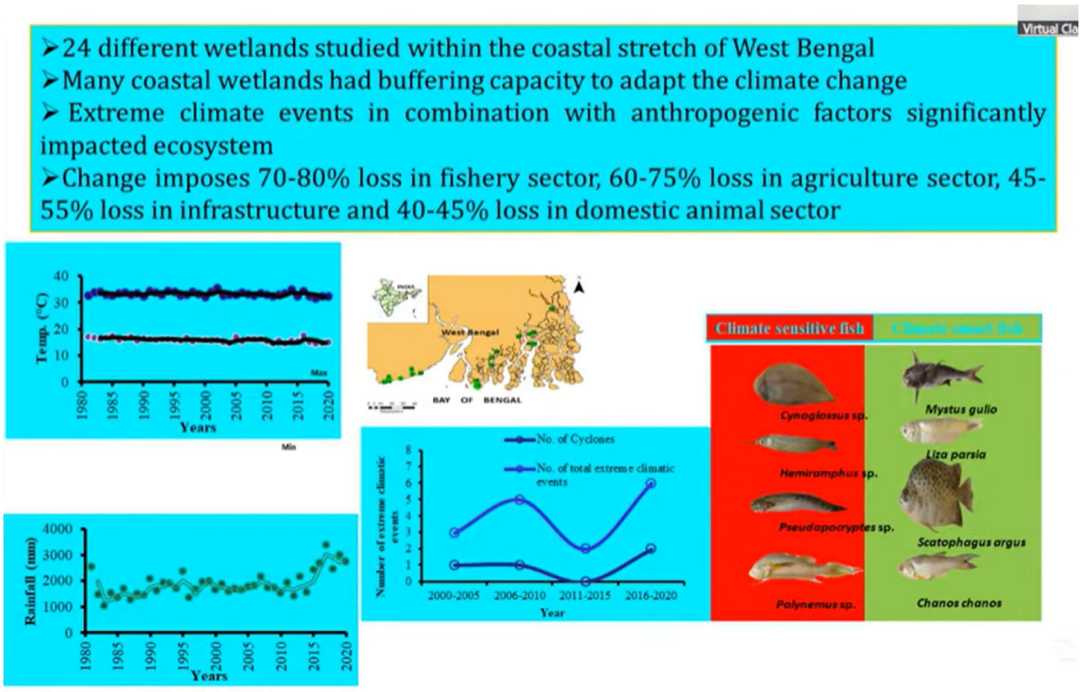


Figure: Impact of climate change on fisheries

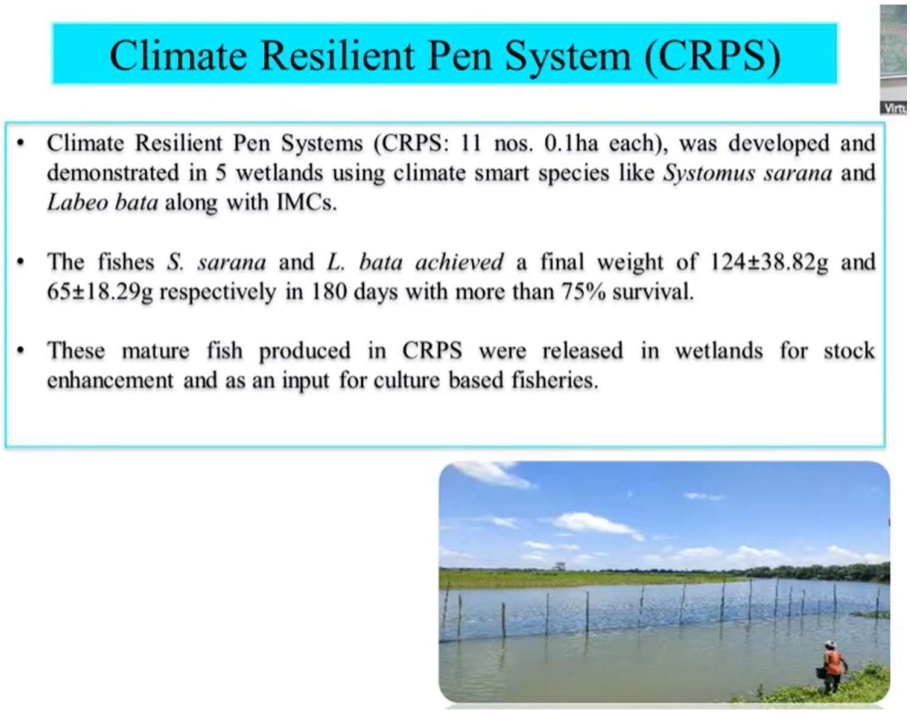
Dr. Ghosh elaborated on climate change forecasts, drawing from the IPCC's 2014 AR5 report, which projected more intense summers, increased thunderstorms, non-seasonal rains, and accelerated hydro-cycles, leading to extreme dry and wet seasons. He stated that the shortening of winters and intensification of the monsoon had already begun affecting the Sundarbans, exacerbating fish habitat loss and declining catch rates. The rise in sea level, he explained, showed no signs of slowing, and unless adaptive strategies were implemented, fisheries and allied activities would suffer serious consequences. He discussed the vulnerability of crab collectors, who relied on unscientific traditional methods in high-risk zones such as Chora Kuppura, Burir Dour, and Bhai Jhuri, making them more susceptible to climate-related occupational hazards. He also noted that the lack of boat license certificates and poor regulatory frameworks had increased the risks associated with crab collection.



Dr. Ghosh detailed how anthropogenic pressures, including over-extraction of water, over-exploitation of fish stocks, pollution, and habitat degradation, had compounded the effects of climate change. He pointed out that fisheries had a low buffering capacity, making them particularly sensitive to climatic shocks. The physiological and ecological impacts on fish populations included shifts in species compositions, with invasive species often outcompeting native species. He cited FAO reports highlighting that the direct impact of climate change on capture fisheries had led to decreased fish productivity, loss of fish habitats, and increased mortality rates among several species. He discussed various vulnerability assessment models, which had been used to analyze ecological, species, reproductive, and geomorphological vulnerabilities in the Sundarbans' fisheries sector. He explained that species such as Mystus cavasius, Eutropiichthys vacha, and Channa punctata had shown resilience to climate variability, while species such as Gudusia chapra were highly vulnerable to environmental changes.

Further, Dr. Ghosh elaborated on the threats faced by the Indian River Shad, explaining that key breeding cues such as rainfall and water temperature had been altered due to climate change. He emphasized that overfishing had compounded the threats posed by rising temperatures and habitat degradation. He provided a detailed breakdown of social vulnerabilities within the fishing community, noting that seasonal occupation patterns had

forced many fishermen into migration and insecure employment. He described how fishermen were vulnerable to physical disabilities, social insecurities, and political challenges that restricted their access to government services. Additionally, he pointed out that issues such as gambling, alcoholism, and debt cycles had worsened the economic conditions of many fishing households in the region.



Dr. Ghosh presented findings from studies conducted across 24 different wetlands along the coastal stretch of West Bengal, revealing that climate change had caused a 70-80% loss in the fishery sector, a 60-75% loss in agriculture, a 45-55% loss in infrastructure, and a 40-45% decline in domestic animal husbandry. He identified key climate-sensitive and climate-resilient fish species, explaining that species such as Cynoglossus sp., Hemiramphus sp., and Mystus gulio were at high risk due to habitat loss, while species like Channa striata and Clarias magur exhibited higher resilience to environmental stressors. He highlighted the role of adaptive fisheries management strategies, including climate-resilient culture-based fisheries, in mitigating losses. He recommended the adoption of sustainable stocking strategies to minimize stress and mortality in fish populations and suggested promoting small indigenous fish species that had a higher capacity to survive in changing climatic conditions. He advocated for the integration of air-breathing fishes in marshy areas to sustain fish production in low-oxygen environments.

Dr. Ghosh discussed several mitigation and adaptation strategies that could rejuvenate the fisheries sector. He called for rebuilding wild stocks, improving fisheries governance, and managing declining incomes through alternative livelihood diversification. He emphasized the importance of ecosystem-based adaptation strategies such as the adoption of scientific cage and pen culture techniques with diversified species. He recommended adjusting fishing pressure to sustainable levels, setting catch limits based on recruitment, growth, and reproductive success, and using adaptive management tools to monitor fish populations. He stressed the need to modify fishing gear and craft types in response to environmental changes.

He described the successful implementation of the Climate Resilient Pen System (CRPS), which had been demonstrated across five wetlands in West Bengal. These systems had been stocked with climate-smart species such as Systomus sarana and Labeo bata, achieving significant survival and growth rates. He also discussed the Climate Resilient Cage System (CRCS), which had been introduced in the Media wetland using floating GI cages to rear resilient fish species. The CRCS initiative had yielded over 2,300 kg of fish, demonstrating its potential for stock enhancement in wetlands affected by climate change. He highlighted the success of climate-resilient aquaculture models, including integrated farming system demonstrations, crab fattening programs, and freshwater ornamental fish farming, which had provided alternative livelihoods for fisherwomen in South 24 Parganas.

Dr. Ghosh stated that the impact of climate change on fisheries had been mixed, with both detrimental and adaptive responses observed. He warned that climate change would continue to impose serious challenges on fisheries, affecting habitat stability, biodiversity, and fish production. He emphasized the urgent need to develop and demonstrate climate-resilient adaptation techniques, such as stocking climate-smart fish species, improving fish health management, and restoring indigenous fish populations. He stressed that environmental impact assessments and responsible fisheries policies should be prioritized to offset climate-related losses. Finally, he urged for a coordinated effort among policymakers, researchers, and fishing communities to implement location-specific, sustainable fisheries management practices that could ensure the long-term resilience of the fisheries sector in the Sundarbans.

Discussions:

The session discussion on climate change, livelihood security, and environmental resilience in the Sundarbans was engaging and insightful, covering various socio-economic and

ecological challenges faced by the region. The discussion commenced with a query on the movement of mangroves due to habitat encroachment from the north and rising sea levels from the south. A participant asked whether a stable settlement zone could be created where mangroves could thrive undisturbed. Panelists acknowledged that while mangrove regeneration was possible in some areas, it would not form a contiguous tiger reserve. They also highlighted that converting agricultural land into mangrove swamps would render it unsuitable for human habitation and farming, necessitating large-scale community relocation. Furthermore, rising salinity levels would make agricultural activities unsustainable, requiring careful planning for land-use transitions and alternative livelihoods.

Another critical issue discussed was the impact of overfishing and the depletion of juvenile fish stocks. A participant suggested that India adopt a seasonal fishing ban similar to Bangladesh's monsoon restrictions to protect breeding fish populations. Panelists confirmed that West Bengal already had a closed fishing season, but enforcement was weak. To mitigate economic losses for fishermen during this period, they recommended promoting alternative short-term aquaculture methods such as monosex tilapia culture, which could mature within three to four months and provide an interim source of income. The discussion also touched on the broader issue of livelihood shifts in the Sundarbans, where more than 50% of residents had moved away from agriculture. A 2020 survey conducted during the COVID-19 pandemic revealed that many households relied on manual labor, embankment construction, and migration for income, with MGNREGA employment schemes playing a crucial role in sustaining families. The panelists cautioned that if such government employment programs were discontinued, the region would face severe economic distress, irrespective of climate change impacts.

Prof. Hazra addressed a question regarding the current and projected sea-level rise in the Sundarbans, explaining that the latest estimates suggested an annual rise of 5 mm, with projections increasing to 6 mm in certain areas. However, he stressed that extreme weather events could cause temporary surges of up to 12 mm per year, significantly impacting local communities. While the Ministry of Earth Sciences had reported a 5 mm annual rise in parliamentary discussions in 2019, other studies, including those by the Centre for Science and Environment (CSE), indicated localized rates as high as 14 mm per year. He also noted that some areas, such as Sagar Island, were sinking at a rate of 10 mm per year, exacerbating the effects of rising sea levels. The panel emphasized that while mathematical projections

provided useful averages, people were more affected by extreme fluctuations rather than gradual increases.

The discussion then shifted to the potential impact of China's planned diversion of the Brahmaputra River and its effect on salinity levels in the Sundarbans. Panelists warned that reduced freshwater inflows from upstream would likely intensify saltwater intrusion, further deteriorating soil quality and reducing agricultural productivity. Additionally, the conversation expanded to include concerns about climate change research focusing too narrowly on temperature and sea-level rise while neglecting other critical environmental factors such as phosphorus and nitrogen cycles. The panelists reassured participants that studies were also examining these geochemical shifts and their influence on soil fertility. They noted that while nitrogen and phosphorus levels were generally adequate in Sundarbans soils, excessive potassium application—often encouraged by agrochemical companies—had led to imbalances that negatively impacted long-term soil health. They cited long-term agricultural experiments indicating that potassium application had shown no significant benefits for rice cultivation in the region, yet farmers continued its extensive use based on commercial recommendations.

A question was raised regarding the differences in sea-level trends between India's east and west coasts. The panel clarified that higher sea-level rise on the east coast was primarily due to the Earth's rotation, which pushed ocean currents toward the eastern coastline. This

phenomenon resulted in greater coastal erosion and a higher frequency of extreme weather events in eastern India. A participant mistakenly linked aquaculture activities to sea-level rise, prompting a clarification that fish farming did not directly impact sea levels but could influence local ecosystem health through excessive water usage and pollution. The panel reiterated that sea-level rise was driven by larger climatic and oceanographic forces rather than localized aquaculture practices.

As the discussion concluded, participants reflected on the importance of holistic climate adaptation strategies. Panelists emphasized the need for an integrated approach that combined environmental conservation, livelihood diversification, and strong governance. They stressed the importance of adaptive fisheries management, climate-resilient agricultural practices, and better enforcement of environmental regulations. The session closed with a reminder that while scientific models and projections provided useful insights, real-world adaptation required localized, community-driven strategies. Participants were thanked for their active engagement, and the session was commended for addressing the pressing socio-environmental challenges facing the Sundarbans.

Compiled by
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School of Environment and Disaster Management

SESSION-5:
EXISTENTIAL CRISIS IN SUNDARBANS: POVERTY, LIVELIHOOD AND MIGRATION

Keynote Address: Agricultural Systems Research: Key Takeaways

Speaker: Dr. Rupak Goswami (Associate Professor, School of Agriculture & Rural Development, RKMVERI, Narendrapur)

Dr. Goswami discusses the agriculture system primarily at the micro level, focusing on student projects and a small-scale initiative, both of which represent the wicked problems of contemporary society. The Sundarban exemplify a complex system in this context. This example illustrates the introduction of a leguminous scrub to examine its relationship with soil dynamics and soil carbon. The topic encompasses the emission and energetics of agriculture, linking the quality of animal products to human health and nutrition. Additionally, it involves the production market, which creates a feedback loop influencing human health, income, and nutrition. Another example is "Crossing the Boundary," which pertains more closely to migration research. Upon initiating the migration process, it became evident that the situation was neither simple nor straightforward. The phenomenon begins with male out-migration, resulting in women assuming increasingly proactive roles in agriculture. This shift contributes to a significant feminization of agriculture in the Sundarban, encompassing both managerial and labour aspects, influenced by various mediating factors that affect the outcomes. Our inception occurred in the 1960s and 1970s. What is the most significant crop, variety, or technology regarding production and profitability? This crop variety is optimal regarding input usage efficiency, environmental externalities, nutritional value, and the social and cultural preferences of stakeholders. We are inquiring about the appropriate advances for socio-ecological niches. The focus extends beyond evaluating technology for its optimal beneficiaries. We advance to inquire about the most appropriate agricultural food systems and value chains based on a specified set of criteria, as well as the performance of various farming systems under differing market and climate change scenarios. The subsequent action

point is as follows, how can we devise equitable agricultural systems that are resilient to stresses such as biotic factors and market fluctuations? Additionally, how can stakeholders be involved in the design of these equitable and resilient farming systems, and what are the pathways for impact creation through agricultural innovation?

In Lesson 1, comprehending heterogeneity is crucial for effective targeting. Social scientists have long worked to examine caste, class, gender, and tenure, employing agricultural economies that utilize landholding data. Typically, we establish a defined project mandate that integrates biophysical, socio-economic, demographic, cultural factors, and specialized mapping techniques, including satellite imagery, at both micro and macro landscape levels. This comprehensive approach can significantly enhance the precision of our interventions, which may be executed through participatory methods or sophisticated quantitative analyses.

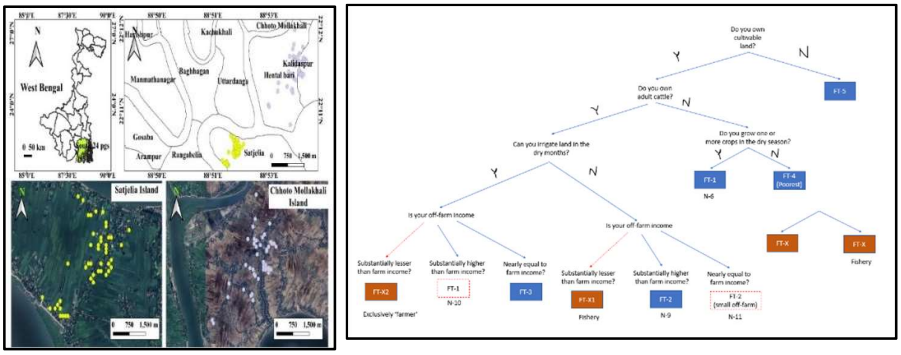


Figure: Scalable classification applied in wider geographical locations

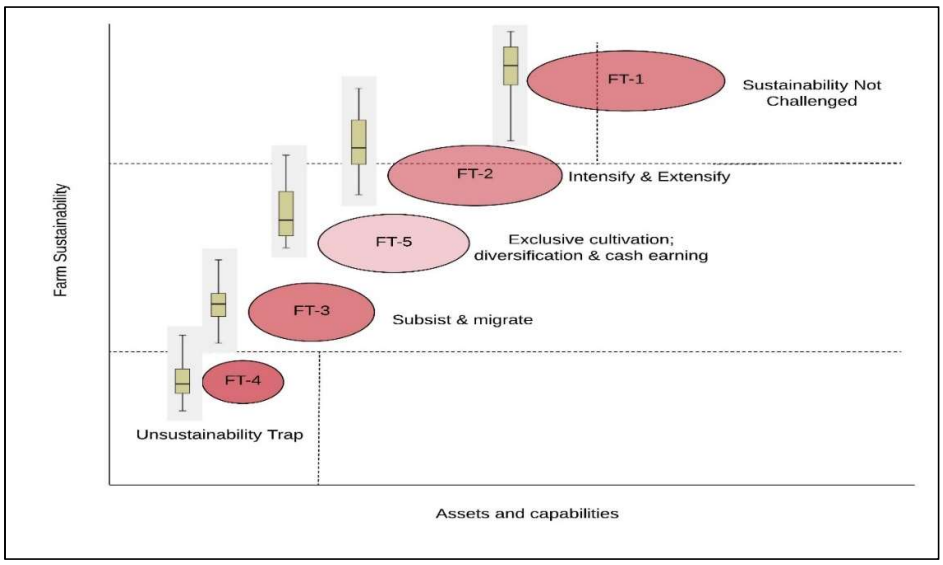


Figure: Farm Sustainability
Source: Goswami et al. (2023)

Various farm types' sustainability regimes concerning their assets and capacities are discussed here. More substantial portions of the ovals are indicative of a greater mean sustainability. A more profound shade of color indicates a bigger revenue earned off the farm. Whiskers display a range of sustainability that is not exactly true to the x-axis, indicating that there is fluctuation and overlap in the range. The point at which various sustainability regimes reach their tipping point is represented by horizontal lines.

In lesson 2, Strategic Choice of Technology of Integrated Farming Systems has seen significant research on land shaping models, which have been circulated. Currently, we are experimenting with this group of technologies under the CSI funding for sustainability intensification. Lesson two focuses on formulating a strategic decision on technology. A substantial amount of technology exists. Circularity and endogeneity are two notions deemed highly significant. We are discussing not only resources but also knowledge. Consequently, we are introducing the cultivation of vegetables with rice during the kharif season to enhance economic returns, and subsequently, we will utilize the residual moisture by cultivating zero potatoes under straw mulch conditions.

Figure: Zero Tillage Potato under Straw

Figure: Vegetable in sac with Kharif Rice Mulch Condition

In lesson 3, Traditional economics or econometric models are used to analyze the effects of technical interventions. However, we are now collaborating with a team of scientists known as system economists to incorporate crop modeling that accounts for environmental uncertainties with integrated profit. Certain crop modeling addresses environmental

uncertainties by integrating predictive adoption models to assess the implications of introducing new technology on adoption rates and overall economic averages over the next 10 to 20 years. Considering climatic variability and market instability.

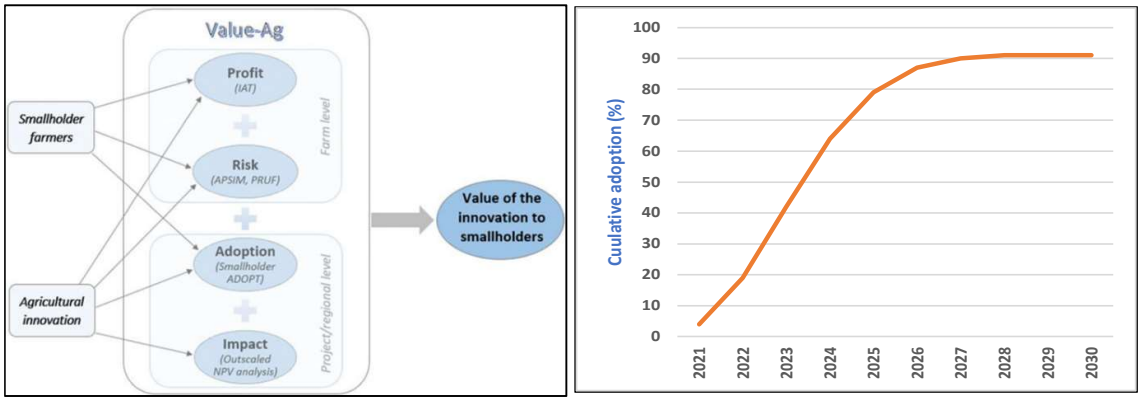


Figure: Value-Ag Framework (Monjardino et al. (2020) Fig: How many people are likely to adopt?

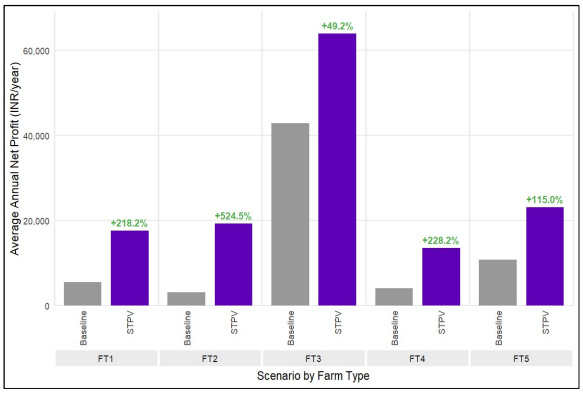


Figure: Who benefits? How much?

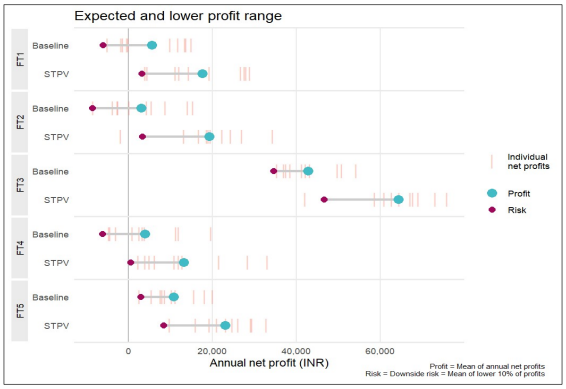


Figure: Whose benefits are less risky?

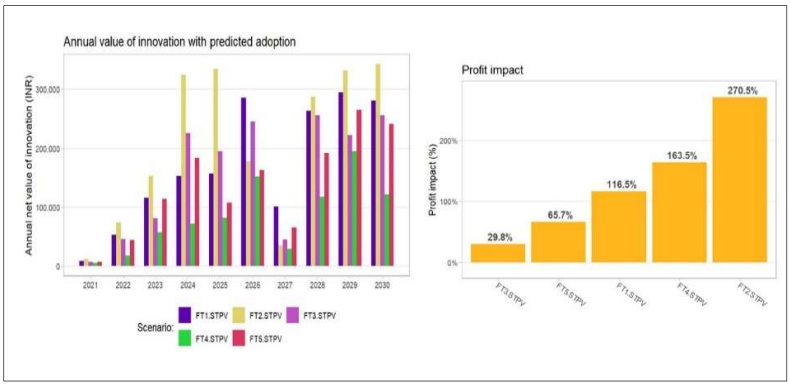


Figure: What is the profit impact in the region?

Source: Goswami et al. (2023)

In lesson 4, Multifunctionality needs to be accepted whether referred to as ecosystem services or intangible heritage, necessitating the establishment of frameworks that encompass this multitasking; otherwise, sustainable agricultural practices will only be viable when they are genuinely sustainable. This serves as a singular illustration, and it is crucial to comprehend the trade-offs among these several elements.

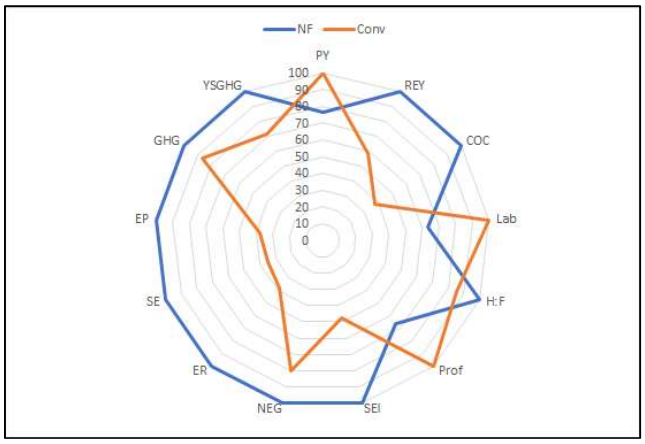


Fig: Paddy yield (PY), Rice Equivalent Yield (REY), Cost of Cultivation (CoC), Labour Engagement (Lab), Hired Family Labour (H:F), Profitability (Prof), System Energy Input (SEI), Net Energy Gain (NEG), Energy Ratio (ER), Specific Energy (SE), Energy Productivity (EP), GHG Emissions (GHG), and Yield-scaled GHG (YSGHG)

Lesson 5, People who are more central to the network are more resilient to disasters, and the evolution of this network has been characterized by fascinating dynamics. The social network has tremendous power to enhance people's resilience. This is another example of how social networks help speed up technology diffusion. We are currently monitoring the current data, potentially encompassing a decade of diffusion information. This does not pertain to the Geotech data, although it illustrates how innovation disseminates from one island to another. Social networks and building their capacity can speed up innovations. You can see that the before and after networks—the after one is so much denser and happened within 6 months—a fantastic project in Sundarban, where the central actors were given kind of mobile phones and internet connectivity. So, we provided advisory service, season-long advisory service, and then after that we measured what happened to the social networks, and we saw how it increased the information flow and more interest from the perspective of a social researcher, that is, the relative position of women in the society that went up, so now they are more central in comparison to the male members, so that's power.

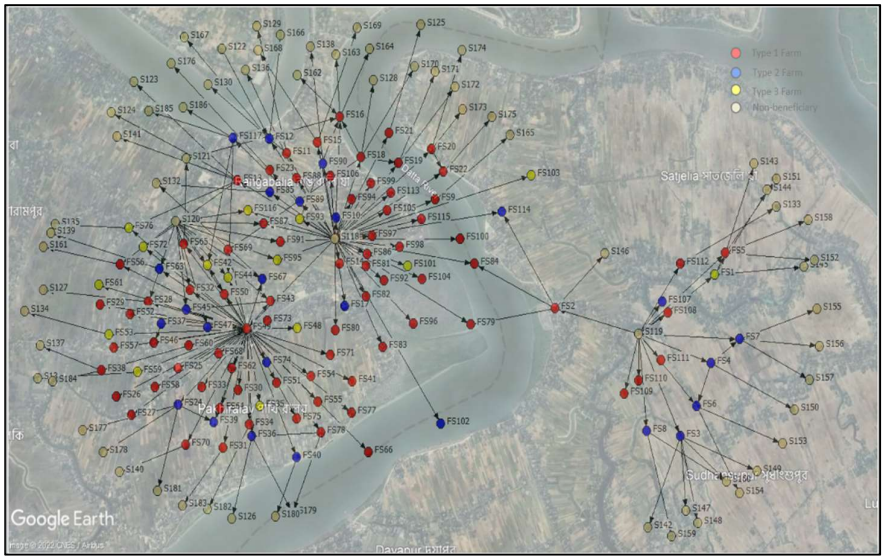


Figure: Social Networks Matter Innovation upscaling

Lesson 6, Stakeholder Wisdom for Decision-making Resilient Strategies after Amphan, during lockdown

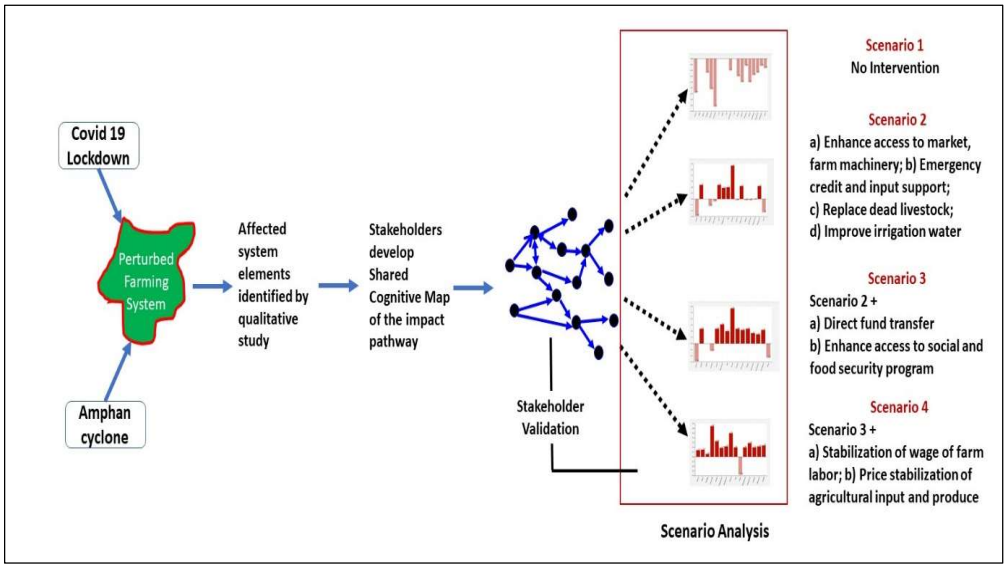


Figure: Decision-making Resilient Strategies after Amphan, during lockdown

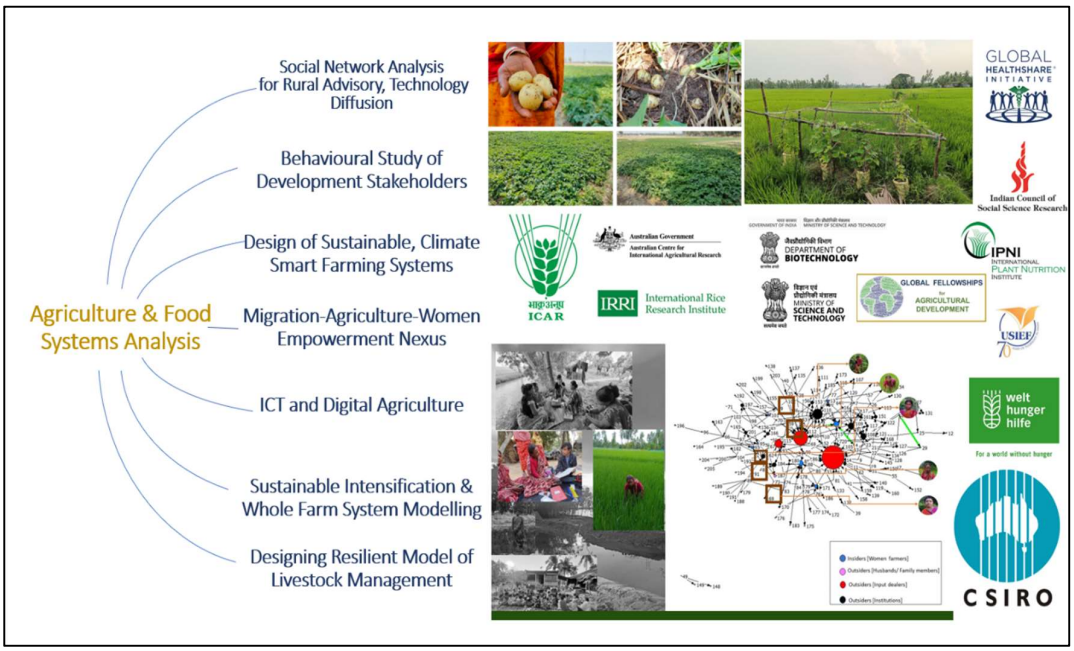


Figure: Agriculture & food system analysis for community building resilience

We have drawn on the knowledge of diverse stakeholders this is called cognitive mapping. Cognitive mapping of different stakeholders was put together to develop a kind of shared model for the region for a complex system.

Topic: Climate Refugees of Sundarbans

Speaker: Dr. Upasona Ghosh (Associate Professor, Indian Institute of Public Health Bhubaneswar)

Lester Brown introduced the term 'environmental refugees' in the early 1970s, which was later defined by El-Hinnawi (1985) as people displaced through either natural disasters or gradual environmental degradation. Environmental refugees were criticized for their vagueness by several scholars who suggested the term 'environmental migrant' as an alternative (Black 1998; Bates 2002). An environmental refugee, as per the book, refers to an individual or group of people who are forced to leave their habitual place of residence due to sudden or gradual changes in their environment that adversely affect their lives or living conditions. These changes can be attributed to natural disasters, such as floods,

droughts, or storms, as well as long-term environmental degradation, sea-level rise, or other climate-related factors. Environmental refugees may face displacement, loss of livelihoods, and risks to their well-being as a result of environmental changes beyond their control. Environmental refugee," alternative concepts such as environmental refugees' and 'climate refugees' (El-Hinnawi 1985) "environmentally-induced migration" (Hugo, 2008), environmentally motivated migrants' (Renaud et al. 2007) and "climate-induced displacement" have recognized the difficulty in labeling refugees in legal terms and also the recognition of multiple drivers of migration including physical vulnerability and climate change.

Uncertainties of Sundarbans:

According to Ghosh, the uncertainties of Sundarban are a combination of three variables, including ecological, knowledge-based, and policy-oriented aspects. Ecological uncertainties in the Sundarban are caused by many human, natural, and climate-related activities. This makes it hard for people to make a living in the Sundarbans, which makes climate-stressed people want to leave. There are scientific strategies to reduce the livelihood vulnerability of distressed people, but some strategies could not connect with the policy due to knowledge uncertainty. That means many stakeholders in Sundarban are working for vulnerability, but there is no correlation between their work, either doing parallelism or their familiar reputation within the island. Now the question is why they are migrating. They did agriculture, fishing, prawn seed collection, crab catching, and agricultural labour; despite all this, they were not able to bring economic balance for living, and they were forced to migrate to survive, which is called distressed diversification. The pattern of migration in Sundarban is like permanent outmigration; those are the educated rural elite because educational statistics are very good. That's a change in the very anthropological concept change in the world views migration as part of the globalization process. Seasonal out-migration is started as a coping after a disaster,

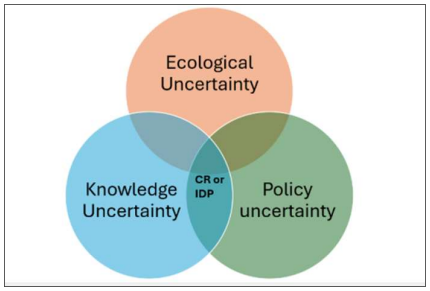


Figure: Uncertainty of Sundarban

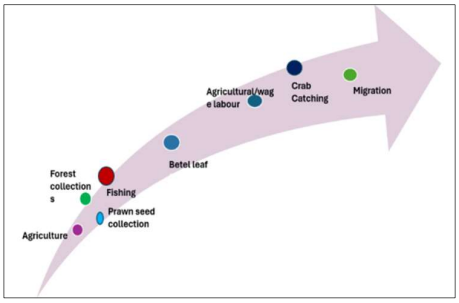


Figure: Livelihood flexibility

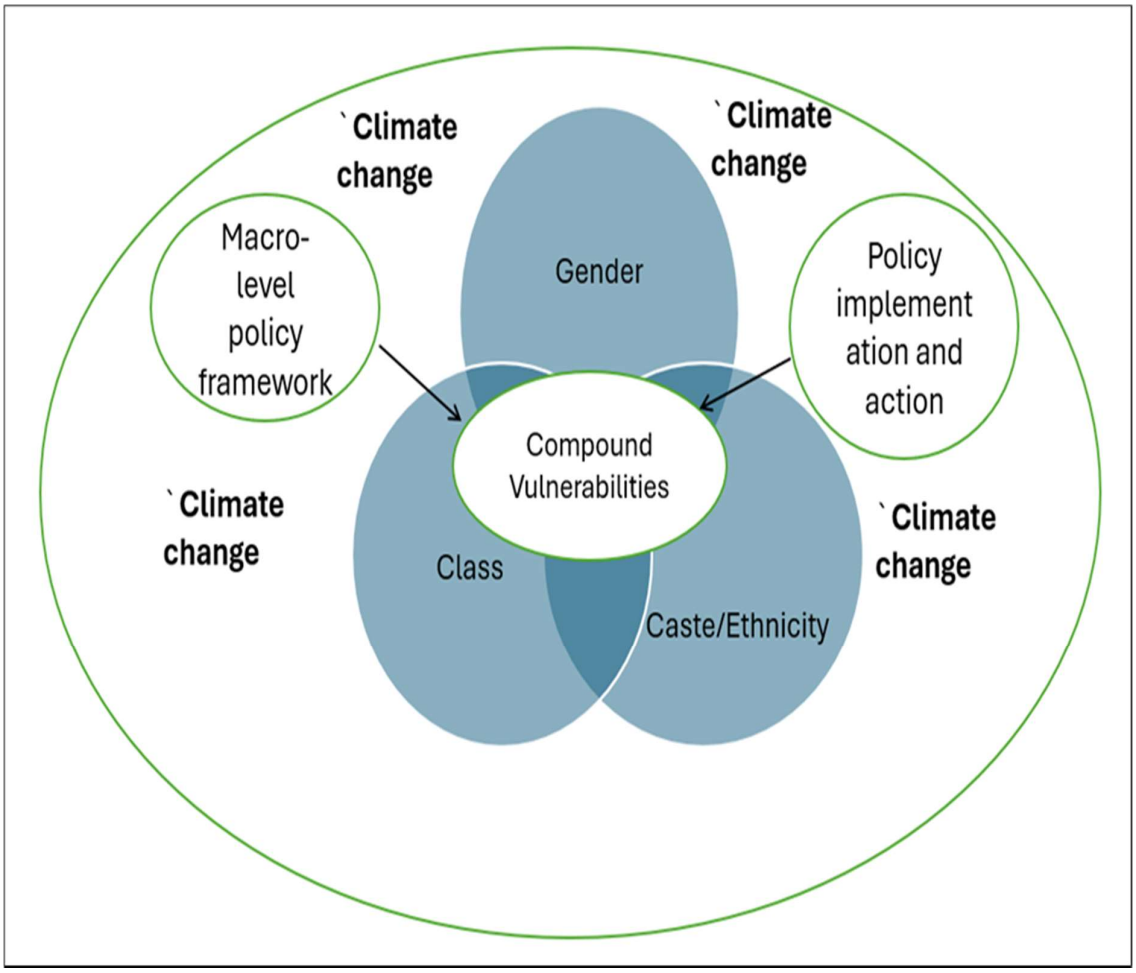


Figure: Layered vulnerabilities

and here males are migrating more than females and emergence of de-facto women-headed households and shown inter and intra-island mobility within the island due to rebuilding homes after a disaster. Especially after any disaster a Cyclone, a huge number of young girls are victims of sex- trafficking due to earning for family and increasing migration 14-15 years young as those boys drop out from school and migrate with their father or brother or uncle to earn the money. So now Sundarban are thinking about their survival, they believe that dependency on the Sundarbans leads to a dangerous and uncertain life, and they do not want that for their children. They treat this job as a necessity not necessarily a part of their core identity.

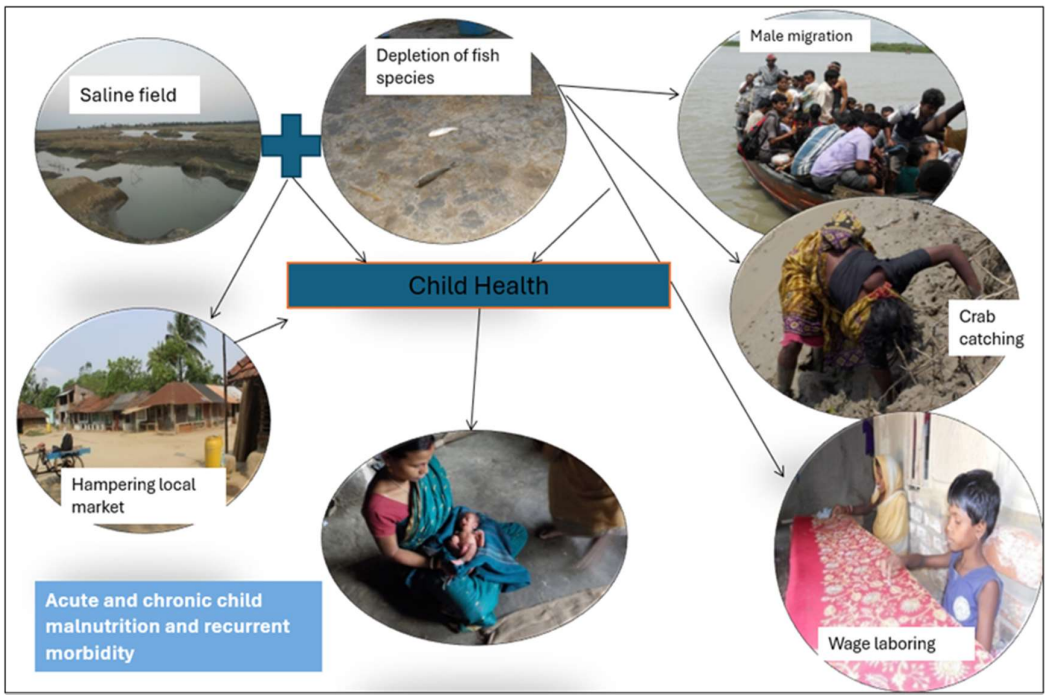


Figure: The impact pathway of climate change on child health in Sundarbans

Migrate with problem:

Adjust in a new setting in terms of language, culture and social practices

Mostly living in urban slums in unhygienic conditions

Prone to physical, mental and nutritional health and well-being

Subject to violence, deprivation and further marginalization

Challenges expressed due to migration in the Sundarbans

Challenge 1: Seasonal migration is not feasible due to

Child and elderly care,

Looking after the household and other residual assets,

Social norms.

Challenge 2: Less or risky options available within the island

Working as Agri-labour in betel leaf cultivation in low-wage

Less available wage laboring options within the village

Strenuous and risky options like crab-catching

Challenge 3: Lack of skills and training to take alternatives

The age-old practice of agro-fishing economy

Lack of training in new skills like embroidery or handicrafts

Not well connected with community-based skill-building organizations

Challenge 4: Domestic violence and mental stressors

Increasing incidences of quarrelling and wife beating

Increasing incidences of adultery

Increasing insecurity about life and future

Occurrence of deliberate self-harm

Challenge 5: Early marriage of girls

Tendency to marry of the girls as early as possible to get them out of the island

Getting support during emergencies if the girls are married outside the island

Difficulties of the parents to maintain the educational cost of the girls

Challenge 6: Breaking of joint families

Increasing livelihood uncertainties and economic burdens lead to the breaking of joint families.

Women's workload increases if they are staying in joint families Women with migrated husbands are in favor of breaking joint families.

Climate migration in loss and damage debate:

Refugees there in the larger debate of loss and damage so loss and damage they gaining to some extent and traditional livelihood. We need to consider non-economic loss and damage such as loss of traditional and cultural knowledge, Loss of identity and heritage, loss of traditional livelihood alteration in social network and family structure psychological challenges of adjusting to a new setting.

What can be done?

Limited evidence is in the migration statistics from the Sundarbans. Policy-making and programmatic action require a detailed understanding of the generation of migration trends. Implementing designated recognition as "climate refugees" is necessary for the people of Sundarbans who have lost their homes and relocated elsewhere. Formal recognition will pave the path for social and medical benefits. Laws that can protect climate refugees.

- International refugee law (IRL)
- International Climate Change Law (ICCL)
- International human rights law (IHRL)

- Climate refugees are a specific vulnerable population with specific livelihood, health and well-being needs. A special plan is the need of the hour for livelihood alternatives and re-settlement
- Special attention is required for the women and children who are left behind by their seasonal migrant male counterparts. Evidence is almost absent regarding their life and well-being.
- Physical and mental health and well-being of seasonal migrants need to be evaluated to make equitable provision for the seasonal migrants.

Topic: Changing Climate, Migration and Precarious Livelihoods in the Sundarbans Delta: Challenges and Opportunities

Speaker: Dr. Debojyoti Das (Lecturer, School of Oriental and African Studies, University of London, UK**)**

Dr. Das raises the question of why he has chosen to title his topic "Changing Climate." The villagers of Sundarban express their concerns predominantly in the present moment. They are less worried about the future but the present vulnerability for which they are seeking solutions. In an interview, I did in 2022, my interlocutors observed, "**This year they have witnessed the late arrival of the monsoon, and when the rain arrived untimely, their standing crop was destroyed. Government help came too late. Many farmers became indebted as they borrowed money from SHG and moneylenders to buy seeds and farm supplies. Many were forced to migrate to neighbouring states to supplement the loss of income and to pay debts".** Here vulnerability is triggered by unpredictable weather conditions (rainfall pattern), but the social impact of the vulnerability is multi-scalar, leading to indebtedness, migration, loss of income, farmers' suicide, and precarious occupations that lead to tiger and crocodile attacks. Therefore, the vulnerability is multidimensional—it has socio-political and economic dimensions besides being a natural cause-and-effect relationship. Often, the "slow onset" and "rapid onset" impacts of climate change principles don't capture these nuances, as these challenges are embedded in the political economy of the place. The economy of the

land, particularly with male and female relationships of migration, how much land they own, and who can migrate, because not everybody is migrating.

Migration Contemporary period:

- Reverse migration- Became most apparent after the Aila Cyclone in 2009 but has been growing even after the 1990s.
- Livelihood crisis central to this dilemma- vulnerability and precarity
- Caused by water scarcity, unpredictable monsoon, soil salinization
- But they are not only determined by changing climate
- There is an intersectionality of factors, not everyone is affected equally by these changes.
- Depends on gender, land holding capacity, type of farming, and decline in the prawn hatchling business.

Our vision is caught between dystopia and utopian logic, so the dystopian logic suggests that environmental ruination is happening everywhere and is going to lead to the mass migration of people, and the only respite lies in the "planned retreat," the "managed retreat," or the "planned relocation" of the population. We are currently kind of debating and putting it in our policy framework. This is guarded by a **utopian** vision that once human settlements are segregated from the delta buffer zone, vibrant biodiversity can be conserved. So, this is our assumption; this is our hunch. What is missing from this grand vision is the community's voice and what they want. Communities in the Delta are tied up to their circumstances which are defined by the availability of land that they have par availability of land the water-based livelihood they have fisheries forest going activities and all these kinds of challenges that they face from the forest department and other kinds of stakeholders in the sundarban those are the kind of real challenges that people are confronted with migration to the city and planned evacuation is not the permanent solution because people are not migrating permanently to the cities they are actually migrating in a circulatory fashion they either going temporarily or they are going seasonally and the migration pattern has itself taken many dimension and often people are trapped to seasonal and circulatory migration. So, this is a very interesting book written by Camelia Dewan, and it's based on a study done in Bangladesh called Misreading the Bengal Delta: Climate Change Development and Livelihood in Coastal Bangladesh. The problem lies in understanding the multi-dimensional nature of poverty, inequality, and inequity in the Sundarbans in terms of landholding,

restrictions on access to commons (minor forest products—wax, honey, firewood, etc.), gender norms, low levels of education and health care facilities, and the loss of food security and sovereignty.

Key research questions:

What temporal and spatial forms of migration are occurring, and who decides to migrate?

1. How do environmental factors, social aspects, and individual motives influence the decision to migrate, and why do some people migrate while others stay in areas affected by environmental disasters?
2. What are the health outcomes of migrants in their new settlement areas?

Case study of three female households who migrate because of diverse motivations:

The author found that the link between climate change and migration to be far more complicated than usually perceived. An audio-visual interview from one household reveals some interesting facts. **The first lady,** the key interviewee, stated that she works as a migrant labourer in Andhra Pradesh seasonally. She started migrating for work soon after the 2009 Aila cyclone. While her husband joined her later from Anadama. Both live together in labour camps but work in separate male and female work parties due to differential wages. **The second lady** we interviewed in her family remains in the village because she believes that the family home is the abode of women which she calls *'samsara*'. She observed in her interview that though women leave the village for work men who stay behind don't take care of the children in the household as women do. The burden comes back to the women to take care of their children and their nephews. Therefore, she has stayed back in the village. **The third lady** of her Sister-in-Law migrated very recently not because of the cyclone's impact on livelihood but because of a crocodile attack. A year ago, when she went to the backwaters to catch Bagda min. This stopped her from venturing into the forest and forced her to migrate to Andhra Pradesh for work during the agricultural season where she now gets wage labour throughout the year.

The interviews with three female heads in the absence of their husband reveal very clearly how the climate refugee phenomenon can be distorting and complicated. An audio-visual ethnography carried out by lead female interviewers reveals the agency of informants who were all women with different perspectives on migration. By managing affairs at home and at places of work where they migrated women shared their triple burden as well as embedded resilience to develop sustainable livelihood and caregiving roles within the household while

at the same time ensuring the economic sustainability of their families. Even from the feminist perspective, the migration story is complicated.

We discovered that the relationship between climate change and migration is significantly more nuanced than commonly believed. There are different motivations for migration and not migrating, so climate change may play a much lesser or secondary role in people's decisions or motivations. Who migrates, and who remains trapped? The burden lies on female members of the family and the elders who take care of the household, so that is the common trend. What we have seen in all our interviews was not uniform. It reflected the multifaceted nature of the gendered experience of migration. While some women started working as migrant labourers when they were mere children, others only started after their children were grown up enough to take care of themselves. The nature of their labour was not uniform either—while some go away for short stints once or twice a year for agricultural labour, others become domestic workers at 'Kothis' or households for longer periods. Most stay away from their homes, missing their families, but at the same time, some of them also mention enjoying the experience of new places and their cultures and earning a solid amount of money to sustain their families and secure their future.

Who migrates and who finds themselves trapped?

The burden lies on the female members of the family and the elderly to take care of the household and manage the farm, dependent children, and aging in-laws and parents. Because of patriarchal norms, unequal wages and poor living conditions in sites of migration such as urban slums women are discouraged from migrating for work. The intersection of gender, patriarchy and class all play a role in shaping household mobility. For some migration is a dream to escape vulnerability for others migration has posed many changes and has resulted in a return back home. Therefore, we need to create more resilient livelihoods.

Opportunities for action:

- Nature-Based Solutions- developing natural fibers, and aqua geophonic to develop crops that are salt tolerant and can survive flood water.
- Promoting a blue economy discourse with care and conviviality
- Community action based on **Eco-*Swaraj*** or **radical ecological democracy.**
- Bridging expert knowledge with citizens' science for better implementation of projects that attend to local needs and capacity.

- From experimental farm to community intervention.

Figure: Eco-*Swaraj*

Topic: Migration, Women and Feminisation of Livelihoods: Unfolding the Narrative

Speaker: Dr Srija Basu (Independent Researcher and Consultant)

Migration and displacement are fundamentally connected to economic and social factors, requiring income generation in areas deficient in natural resources and resulting in environmental and economic migrants (ECOSOC 2011). Rural-to-urban migration is driven by factors such as diminishing agricultural output, adverse weather conditions, drought, flooding, and hunger. Migration, a social factor of health (WHO 2005; IOM), including migratory workers who remain and bear an increased burden of responsibilities. Intra-regional migration in Africa, India, Latin America, Morocco (Najjar et al., 2018), and Tajikistan (Mukhamedova and Wegerich, 2014) involves women relocating within rural areas to participate in agricultural labor. Adaptation and agency can mitigate distress migration. The ILO 2017 analysis indicates that the disparities in social protection coverage are most pronounced in Asia and the Pacific (61%) and in Africa (82.2%) (Basu 2021).

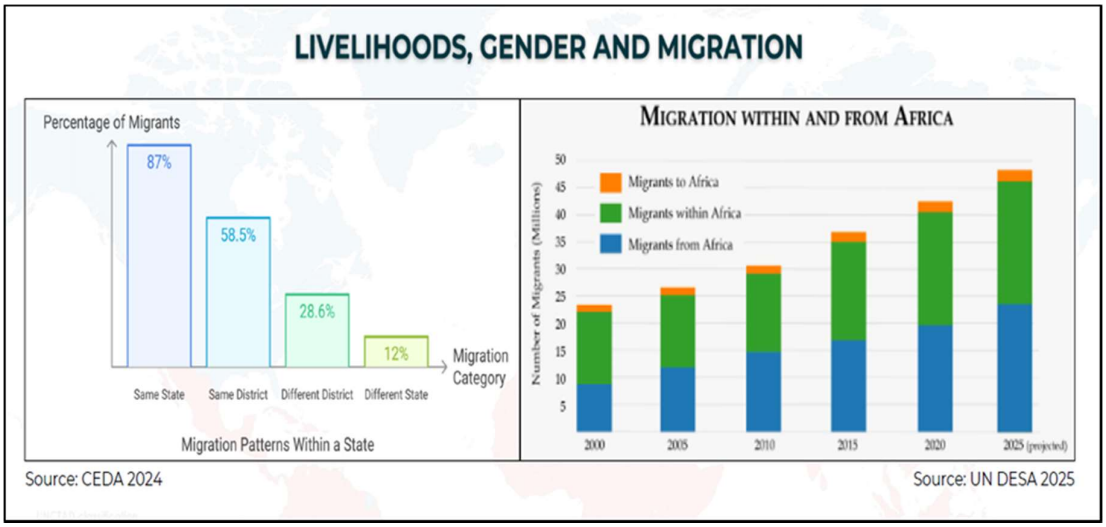


Figure: Livelihoods, gender and migration in Africa

Dr Basu claims that mitigation measures cyclical poverty and adverse health. In India, women are mostly farmers but also secondary earners. This is a problem that is similar to what happens in Africa when you look at women and coastal livelihoods. To help the most vulnerable people and women in India's coastal areas, the MoEFCC, the Government of India, and the UNDP worked together on the project called "Enhancing Climate Resilience of India's Coastal Communities" (2019–2024). But I want to talk about gender equality and women's work and contributions. I want to talk about the most vulnerable people and women in coastal areas, which is probably more relevant for the Sundarban. If you look at places like West Africa, you'll see that women are getting more opportunities in the fishing industry; they're known as resource users who lead fisheries, and they're taking part in more administration and co-management within communities. Studies have shown that the fishing and fisheries industries have historically been gender-based and organized to favor men over women. We hope that some of this can change, even in India.

Insights	Opportunities:
West Africa - (EO Chuku 2022) Tanbi wetlands (the Gambia); Densu Delta; promote women resource user-led fisheries in co-management **India** - (fieldwork) in Majuli islands Assam - decline of wetlands has led to male	Comprehensive social assessment; integrate gender equitable opportunities in climate adaptation strategies with gender-responsive climate action. Perceive beyond “reflexive” (World Bank 2021) short-term compensations -

outmigration and coping to find alternate livelihoods; Mishing tribe women overburdened	Promoting infrastructure/boosting social security & livelihoods and reducing multidimensional vulnerabilities.

Dr Basu engaged with numerous communities, observing significant male out-migration and individuals seeking diversification of livelihoods, while women bear the brunt of fishing. Additionally, issues of hierarchy persist. They are unaware of the potential benefits of money generating. Women are inherently diligent and industrious, hence they seek greater chances in weaving and similar fields to empower themselves. Some of the social protection initiatives in the global South these are interesting and perhaps again as good practice can be adopted in the India context because we see that while social protection and safety net is meant to you know make and Empower vulnerable communities and increase their livelihood opportunities and give them sort of security and we see that in East Africa cash transfers productivity you know cash transfers have led to minimize out migration because that's what they prefer it has increased productivity and adaptation mechanisms as well whereas in southern Africa in some of these regions we see that benefited Children and Youth and accelerated economic and short distance mail out migration and in Ethiopia also the productive safety program which kind of tries to discourage climate migration rather labor migration in during low agricultural periods to protect them and you know through food security safety and help them find to generate non-farm income and this is again Brazil which Cash-for-work programs show minimized outmigration & displacement , better coping mechanisms.

In the Indian context, the Maharashtra field study examines a concept known as payment for ecosystem services, which aims to recompense individuals for their poverty. Addressing poverty issues enhances livelihood security while simultaneously conserving the environment; in return, the government provides incentives to help individuals manage climatic stress.

Key findings on Migration patterns in Maharashtra:

- Maharashtra - skilled & unskilled migration BPL/Dalits /Adivasis); temporary migrants
- Inter-district and inter-state migration - sugar factories and brick kilns

- Male (inter-district) outmigration to - Ottur, Junnar, Rajuri; Pune and Mumbai- construction laborers, waiters/cleaners
- Women commute 20 km to flower/vegetable farms/sugarcane fields
- Partial earnings to employee contractors as commissions; earn INR 10,000-12000 annually.
- Construction sites: Women INR 200; men INR 500

Parameters	2023	2024	2025
Seasonal unemployment	34 %	32%	31%
Low wages	31%	30%	33%
Emergency expenditure	22 %	22%	20%
Debt repayment	15%	16%	16%

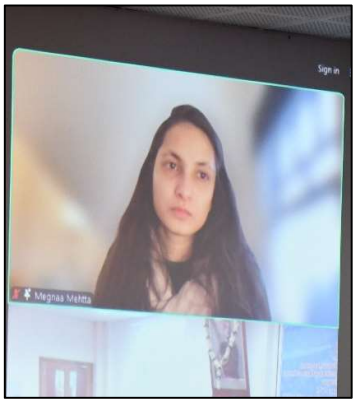
Source: Maharashtra Migration Survey (2021-2025)

Recommendations:

- Agenda 2030 for Sustainable Development (SDGs)
- Sendai Framework for Disaster Risk Reduction (2015–2030)
- Nansen Protection Agenda and the Guiding Principles on Internal Displacement
- UNFCCC's Enhanced Gender Action Plan (2019) for resilience-building
- Climate policy-making - gender-inclusive/responsive practice, assess the gendered push and pull factors
- Contextualizing global interventions/programs to scale up regional & local scenarios for (gender) equitable climate action
- Prioritising experiences of women & girls as migrants(workers/spouses/members)
- Women's land ownership/assets in resource-based livelihood
- Nuanced quantitative & gender-disaggregated data imperative

Topic: Multi-Dimensional Poverty in Sundarbans

Speaker: Megnaa Mehtta (Lecturer in Social Anthropology, Institute of Risk and Disaster Reduction, University College of London, UK



The Multidimensional Poverty Index (MPI), set up in 2010 by the Oxford Poverty & Human Development Initiative (OPHI) and the United Nations Development Program incorporates many criteria from the University of Oxford, which was founded in 2007. Poverty can often be explained by singular metrics, such as income. However, no single metric can capture the various dimensions that define poverty. Multidimensional poverty comprises various characteristics that define the deprivation experienced by impoverished individuals, including poor health, insufficient education, inadequate living standards, lack of income, isolation, substandard employment, and exposure to violence. People who live in circumstances that fall short of the minimal internationally accepted norms for basic functioning—such as having access to clean water, enough nutrition, or education—are included in MPI. It describes people who live in circumstances that prevent them from simultaneously meeting the minimal requirements in multiple areas. Stated differently, the MPI assesses those who face several deprivations, such as those who lack clean fuel, clean drinking water, or proper sanitation in addition to being undernourished. The author discusses multidimensional poverty in the Sundarban and her investigations. She is a social anthropologist. The author conducted long-term fieldwork in the Sundarbans, focusing on conservation from the perspective of fishing communities as well as consumption patterns, which are inextricably linked. So, what are the causes of poverty and what is the solution? As a result, a major portion of coastal dwellers' current poverty and vulnerability can be attributed not just too rising oceans but also to an environment of weak governance and the intrigues of local political parties.

We acknowledge that some of the issues are governance-related. We cannot blame climate change for poverty, as it has existed and existed before climate change became a climate emergency. The author means, people in the Sundarbans, as we know, have been living with endemic cyclones, storm surges, and flooding, so this is not new in the Sundarbans of the Bengal Delta, but the author thinks some of the challenges of poverty are very much due to governance, and of course, West Bengal, as mentioned, is famous for its political violence,

and this is something that we'll have to take into consideration when we think about the implementation of all of the recommendations and the roadmap. Conservation is crucial to this heritage site because it is the only mangrove forest in the world with Bengal tigers. The forest department has a huge role to play in the work of conservation. We need to question conservation to protect the ecosystem; we've got buffer zones and sanctuary areas from the Wildlife Protection Act, which was passed in 1972. Most of all fishing communities cannot enter the core and sanctuary because the buffer is on Bangladesh's borders and inaccessible. Those who would have done research in the Sundarbans will be aware that you need to hire a BLC or a boat license. There are 924 active BLCs in existence for the nearly 140,000 fishers in the region. Some have a Fisherman ID card issued by the Fisheries Department, and some would be eligible for compensation from the Wildlife Protection Act as well as that of the Fisheries Department. The compensation would amount to about 7 lakhs.

Land Acquisition:

"It all depends on politics. If you keep good relations with the political party in power, you will get all the benefits. We don't own the land, and we get no compensation. "In the Sundarabns, often the worst off are not SC/ST but Muslims.SC and ST communities had obtained government caste certificates, entitling them to several government welfare schemes, whereas the Muslim community was unable to access even basic government assistance. – because they were categorized within the government nomenclature of OBC (Other Backward Castes).

The absence of an integrated River management approach:

Civil engineers build huge structures but do not understand the workings of the river. A narrow sectoral attitude and the lack of a holistic approach to river management should ideally be brought under a single umbrella—these different ministers, officials, and bureaucrats need to speak with each other. These stakeholders don't talk to one another. We need open-access data.

Basic Infrastructure:

Resorts and hotels are being constructed. Residents still have very inadequate access to basic roads, embankments and transportation.

Figure: poor transportation and embankment

Compensation and Corruption:

Cyclone Bulbul caused a lot of damage. We were fine in Amphan, there were huge amounts of relief that came for Amphan but there was no help for Bulbul. If they announced the cyclone in Kolkata, then they came with packaged food and water for Bulbul, we didn't have drinking water for days. But it was during Yaas and the salt water which entered our homes that forced us to move… all those people who do the Party got the compensation. We didn't get anything"

Perils of Proposed Climate Adaptations:

Climate reductive agendas suggest that as sea levels rise and salinity increases, villagers should convert their paddy fields to cultivate shrimp for export. Saltwater shrimp are entangled in environmental degradation.

Planned Retreat or a "planned green partition"?

WWF and ORF technocrat economists and conservationists suggest that evicting poor and vulnerable persons from their land is justified due to the long-term economic-ecological benefits of conservation. The retreat is a form of double dispossession—a negation of human and nonhuman life worlds. Conservation as a Carbon Trading and a "Planned Green Partition".

Vulnerabilities beyond the climate:

Coastal residents' concerns were about the poor access to healthcare, which is the single biggest cause of indebtedness. Their anxiety was not sea-level rise but a lack of dignified work. The forests opposite their homes had become increasingly difficult to earn a livelihood

from. Healthcare, access to water, and food security were of paramount concern. These are issues of long-standing governance and not of a warming world.

Women's Everyday Struggles:

Bad marriages,

Domestic abuse,

Unwanted/early pregnancies,

A transition from arranged marriages to love marriages,

Seeking better education for their children,

Better healthcare,

Escaping the role of social reproduction.

The author concludes that MPI, when combined with physical and social vulnerability, delineates specific aspects of each. Physical vulnerability encompasses erosion, flooding, increasing salinity, and river management, while social vulnerability pertains to healthcare, access to water, food security, poor quality of education and other factors influenced by poor government policy and political violence.

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Session-6:
Reducing Risks of Disasters: Structural and Non-Structural Solutions

Keynote Address: Dr. Indrajit Pal (Associate Professor and Chair Disaster Preparedness, Mitigation and Management Program, Asian Institute of Technology, Bangkok)

Dr. Indrajit Pal talked about "*Delta resilience*", summarizing the content from his two recently published articles on Asian mega deltas and its key issues in attaining resilience.

1. Building Resilience in Asian Mega-Deltas: A Scientific Summary

The five Asian mega-deltas (5AMDs) — the Yangtze, the Pearl, the Chao Phraya, the Mekong, and the Ganges–Brahmaputra–Meghna (GBM) deltas are home to approximately 80% of the global deltaic population and account for 90% of global flood exposure. These deltas face escalating threats from climate change and human activities, such as coastal flooding, saline intrusion, and erosion. This review aims to identify transferable lessons and strategies to build climate resilience across these critical deltaic regions.

Current Hazards in the 5AMDs

The 5AMDs experience similar climatic hazards, primarily driven by their location in the South and Southeast Asian Monsoonal Climate Zone. Key threats include:

- **Monsoonal Flooding:** Up to 90% of the annual rainfall occurs from June to September, leading to significant flood risks.
- **Coastal Erosion:** Reduced sediment flow due to upstream dam construction and sand mining exacerbates coastal erosion.
- **Saline Intrusion:** Rising sea levels and reduced freshwater influx push saline water further inland.

- **Cyclones and Storm Surges:** Cyclonic activity, especially in the GBM and Mekong deltas, causes devastating storm surges and extensive damage.

Individual Delta Challenges

1. **GBM Delta:**
    - Home to 140–190 million people, this delta faces severe cyclonic activity and flooding.
    - Extensive polder construction since the 1960s has reduced coastal flooding but increased pluvial flooding.
    - Strategic efforts include the Bangladesh Delta Plan 2100.
2. **Yangtze Delta:**
    - Highly urbanized with a population density of 656 people/km².
    - Monsoonal flooding and typhoons cause significant economic losses.
    - Dependence on engineered infrastructures, such as seawalls and levees, has increased exposure to coastal flooding.
3. **Pearl Delta:**
    - Hosts 50 million people across low-lying floodplains.
    - Threats include subsidence due to groundwater extraction and saline intrusion.
    - Technological advances like real-time hazard monitoring have been implemented.
4. **Mekong Delta:**
    - Supports 30 million people, with a strong reliance on agriculture and aquaculture.
    - Faces sediment starvation due to upstream dams and sand mining.
    - The Mekong Delta Plan and Regional Masterplan outline sustainable development and adaptive strategies.
5. **Chao Phraya Delta:**
    - Encompasses Bangkok, a major economic hub.
    - Prone to flooding due to heavy rainfall and land subsidence.
    - The Climate Change Master Plan aims for sustainable growth and disaster mitigation.

Future Challenges

The 5AMDs face compounded risks from climate change and human intervention, including:

- **Sea-Level Rise:** Expected to rise by 0.6–1.2 m by the end of the century.
- **Cyclone Intensification:** More frequent and intense cyclones will exacerbate coastal hazards.
- **Increased Population Pressure:** The 5AMDs' population is projected to rise from 400 million to 500 million by 2100.
- **Upstream Interventions:** Dams and diversions are reducing sediment delivery and freshwater flow, heightening risks.

Resilience Strategies

1. **Strategic Delta Planning:**
    - GBM and Mekong deltas use long-term strategic plans (Bangladesh Delta Plan 2100, Mekong Delta Plan) to identify risk hotspots and guide adaptation strategies.
2. **Technological Advancements:**
    - The Yangtze and Pearl deltas use forecasting systems, real-time hazard monitoring, and mobile apps to enhance disaster preparedness.
3. **Nature-Based Solutions:**
    - Coastal mangrove afforestation and wetland restoration in GBM and Mekong deltas help mitigate erosion and storm surges.
    - Sponge cities in the Yangtze and Pearl deltas integrate green and blue infrastructure to manage urban flood risks.
4. **Community-Based Initiatives:**
    - Rural communities in the GBM delta practice tidal river management and diversify livelihoods (e.g., combining rice farming with shrimp aquaculture).

Transferable Lessons

Cross-delta collaboration can strengthen resilience by sharing successful strategies:

- **Urban Areas:** The Sponge City Programme's success in the Yangtze and Pearl deltas offers a model for flood mitigation in urban centers of the GBM, Mekong, and Chao Phraya deltas.
- **Rural Settings:** GBM and Mekong deltas' approaches to livelihood diversification and mangrove conservation can inform other deltas.
- **Forecasting and Insurance:** Real-time monitoring and flood insurance programs in the Yangtze and Pearl deltas can inspire similar systems elsewhere.

Conclusion and Future Perspectives

To build long-term resilience in the 5AMDs:

- Integrate top-down (policy-driven) and bottom-up (community-driven) approaches.
- Foster cross-delta collaboration through initiatives like a **Regional Delta Resilience Alliance**.
- Align development strategies with changing delta dynamics due to climate change.
- Enhance data sharing, forecasting systems, and nature-based solutions.

By embracing shared knowledge and innovative solutions, the 5AMDs can collectively work towards sustainable delta management and climate resilience.

2. Multi-Hazard Livelihood Security and Resilience of Lower Mekong Basin Communities:

The Lower Mekong Basin (LMB) is a critical region within the Mekong River system, supporting approximately 50 million people who depend on its natural resources for their livelihoods. The LMB spans Cambodia, Lao PDR, Thailand, and Vietnam and is a socio-ecological hub with diverse agricultural, aquacultural, and small business activities. However, the region faces increasing exposure to multiple hazards, predominantly floods and droughts, exacerbated by climate change and anthropogenic activities. Understanding these interconnected risks is essential for developing robust strategies to enhance livelihood security and resilience.

Multi-Hazard Vulnerability and Risks:

The LMB experiences a complex array of hydrometeorological and climatological hazards. Floods, while often destructive, also bring benefits such as nutrient deposition and fish replenishment, critical for agricultural productivity. Conversely, droughts severely impact soil moisture, crop yields, and water availability. The frequency and intensity of both hazards have risen due to climate change, leading to unpredictable precipitation patterns and increased evapotranspiration rates.

Anthropogenic factors like dam construction, deforestation, and urbanization have further strained the LMB's ecosystems. The modification of natural flow regimes disrupts aquatic ecosystems, reduces sediment transport, and intensifies flood and drought cycles. Additionally, transboundary water governance complexities among the Mekong River Commission's member countries pose challenges for coordinated hazard management.

Livelihood Security and Resilience:

Livelihoods in the LMB are primarily agrarian, centering on paddy farming, livestock rearing, and aquaculture. These activities are highly vulnerable to climate extremes, as rural economies rely heavily on rain-fed agriculture. The study identifies that livelihood resilience in the LMB depends on the ability to maintain agricultural production, ensure household food security, and protect economic assets from hazard impacts.

The resilience concept encompasses ecological, social, economic, and livelihood dimensions. Social resilience refers to a community's capacity to adapt to socio-political and environmental changes, while ecological resilience pertains to an ecosystem's ability to withstand disturbances. These two are interlinked, especially for LMB communities reliant on natural resources.

Methodology:

The study applied the Standardized Precipitation Index (SPI) to assess drought characteristics over a 41-year period (1981–2021), using CHIRPS data. The SPI allowed for temporal comparisons of short-, medium-, and long-term drought events, highlighting increasing drought duration and severity post-2000. Flood frequency analysis was also conducted, showing a rise in flood occurrences, particularly in Cambodia and Vietnam.

An expert workshop at the Asian Institute of Technology, Thailand, provided qualitative insights into livelihood resilience. Experts identified five key questions for assessing resilience:

1. Resilience of WHAT (livelihood systems)
2. Resilience to WHAT (specific hazards like floods, droughts)
3. Resilience for WHAT PURPOSE (sustaining agricultural productivity, economic security)
4. WHAT are Resilience Capacities (early warning systems, agro-advisories, structural measures)
5. WHAT enhances Resilience (collaborative strategies, capacity building, technology transfer)

Findings:

Drought analysis showed the central and southeastern LMB experiencing the longest and most severe dry events, largely due to delayed monsoons and El Nino events. Flood mapping

revealed high-risk areas in the lower basin, with increasing inundation depths in downstream regions.

The workshop emphasized that resilience strategies must integrate structural measures (e.g., flood dikes, irrigation systems) and non-structural measures (e.g., land use planning, drought-tolerant crop varieties). Migration emerged as a significant adaptation strategy, with rural households often sending young members to urban areas to diversify income and reduce livelihood vulnerability.

Proposed Livelihood Resilience Framework:

The study recommends a Livelihood Security and Resilience Assessment (LiSeRA) framework tailored to the LMB's context. The framework builds on the Department for International Development's (DFID) sustainable livelihood model and incorporates specified resilience, examining what and who needs protection, the nature of risks, and appropriate adaptive capacities.

Key components include:

- **Exposure and Sensitivity Analysis**: Identifying vulnerable livelihood activities and the severity of hazard impacts.
- **Adaptive Capacity Evaluation**: Assessing institutional support, technology adoption, and community resourcefulness.
- **Integrated Decision-Making**: Promoting stakeholder collaboration (governments, NGOs, academia) for disaster risk reduction.

Conclusion:

The LMB faces an intricate web of hazards and vulnerabilities, where the intersection of climate change, anthropogenic stressors, and socio-economic reliance on natural resources necessitates an integrated resilience strategy. The LiSeRA framework offers a pragmatic tool for policymakers and development partners to enhance livelihood security by balancing immediate hazard response with long-term adaptive planning.

Moving forward, transboundary collaboration, investment in climate-resilient technologies, and capacity building at the community level are pivotal for sustaining the LMB's ecological and economic vitality.

Topic: Protecting embankments from storm surges and sea level rise

Dr. Chandan Ghosh (Former Professor, National Institute of Disaster Management)

The presentation by Prof. Chandan Ghosh, provides a profound and comprehensive analysis of bioengineering solutions, with a particular focus on the strategic use of Vetiver grass (Chrysopogon zizanioides) for disaster risk reduction and sustainable land management.

Context and Background: Prof. Ghosh's presentation sets a critical foundation by drawing a clear distinction between disaster and development, emphasizing the urgency of adopting proactive strategies to mitigate the impact of natural hazards, including earthquakes, landslides, and storm surges. He challenges the conventional reliance on traditional geotechnical methods for risk assessment in engineering, advocating instead for calculated, innovative approaches. This thought-provoking introduction paves the way for an exploration of nature-based solutions, particularly bioengineering, as a sustainable and effective means of enhancing disaster resilience.

Vetiver Grass: An Overview- Vetiver grass emerges as the centerpiece of Prof. Ghosh's bioengineering narrative, presented as a cost-effective, eco-friendly alternative to conventional geotechnical interventions such as retaining walls. Its remarkable biological and ecological attributes position it as a powerful tool for environmental protection and climate adaptation. Key characteristics of Vetiver grass include:

- **Adaptability:** Vetiver thrives under extreme environmental conditions, withstanding temperatures ranging from -15ºC to 55ºC and tolerating a wide soil pH range (3.0 to 10.5). It can endure submergence for up to five months, making it highly suitable for flood-prone areas.
- **Root System:** The plant's dense and vertical root system penetrates the soil up to 3 meters deep, boasting a tensile strength of 75 MPa. These "bio-nails" anchor the soil, curbing erosion and reinforcing slope stability.
- **Resilience:** Vetiver exhibits robust resistance to high toxicity levels, faces minimal threats from pests and diseases, and poses no competition to adjacent crops, ensuring agricultural harmony.
- **Economic Benefits:** Vetiver-based solutions require low financial input and bypass the need for costly technical surveys, such as borehole logging or drone mapping. This makes it an accessible and sustainable choice for rural communities.

Applications of Vetiver Grass: Prof. Ghosh underscores the multifaceted applications of Vetiver grass, extending its utility beyond simple erosion control to diverse domains of environmental and infrastructural protection:

1. **Slope Stabilization:** Vetiver's deep root network strengthens slopes, offering a sustainable remedy for sheet and gully erosion. Successful deployments in Assam (2010) and Kohima, Nagaland, highlight its efficacy when paired with proper irrigation and care.
2. **Coastal and Riverbank Protection:** Serving as a natural buffer, Vetiver mitigates storm surge impacts by reducing soil infiltration and enhancing surface drainage, thereby stabilizing vulnerable riverbanks and coastal regions.
3. **Canal Lining:** Vetiver grass provides a low-cost alternative for canal lining, effectively preventing soil erosion, promoting groundwater recharge, and supporting sustainable water management.

4. **Infrastructure Protection:** Planted along road shoulders, bridge embankments, and pathways, Vetiver reduces slope failures, enhances soil porosity, and intercepts stormwater runoff, safeguarding vital infrastructure.
5. **Agricultural Benefits:** Vetiver hedges act as natural barriers against soil erosion, protect crops from nutrient runoff, and coexist without competing for essential resources, promoting sustainable agricultural practices.
6. **Carbon Sequestration:** Vetiver's extensive root biomass actively sequesters carbon, contributing to climate change mitigation by enhancing carbon storage in soil ecosystems.
7. **Wastewater Treatment:** The fibrous root system of Vetiver plays a crucial role in phytoremediation, effectively absorbing pollutants, including heavy metals, and offering a nature-based solution for wastewater treatment.

Engineering vs. Bioengineering Approaches: A key theme in Prof. Ghosh's presentation is the critical evaluation of conventional geotechnical approaches, often characterized by rigid, high-cost infrastructure solutions like retaining walls. He critiques the over-reliance on such methods, pointing out their limitations, such as exacerbating slope instability due to inadequate drainage. In contrast, bioengineering with Vetiver grass provides a dynamic, cost-effective, and eco-friendly alternative. Vetiver's adaptability, minimal maintenance, and environmental benefits highlight the pressing need to integrate bioengineering into mainstream disaster risk management strategies.

Future of Vetiver Grass: Looking ahead, Prof. Ghosh envisions an expanded role for Vetiver grass in bolstering climate resilience and sustainable development. He stresses the importance of public awareness and governmental support in scaling up Vetiver-based initiatives. His vision includes nationwide campaigns promoting Vetiver's adoption for wastewater treatment, climate adaptation, and disaster mitigation. Prof. Ghosh calls for strategic collaborations among scientists, engineers, policymakers, and local communities to mainstream Vetiver grass bioengineering in infrastructure planning and environmental conservation.

Conclusion: In conclusion, Prof. Ghosh's presentation advocates for a transformative shift from costly, conventional engineering solutions to innovative, nature-based approaches. Vetiver grass epitomizes sustainable resilience, offering a holistic and scalable solution for embankment protection, slope stabilization, and climate risk mitigation. By fostering

interdisciplinary collaboration and public engagement, Vetiver grass bioengineering can play a pivotal role in advancing disaster risk reduction, supporting sustainable land management, and contributing to global climate adaptation efforts. Prof. Ghosh's call to action emphasizes the need for a collective commitment to harnessing Vetiver's potential for a more sustainable and resilient future.

Topic: Disaster and climate safe houses and infrastructure

Dr. Souvanic Roy (Professor, Department of Architecture & Planning, Indian Institute of Engineering Science & Technology (IIEST), Shibpur)

The Sundarbans, a unique and fragile ecosystem, presents a multifaceted challenge in harmonizing economic advancement with ecological preservation. This presentation by Professor Souvanic Roy from the Department of Architecture & Planning at IIEST Shibpur underscores the pressing necessity for disaster and climate-resilient housing and infrastructure, especially in light of recent extreme weather events such as Cyclone Yaas (2021) and the Aila embankment breach (2009). The emphasis lies not merely on conventional construction methodologies but on adopting a comprehensive, integrated approach to habitat development.

Housing in a Fragile Ecosystem:

Housing in the Sundarbans transcends being a mere physical entity; it is a dynamic process intricately linked to social, cultural, and environmental dimensions. Given the region's heightened climate-induced vulnerabilities, interventions must navigate the delicate balance between two often conflicting priorities:

- **Conventional Infrastructure:** Aimed at enhancing living standards and catalyzing economic growth.
- **Ecological Preservation:** Acknowledging the Sundarbans' exceptional ecological significance as one of the world's most dynamic and fragile ecosystems.

This inherent tension creates an "adaptation dilemma," where developmental aspirations frequently intersect with the imperative to conserve natural ecosystems. Addressing this duality necessitates innovative strategies that merge resilience, sustainability, and inclusivity.

Key Elements of Adequate Housing:

As per UN-Habitat, the Right to Adequate Housing comprises several pivotal elements, all of which require contextual adaptation for the Sundarbans:

1. **Security of Tenure:** Ensuring legal protection against forced evictions, offering residents a sense of stability.
2. **Availability of Basic Services:** Guaranteeing access to clean water, sanitation, energy, and waste management systems.
3. **Affordability:** Making housing financially accessible without jeopardizing other essential needs.
4. **Habitability:** Providing safe, structurally sound dwellings with adequate space to withstand climatic adversities.
5. **Accessibility:** Addressing the needs of marginalized groups, including the elderly, disabled, and women.
6. **Location:** Strategically situating housing near employment, education, and healthcare facilities, while steering clear of ecologically vulnerable zones.
7. **Cultural Adequacy:** Incorporating traditional architectural practices, local technologies, and indigenous ecological knowledge into sustainable housing designs.

The Need for a Paradigm Shift:

Effectively tackling the housing and infrastructure challenges in the Sundarbans necessitates a transformative shift in thought and action:

1. **From Shelter to Habitat:** Redefining housing beyond mere structures to encompass the broader concept of habitat — integrating scientific understanding with traditional wisdom to foster sustainable environments.
2. **From Top-Down to Bottom-Up:** Transitioning from centralized, bureaucratic planning to participatory, community-driven models. The Rural Nirmthi Kendra model serves as a Knowledge and Skill Dissemination Center, empowering local populations with practical expertise in sustainable building practices.
3. **Integration of Resource Conservation and Development:** Aligning developmental objectives with resource conservation strategies to ensure long-term sustainability.

4. **Materiality Shift:** Moving away from hard infrastructure-centric solutions reliant on concrete and steel towards landscape-sensitive materiality — leveraging locally sourced, eco-friendly materials that blend with the natural environment.
5. **Socio-Ecological Resilience:** Strengthening community agency and fostering resilience by promoting adaptive practices rooted in local socio-ecological contexts.

Social Production of Habitat:

Drawing inspiration from John F. C. Turner's philosophy, the presentation accentuates that genuine community resilience flourishes when residents assume control over critical decisions and actively engage in the design, construction, and management of their habitats. This inclusive, participatory process not only cultivates sustainable environments but also bolsters social cohesion and individual empowerment.

Rather than perceiving housing and infrastructure as static construction projects, they should be reimagined as the **social production of habitat** — a continuous, collaborative effort that intertwines community strength, traditional knowledge, and scientific innovation. This approach fosters a dynamic ecosystem where both human settlements and natural landscapes coexist in mutual resilience.

Conclusion:

Building climate-resilient housing and infrastructure in the Sundarbans demands more than isolated engineering solutions. It calls for an integrated, inclusive approach that:

- Honors the delicate balance between development and ecological conservation.
- Advocates for participatory planning rooted in local knowledge and community agency.
- Reinforces socio-ecological resilience by embedding adaptive strategies into housing and infrastructure design.
- Promotes the concept of habitat over mere housing, acknowledging the intricate interplay of cultural, environmental, and social factors.

By embedding sustainability into both design and decision-making processes, the communities of the Sundarbans can forge a future that is not only climate-resilient but also adaptive, inclusive, and deeply rooted in their ecological and cultural heritage. This paradigm shift will empower communities to transcend conventional boundaries, creating habitats that embody resilience, innovation, and sustainability.

Topic: Cyclone shelters of Sundarbans

Dr Gupinath Bhandari (Professor Civil Engineering, Coordinator, Centre for Disaster Preparedness & Management, Jadavpur University, Kolkata)

Introduction: The Shelter Centric Disaster Management Plan is a comprehensive framework

that emphasizes strengthening the capacity to combat natural calamities and ensuring sustainable recovery, while simultaneously reducing people's vulnerability to disasters through proactive measures and strategic planning. This approach is meticulously designed by integrating three key components: Search and Rescue, Evacuation Plan, and Logistic Plan, each tailored to provide comprehensive protection, rapid response, and continuous support for communities during crises, thereby fostering resilience and enhancing adaptive capacities.

Concept of Shelter Centric Disaster Management:

Shelter-centric disaster management refers to a strategic approach to disaster preparedness, response, and recovery, revolving around designated shelters that serve as multipurpose infrastructure, providing refuge during emergencies and supporting community activities in normal times. These shelters are critical assets for both predictable disasters, such as cyclones and floods, and unpredictable ones, like earthquakes and tsunamis, ensuring that affected populations have immediate access to safe and secure locations.

Key principles include:

- Multipurpose Use: Shelters should not only function as emergency refuges but also serve community purposes, such as hosting educational programs, health camps, and skill development workshops, when not used for disaster management, ensuring continuous utility.

- Strategic Location: These shelters should be strategically situated on higher ground or other geologically safe zones to prevent inundation from floods or storm surges, reducing the risk of further harm to already vulnerable populations.
- Structural Stability: The design and construction of shelters must adhere to stringent engineering standards to withstand high-intensity wind events, seismic shocks, and other extreme weather conditions, ensuring the physical safety of occupants.
- Inclusive Design: Shelters must be equipped with facilities that accommodate people with disabilities, pregnant women, children, the elderly, and other vulnerable groups, reinforcing the principle of equity and inclusivity in disaster management.

Planning and Design of Shelters:

Effective planning and design of disaster shelters require a thorough consideration of several interconnected factors, ensuring the shelters' functionality and accessibility during emergencies:

- Influence Area: Clearly defining the geographical area that a particular shelter will serve helps in estimating capacity requirements and ensuring that people within the influence zone have timely access to safe spaces.
- Demographic Data: Incorporating census reports and population estimates allows planners to determine the size and facilities of the shelter, ensuring adequate space, sanitation, and medical supplies for all potential occupants.
- Accessibility: Ensuring that shelters are connected by motorable roads and pedestrian pathways enhances rapid evacuation processes, enabling emergency vehicles and relief materials to reach the site efficiently.
- Structural Integrity: Conducting rigorous assessments of seismic risks, soil conditions, and vulnerability to extreme weather events ensures that shelters are resilient to natural hazards.
- Amenities: Providing basic facilities such as potable water, sanitation, electricity, and emergency medical supplies, along with special provisions for physically challenged individuals, guarantees a humane and supportive environment during crises.

Disaster Management: A Collective Effort:

Disaster management is inherently a collaborative and multidimensional process, requiring the coordinated efforts of various stakeholders to achieve effective preparedness, response, and recovery. Key participants include:

- Administrators: Responsible for policy formulation, resource allocation, and strategic planning to mitigate disaster risks.
- Army Personnel: Providing logistical support, conducting rescue operations, and maintaining law and order during emergencies.
- Policy Makers: Crafting resilient policies, building regulatory frameworks, and ensuring resource mobilization for disaster mitigation and recovery.
- Social Scientists: Analyzing community vulnerabilities, designing awareness programs, and evaluating the socio-economic impacts of disasters.
- Engineers: Ensuring the structural stability of shelters and other critical infrastructure, enhancing disaster resilience through robust designs.
- Medical Professionals: Offering emergency healthcare services, trauma counseling, and disease prevention strategies during and after disasters.
- Local Communities: Serving as first responders, participating in preparedness drills, and contributing indigenous knowledge for effective disaster response.
- Disaster Managers: Coordinating all disaster management activities, ensuring efficient use of resources, and facilitating communication among stakeholders.

Disasters in India: An Overview:

India is highly susceptible to a wide range of natural disasters due to its diverse geography and climatic variations. The major disasters impacting the country include:

- Cyclones: Affecting nine coastal states and island groups, often causing extensive damage to life and property.
- Floods: Covering approximately 40 million hectares of river basins, leading to loss of livelihoods, infrastructure damage, and displacement of communities.
- Droughts: Impacting 14 states, exacerbating water scarcity, and threatening agricultural productivity and food security.
- Earthquakes: With 59% of the country lying in seismic zones IV and V, earthquakes pose significant risks to densely populated areas.
- Landslides: Prevalent in the sub-Himalayan region, frequently disrupting transportation networks and endangering lives.
- Forest Fires: Occurring predominantly in Bihar, West Bengal, and northeastern states, affecting ecosystems and local communities.

- Tsunamis: Affecting both eastern and western coastal regions, posing severe risks to coastal populations and infrastructure.

Key Components of the Plan:

Search and Rescue:

- Establishing highly trained search and rescue teams equipped with advanced tools and technologies to efficiently respond to disaster situations.
- Deploying proper equipment such as life detectors, ropes, and cutting tools to enhance the effectiveness of rescue missions.
- Conducting regular drills and simulations to keep teams prepared for rapid deployment and coordinated actions during emergencies.

Evacuation Plan:

- Identifying safe zones and temporary shelters in advance, ensuring clear evacuation routes are mapped and communicated to communities.
- Creating detailed route maps and strategically placing signages to guide evacuees safely during a crisis.
- Ensuring community awareness through regular education programs, mock drills, and emergency response training to build a culture of preparedness.

Logistic Plan:

- Stockpiling emergency supplies such as food, water, medicines, and blankets to ensure immediate relief for affected populations.
- Establishing robust communication systems to facilitate real-time information sharing and coordination among disaster management teams.
- Coordinating transportation for relief materials and personnel, ensuring swift and efficient deployment of resources to disaster-hit areas.

Essential Tools for Disaster Management

- Mapping: Utilizing topographic, hazard, and population maps to identify vulnerable areas and plan mitigation strategies.
- Planning: Developing evidence-based strategies using historical disaster data and predictive modeling.
- Building Regulations: Enforcing zoning laws and building codes to promote disaster-resistant construction and infrastructure.

- Financial Incentives: Providing subsidies and tax benefits to encourage the adoption of resilient construction practices.
- Environmental Management: Implementing reforestation, watershed management, and soil conservation measures to mitigate environmental risks.
- Communication: Establishing wireless networks and emergency broadcasting systems to disseminate real-time alerts and warnings.

Preparedness and Response:

Key steps to enhance disaster preparedness and response include:

- Data Collection: Gathering historical disaster data to identify patterns and forecast future risks.
- Hazard Mapping: Pinpointing high-risk areas to focus mitigation efforts and resource allocation.
- Vulnerability Assessment: Evaluating community-specific risks based on socio-economic and geographical factors.
- Livelihood Security: Supporting distressed populations through job programs, skill development, and economic resilience initiatives.
- Public Awareness: Organizing community education programs to build disaster literacy and proactive engagement.
- Emergency Training: Empowering local volunteers and community leaders with the skills to manage emergency situations effectively.

Forecasting and Warning Systems:

Disaster forecasting involves a systematic process of:

- Collecting observation data from meteorological and geological sources.
- Transmitting critical information to forecast centers for analysis.
- Analyzing data to create vulnerability maps and risk assessments.
- Disseminating timely warnings through electronic media, mobile alerts, and public announcements to minimize loss of life and property.

Conclusion:

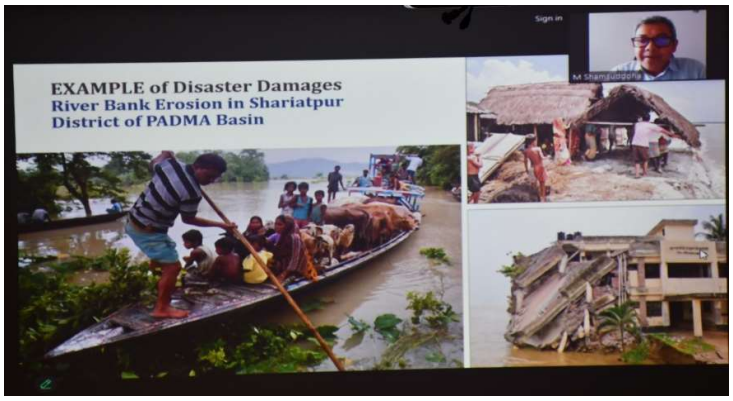
Shelter Centric Disaster Management transcends mere construction of shelters; it embodies a holistic approach to disaster risk reduction by integrating proactive planning, effective response strategies, and inclusive community involvement. Achieving sustainable recovery and long-term resilience necessitates the collective effort of policymakers, scientists,

engineers, and local communities, all working in unison to build an adaptive, disaster-resilient society.

Topic: Community Based Disaster Risk Management

Speaker: Md. Shamsuddoha (Chief Executive, Centre for Participatory Research and Development, Dhaka, Bangladesh)

Community-Based Disaster Risk Reduction (DRR) in Bangladesh: Practices and Limitations



Introduction:

Bangladesh, a country prone to various natural hazards, has increasingly emphasized community-based Disaster Risk Reduction (DRR) to mitigate the adverse effects of disasters. This approach acknowledges that communities are the first responders to disasters and leverages local knowledge and participation to build resilience. This document synthesizes the key concepts, practices, and challenges of community-based DRR in Bangladesh, as presented by Md. Shamsuddoha, Chief Executive of CPRD.

Case Study: River Bank Erosion in Shariatpur District:

Riverbank erosion is a significant and recurring disaster in Bangladesh. The Padma River's erosion in Shariatpur, particularly in Naria Upazila, has had devastating consequences. Key highlights include:

- Between 1973 and 2017, the Padma devoured 9627 hectares of land in Shariatpur.
- From 2016, the erosion rate increased to 1.33 square kilometers annually.
- In 2018, erosion consumed 13 square kilometers, displacing over 5000 people and destroying 500 businesses.

Primary Impacts:

- Loss of homesteads, crops, and livestock
- Damage to infrastructure and agricultural land

Secondary and Tertiary Impacts:

- Forced to take undignified jobs (rickshaw pulling, begging, etc.)
- Increased school dropouts, child labor, and early marriage
- Psychological trauma and loss of social identity
- Destruction of religious and social infrastructure

Current DRR Practices: Reactive and Limited:

The current disaster response in Bangladesh is largely reactive, focusing on short-term relief efforts rather than long-term resilience. Key actors include:

- **Government:** Ministry of Disaster Management and Relief provides immediate food and cash assistance.
- **NGOs:** Serve as first responders offering food, water, and medical aid.
- **Regional and Global Funds:** Mobilize short-term rehabilitation efforts through local NGOs.
- **Private Sector/Individuals:** Contribute through Corporate Social Responsibility (CSR) funds, often influenced by political motives.

These efforts primarily address **economic losses and damages (L&D)**, while **non-economic L&Ds**—such as psychological trauma, loss of identity, and cultural disintegration—receive little attention.

Community-Based DRR Initiatives:

One prominent initiative is led by SDS (a community-based NGO), supported by START FUND:

- Provided BDT 4500 cash and materials worth BDT 4000 to each of the 4600 displaced families.
- Distributed 750 assistive devices to physically challenged individuals.
- Delivered medical support to 2150 families.

However, these interventions remain inadequate compared to the scale of the disaster, often perceived as mere charity due to a lack of systematic planning and sufficient resources.

Proactive Measures and Anticipatory Actions:

A shift towards **anticipatory action** is gaining traction in Bangladesh's DRR landscape. The process involves:

1. **Risk Knowledge & Design Threshold:** Expert groups forecast disasters and design thresholds for action.
2. **Pre-Defined Actions:** Communities and stakeholders collaborate to prioritize actions.

3. **Monitoring Threshold:** Real-time observations help adjust plans.
4. **Anticipatory Actions:** Once a threshold is met, pre-agreed actions are executed.

Example: Anticipatory Action for Riverbank Erosion

- **Agency:** Manab Mukti Shangstha
- **Fund Allocated:** 25,000 GBP
- **Prediction:** Experts identified 115 households at risk of erosion in Shahjadpur, Sirajganj; 80 were ultimately affected.
- **Actions:**
    - Conditional cash support for relocation
    - Advocacy for finding new homes and livelihoods

Studies show that **anticipatory action** reduces L&D costs—every $1 spent proactively saves $4.35 in reactive response.

Disaster Risk Financing (DRF):

DRF aims to ensure pre-positioned funding for forecasted crises through innovative risk analysis and collective planning. Bangladesh's DRF strategy includes:

- **Risk Analytics:** Multi-hazard and household economic analysis.
- **Operational Protocols:** For floods and cyclones.
- **Contingency Planning:** Collaboratively developed for 8 districts.
- **Funding:** 1.55M GBP secured for 2023–2024 to support proactive measures.

Institutional and Policy Gaps:

Despite these efforts, significant gaps remain in addressing non-economic L&Ds. The current frameworks largely focus on immediate economic support, neglecting long-term community recovery and psychosocial impacts.

Key policy recommendations:

- Develop comprehensive strategies for climate-induced displacement and migration.
- Ensure rights-based rehabilitation, including land allocation, housing, and livelihood support.
- Empower displaced women through self-employment and legal support.
- Provide special stipends for girls' education.
- Strictly enforce anti-dowry laws.

Conclusion:

While Bangladesh has made strides in disaster response, its community-based DRR still leans heavily on reactive measures. The shift towards anticipatory action and disaster risk financing is promising, but these efforts need to be expanded to address non-economic L&Ds. A holistic, community-centric strategy, backed by proactive funding and inclusive policy frameworks, is essential for building true disaster resilience.

Panel Discussion and Q & A (Session 6):

Compiled by

Dr. Sumanta Das, Assistant Professor

School of Environment and Disaster Management

SESSION-7:
ADAPTING TO CLIMATE CHANGE: INNOVATIVE TECHNOLOGY AND PRACTICES

Session 7 of the *International Symposium on Building Resilience of Communities in Sundarbans* focuses on **innovative technology and practices** for adapting to climate change. As the Sundarbans face increasing challenges from rising sea levels, extreme weather events, and environmental degradation, adaptation strategies must integrate scientific advancements with traditional knowledge to ensure sustainable resilience. This session brings together **leading experts and practitioners** to discuss cutting-edge approaches in climate-resilient agriculture, untapped fisheries potential, indigenous coping mechanisms, and the evolving landscape of river and estuarine fisheries.

Session Chair:

The session was chaired by *Prof. Tapash Dasgupta*, the Dean of Ramakrishna Mission Vivekananda Educational and Research Institute (RKMVERI), Narendrapur**,** is a distinguished academician and researcher in the field of environmental management and sustainable development**.** Dr. Dasgupta highlighted the key areas of focus within the symposium, which include disaster management, livelihood sustainability, and plant system resilience**.** He emphasized the importance of incorporating modern scientific and technological advancements into community resilience strategies.

Keynote Address:

Dr. Sanjay Srivastava Chief Disaster Risk Reduction, UNESCAP, Bangkok delivered an insightful and comprehensive keynote address on the pressing issue of climate change adaptation through innovative technologies and best practices. His presentation highlighted the increasing role of technological advancements in addressing climate vulnerabilities, particularly in ecologically sensitive regions such as the Sundarbans. His discussion revolved

around key technological trends, adaptation strategies, and the importance of bridging existing gaps in climate resilience efforts.

Dr. Srivastava began his presentation by outlining the key trends in technology and adaptation. He noted that the landscape of technology was evolving at an unprecedented rate, significantly impacting disaster resilience and climate adaptation. He emphasized how technology and data ecosystems were rapidly converging, forming an interconnected digital framework that facilitated improved decision-making processes. This integration allowed for better resource allocation, predictive modelling, and real-time monitoring of climate risks. Furthermore, he discussed the democratization of platforms, explaining how open-source and collaborative technologies were enabling communities and policymakers to make informed choices. The rise of start-ups in the disaster technology space was also noted, as these emerging businesses were actively innovating and operationalizing solutions aimed at enhancing resilience against climate change.

A critical part of his address was the Adaptation Technology Cluster, where he pointed out that over 25% of adaptation technologies had significant overlaps with mitigation efforts. This demonstrated how adaptation strategies could complement broader climate action plans. He stressed that for adaptation to be effective, a combination of economic incentives, robust policy frameworks, and localized implementation was necessary. By leveraging existing technologies and fostering research-driven innovations, countries could build a resilient infrastructure that supports long-term climate adaptation.

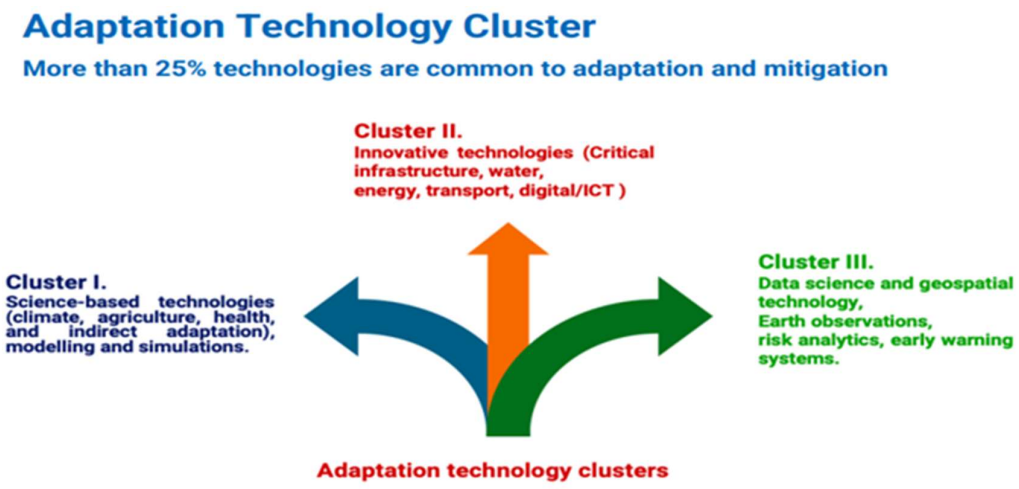


Figure: Adaptation Technology Cluster (from Dr. Srivastava's presentation)

Dr. Srivastava then delved into the various technologies that played a crucial role in climate adaptation. He elaborated on six major technologies that were driving climate resilience efforts: He explained how AI was transforming climate models, making them more precise by integrating land, ocean, and atmospheric interactions. AI-driven analytics helped improve early warning systems and disaster response mechanisms. Drones played a vital role in collecting high-resolution visual data for risk assessment and disaster response. They were particularly useful in monitoring hard-to-reach areas affected by climate-related disasters. Satellite imagery and remote sensing technologies were being widely used for risk assessment, climate monitoring, and early warning systems. These technologies provided critical insights into ecosystem changes, urban expansion, and extreme weather events. High-performance computing allowed for better climate forecasting and disaster preparedness by simulating complex environmental processes with greater accuracy. IoT-connected devices facilitated real-time data collection, monitoring infrastructure health, and predicting failure points in disaster-prone regions. These technologies created immersive experiences that helped policymakers and communities visualize the impact of climate change and plan effective adaptation strategies.

Dr. Srivastava further emphasized the need for digitalization in early warning systems (EWS). He described how advanced multi-model forecasting, coupled with AI, was improving the accuracy and speed of disaster warnings. He highlighted how cloud computing services from companies like Amazon, Google, and Azure had facilitated real-time impact

forecasting. He also discussed geo-intelligence platforms, such as Maxar and Planet Lab, which provided satellite-based risk mapping to track climate changes with high precision. The digital transformation of early warning systems was seen as a crucial step toward proactive disaster management.

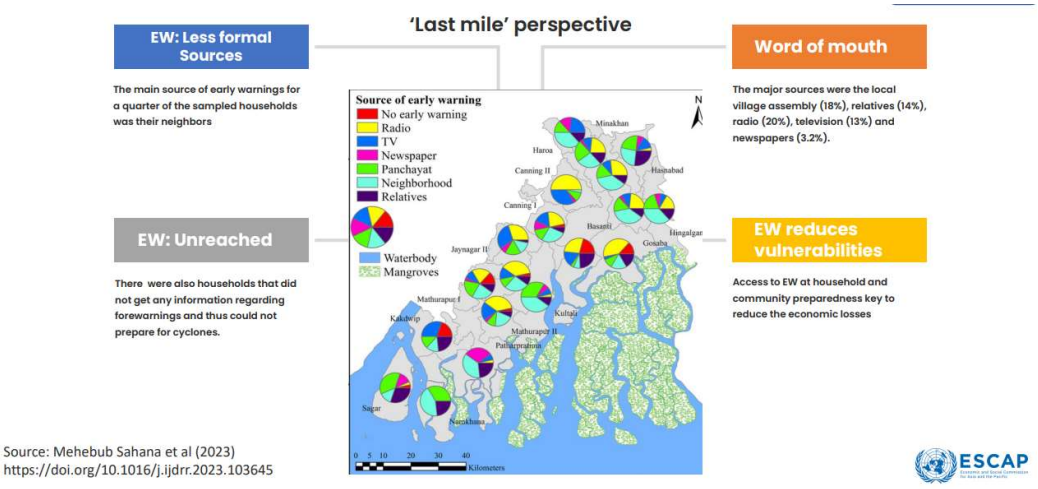


Figure: Early warning systems (from Dr. Srivastava's presentation)

Another significant aspect of his address focused on bridging the adaptation gaps. He identified four key areas where action was urgently needed: He stressed the importance of reducing greenhouse gas emissions to curb the intensity of climate hazards. Investing in early warning systems, nature-based solutions, and sustainable food-water-energy systems was necessary to strengthen adaptation capacity. Addressing irreversible losses, such as glacier melt and coral reef degradation, was critical in long-term resilience planning. He underlined the need for strengthening emergency response mechanisms to better manage residual disaster risks. A key highlight of his presentation was the Cyclone Warning Dissemination in Sundarbans. He presented findings from field surveys conducted in the region, which revealed that many households received cyclone warnings only 12 hours before landfall, leading to inadequate preparedness. He emphasized that improving last-mile connectivity for early warning systems was crucial in reducing the economic and human costs of disasters. Data indicated that community-based warning dissemination through village assemblies, radio, and social networks played an essential role in preparedness efforts.

Dr. Srivastava also discussed the role of Earth Observation for Resilience, introducing the Global Mangrove Watch (GMW). This tool provided near real-time monitoring of mangrove

forests, detecting changes with over 90% accuracy using Sentinel-2 satellite imagery. He explained how GMW's heatmap visualization helped identify areas of rapid mangrove loss, which was critical for conservation efforts in the Sundarbans. The use of Drone Technology in Adaptation was another key focus. He highlighted Drone-as-a-Service (DaaS), a collaborative initiative by IBM and Capgemini, which enabled real-time drone inspections for environmental monitoring. These drones were instrumental in mapping coastal ecosystems and improving climate adaptation responses.

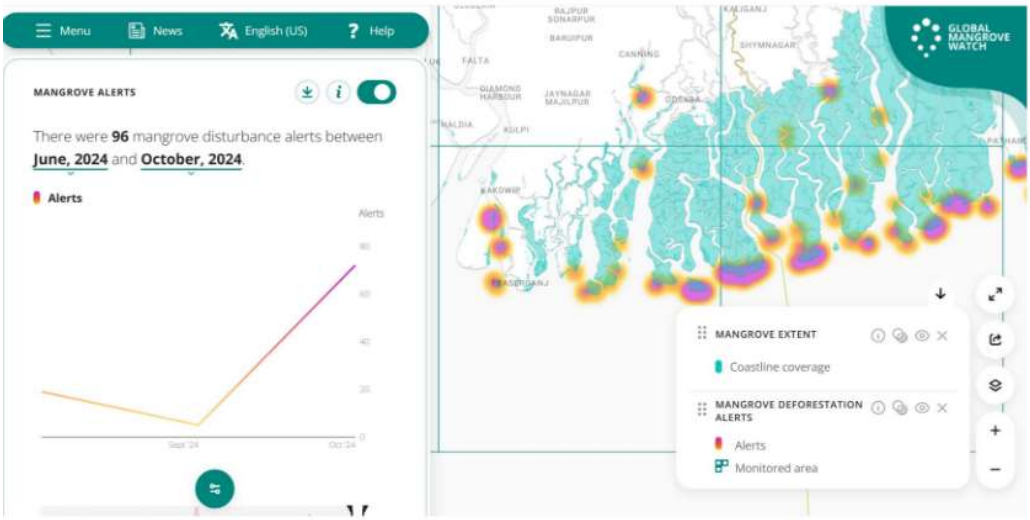


Figure: Global Mangrove Watch (GMW) (from Dr. Srivastava's presentation)

Dr. Srivastava then addressed challenges in climate adaptation, referencing reports from 2022-2024 that indicated slowing progress in adaptation despite increasing climate risks. He warned that inadequate investment and policy implementation were leaving vulnerable regions like the Sundarbans exposed to extreme climate events.The Asia-Pacific Disaster Report 2024, published by ESCAP, was a key resource that he cited. This report identified the Ganges-Brahmaputra-Meghna basin and the Indus basin as high-risk zones for intensifying multi-hazard threats. He expressed concern over biodiversity loss in these regions, particularly the degradation of mangrove ecosystems, which served as natural buffers against climate disasters.

In his closing remarks, Dr. Srivastava underscored the need for a multi-sectoral approach that integrated policy reforms, technological innovation, and community participation. He

reiterated that adapting to climate change required a combination of scientific advancements, economic incentives, and social resilience strategies. The session provided valuable insights into cutting-edge technologies, best practices, and policy measures essential for building a climate-resilient Sundarbans and beyond.

Dr. Prabir Kumar Garain, **SMS (Plant Protection), Ramakrishna Mission Ashram KVK, Nimpith, South 24 Paraganas** delivered a comprehensive presentation on "climate-resilient agriculture in the Sundarbans", describing the challenges, adaptation strategies, and technological innovations aimed at mitigating the impacts of climate change on agricultural practices in the region. He began by describing the Sundarbans as the largest deltaic mangrove forest, spanning across India and Bangladesh, designated as a World Heritage Site by UNESCO. The region was characterized by a complex network of tidal waterways, mudflats, and small islands, with five million people relying on non-timber forest products, fisheries, and agriculture. He highlighted that the biodiversity of Sundarbans included 300 flora, 425 wildlife species, and 63 types of mangroves. However, he also pointed out the human-wildlife conflicts, with 36 human deaths per year due to tiger attacks. He referred to IPCC reports which identified the Sundarbans as highly vulnerable to climate change due to its geographical location.

Dr. Garain explained that agriculture in Sundarbans was shaped by various environmental challenges, including brackish water rivers, poor drainage, saline soils, and low-lying topography. He noted that 56% of the land mass was less than 5 meters above sea level, making it susceptible to flooding and salinization. He elaborated on traditional cropping patterns, stating that farmers practiced a Paddy – Lathyrus – Fallow cycle, as well as HYV Paddy – Vegetable – Fallow rotations. Due to resource limitations, farmers had limited crop

choices, primarily cultivating paddy, lathyrus, greengram, and vegetables. He pointed out that embankment breaches had led to loss of standing crops, livestock, and stored food.

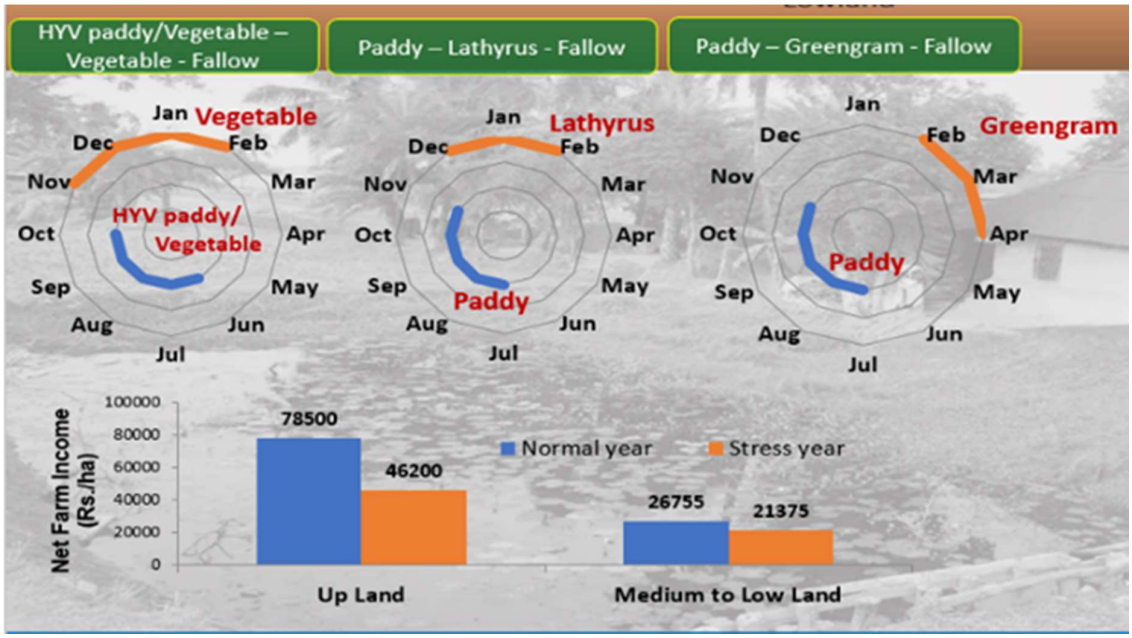


Figure: Major Crops in respect of topography and drainage (from Dr. *Garain's* presentation)

He described the increasing intensity of climatic vagaries in the region, presenting a timeline of major cyclones that had impacted the Sundarbans, such as Sidr (2007, 215 km/h), Aila (2009, 120 km/h), Fani (2019, 185 km/h) & Bulbul (2019, 155 km/h), Amphan (2020, 180 km/h) & Yaas (2021, 140 km/h), and Remal (2024, 100 km/h). He reported that sea-level rise in the region had reached 12 mm per year between 2002 and 2009, significantly higher than the global average. He also discussed increasing rainfall variability, delayed transplantation, and prolonged submergence, which had led to crop loss and increased soil salinity.

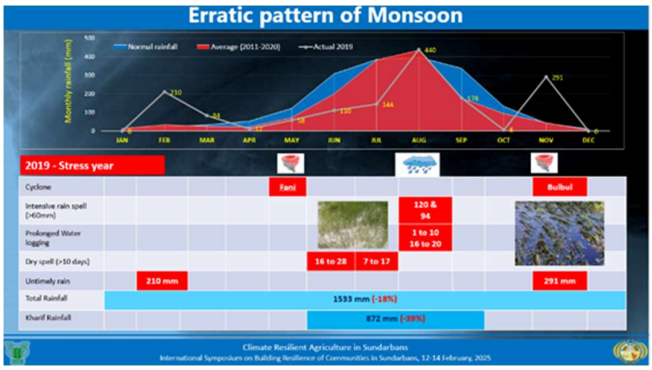


Figure: Erratic pattern of Monsoon (from Dr. *Garain's* presentation)

Dr. Garain outlined various strategies implemented under the National Innovations in Climate Resilient Agriculture (NICRA) initiative since 2012. These included strengthening river embankments through mangrove rejuvenation, where villagers collected mangrove seeds, cultivated them in nurseries, and transplanted them along riverbanks. The mangrove belt protected villages from major cyclonic storms, including Amphan and Yaas. Renovation of drainage canals was another major initiative, which included desiltation of 4 km of canals and repairing sluice gates, allowing quick drainage of floodwater and storage of rainwater for irrigation. Land shaping and rainwater harvesting were also emphasized, with farmers excavating ponds on one-fifth of their land and elevating adjacent fields with dug-out soil. This technique reduced prolonged water stagnation, improved soil conditions, and allowed multiple cropping cycles. Additionally, the Broad Bed and Trench (BBT) System was introduced, where raised beds protected vegetables from submergence and rainwater stored in trenches was used for paddy-fish farming and irrigation during dry spells. Farmers reported a 238% increase in cropping intensity and 10 times higher net income compared to conventional farming.

Dr. Garain emphasized the need for stress-tolerant crop varieties, including submergence-tolerant rice varieties such as Swarna Sub-1 (41.8 q/ha) and CR 1009 Sub-1 (44.6 q/ha), salt-tolerant rice varieties like SR 26B (36.25 q/ha) and Luna Suvarna (39.4 q/ha), and short-duration greengram such as IPM-205-7 (60-65 days). He also suggested cotton as an alternative for rice fallows, with the Surabhi variety yielding an income of Rs. 80,000-90,000/ha. He discussed alternative farming techniques, such as floating seedbeds for flood resilience, green manuring with Dhaincha for soil fertility, and micro-irrigation and mulching to conserve water. Additionally, he highlighted beekeeping, poultry, and ornamental fish farming as alternative livelihoods to support income diversification in the region.

He presented the impact of climate-resilient farming models, noting a 252% increase in income under diversified farming systems and government funding of Rs. 25 crore for land shaping projects in Sundarbans. He also emphasized the integration with national schemes like Krishi Unnati Yojana, which provided support to farmers adopting climate-resilient agricultural practices. He stressed that community-based adaptation, such as mangrove restoration and water conservation, was essential for long-term climate resilience in Sundarbans.

Dr. Garain concluded by emphasizing that adapting to climate change required a combination of scientific innovation, traditional knowledge, and policy support. He urged farmers to embrace climate-smart techniques and diversify their livelihoods to enhance sustainability and resilience against future climatic uncertainties. He reiterated that the Sundarbans required a holistic approach to climate resilience, combining environmental conservation, sustainable agriculture, and alternative livelihood strategies to secure the future of communities in the region.

Dr. Parthapratim Chakrabarti, **Former Principal Scientist and Scientist-in- charge, Regional Research Centre, Rahara and Kalyani, ICAR-CIFA** delivered a detailed presentation on the "untapped potential of inland fisheries in the Sundarbans", focusing on enhancing freshwater pond productivity through better management practices (BMP) and aquaculture. He began by identifying the major challenges that the region faced, which included over-dependency on natural resources for livelihood, a significant knowledge gap in scientific fish culture, the lack of hatcheries for quality seed production, inefficient management of backyard livestock farming, and the absence of specific ponds designed for different aquaculture activities. He emphasized the urgent need for scientific interventions to address these issues. Dr. Chakrabarti outlined the objectives of his project, which aimed to enhance pond productivity through BMP, train 200 beneficiaries in induced breeding, scientific seed rearing, and the development of carp brood stock in the islands. His goal was to promote integrated aquaculture for the economic upliftment of SC/ST communities in the region. To achieve this, training and demonstration programs were conducted in a cluster mode across multiple Aila-affected villages in the Basanti Block (Chunakhali) and Gosaba Block (Bali Island) in the Sundarbans. He described the framework for intervention, which involved skill development through hands-on demonstrations, training, and continuous monitoring.

One of the primary focuses of the presentation was the implementation of BMP in brood stock management. He noted that before the project, local communities lacked the concept of brood fish management, proper feeding practices, and water quality management. Through the demonstration program, high-quality brood stock selection was conducted, wherein 1000 pieces of brooders were stocked in designated ponds. The beneficiaries were trained in periodic netting, liming, fertilization, water exchange (5-10%), and the use of quality brooder diets such as CIFABROOD TM. He highlighted that a 0.4-hectare water body was used for this purpose, benefiting 20 individuals who received hands-on experience in brood stock maintenance. Dr. Chakrabarti elaborated on the quality seed production process using Fiber Reinforced Plastic (FRP) hatcheries. He explained that previously, only a single fish species was selected and kept in breeding pools, which led to hybridization risks.

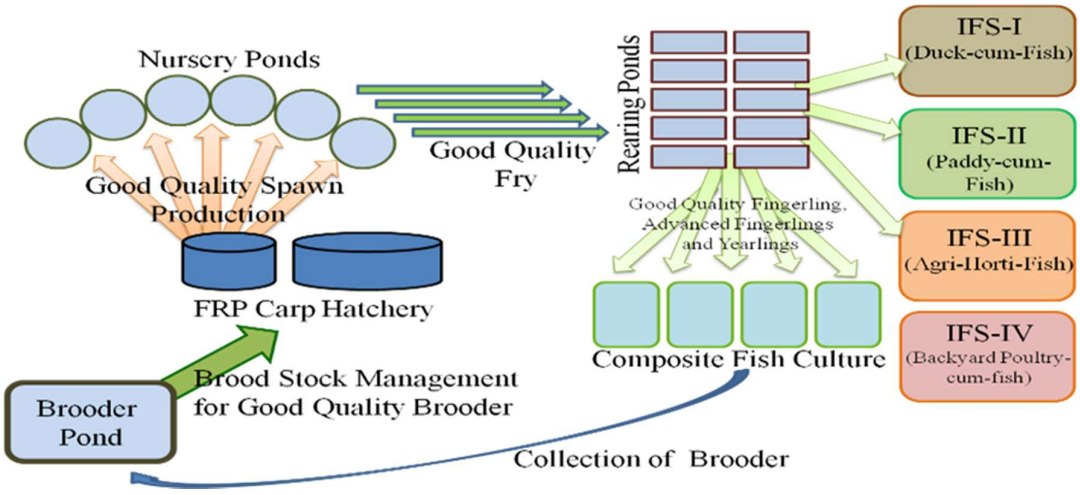


Figure: Enhancement of Pond Productivity (from Dr. Chakrabarti's presentation)

The project implemented BMP in hatchery operations by ensuring a zooplankton-free water supply, using synthetic gonadotropic hormones for induced breeding instead of pituitary gland extracts to minimize stress on brooders, and treating spent broodfish with potassium permanganate before reintroduction to ponds. He pointed out that a pre-existing FRP hatchery at Bali Island had been made operational in 2016, and a new hatchery was installed in Chunakhali in 2018. A total of 16 beneficiaries were trained in spawn production using FRP hatcheries, significantly improving seed availability in the region.

Regarding nursery pond preparation, he mentioned that Chunakhali initially lacked suitable low-depth ponds for nursery operations. As an innovative solution, nylon hapa enclosures were introduced to serve as temporary nursery ponds. He explained that 12-day-old fry were transferred to 0.4-hectare rearing ponds, resulting in the production of approximately 1.23 lakh fingerlings from eight beneficiary sites. He further detailed the BMP for nursery pond management, which included pond selection, drying to remove predatory fish, repeated netting, and rainwater harvesting to enhance spawn survival. Locally available cost-effective feed ingredients, such as finely dusted mustard oil cake and flour, were used as alternatives to the expensive groundnut oil cake. The project also focused on stunted fingerling production, an essential aspect of sustainable aquaculture. Demonstration sites covering 1.66 hectares were established, benefiting 28 individuals who collectively produced over 3500 kg of stunted fingerlings comprising Catla, Rohu (Jayanti), Mrigal, and Bata fish. He emphasized that this approach helped improve fish stocking rates while ensuring higher survival rates in grow-out ponds. Similarly, composite fish culture demonstrations were carried out in 1.21 hectares of ponds, benefiting 29 individuals. The average fish production from these ponds reached 3250 kg per hectare per year, significantly higher than traditional methods.

Dr. Chakrabarti provided insights into the training program under the DBT project, which trained a total of 375 individuals in various aspects of aquaculture and hatchery operations. Out of these trainees, 179 from Bali Island and 42 from Chunakhali successfully adopted the demonstrated technologies, resulting in an adoption rate of approximately 59%. He noted that some additional beneficiaries had also independently adopted the improved practices after observing the project's success. The adoption of integrated aquaculture had not only enhanced household incomes but had also provided a stable livelihood alternative to communities that previously depended on unsustainable resource extraction. He discussed the social and economic impact of the project, stating that the creation of alternative livelihoods had significantly reduced human-wildlife conflicts by minimizing dependence on forest areas for honey and crab collection. Migration to urban centers in search of employment had declined, as families were now able to sustain themselves through aquaculture. He highlighted that backyard agri-horti-livestock integration had played a crucial role in empowering women by involving them in fish farming, poultry rearing, and vegetable cultivation. This had led to improved nutritional security through increased access to fish, eggs, meat, and high-value winter crops such as broccoli, lettuce, Chinese cabbage, and hybrid chili. From an economic

standpoint, he pointed out that knowledge dissemination on optimal stocking densities for composite fish culture had resulted in a 34% reduction in fish seed expenditure. Additionally, training in basic fish medication and poultry vaccination had successfully prevented mass mortality events, saving beneficiaries from financial losses. The introduction of high-yielding varieties of ducks such as Khaki Campbell and Vanaraja had significantly boosted egg and meat production. He also noted that improved pond management practices, including liming and fertilization, had led to increased fish growth rates, ultimately enhancing profits for farmers.

Dr. Chakrabarti concluded his presentation by mentioning that the success of the project had gained significant recognition, prompting the Department of Biotechnology (DBT) to produce a documentary highlighting its impact. The video was featured on government platforms and was even considered for showcasing to the Hon'ble Prime Minister of India. He provided links to the video, which demonstrated the transformation of aquaculture practices in the Sundarbans and the broader socio-economic benefits it had delivered to the SC/ST communities in the region.

Dr. Anshuman Das, Senior Programme Manager, Welthungerhilfe- India, Kolkata delivered a detailed presentation on "*indigenous coping mechanisms and traditional wisdom for survival*" emphasizing how indigenous practices played a crucial role in sustaining livelihoods, conserving biodiversity, and adapting to climatic challenges. He began by discussing the significance of wild edible plants, which had been a critical food source for local communities. He listed various plants such as Nunia, Helencha, Amrul, Kulekhara, Thankuni, Telakucho, and Bathua, which had not only served as nutritional supplements but also possessed medicinal properties. These uncultivated foods had provided sustenance during periods of food scarcity, making them an essential part of the local food system. He noted that customs and rituals had traditionally protected and encouraged the consumption of these plants, ensuring their sustainable use over generations. Dr. Das then

shifted focus to saline-tolerant paddy varieties, which had been cultivated in the Sundarbans for centuries. He mentioned traditional varieties such as Hamilton, Dudher Sor, Baktulsi, Talmugur, and Nonabokhra, which had shown remarkable resilience in adverse climatic conditions. While these varieties had lower yields compared to high-yielding varieties (HYVs), they required fewer agrochemicals and thrived in saline water conditions. Their taller structure made them more resistant to flooding, which was a frequent threat in the Sundarbans. He highlighted how these rice varieties had played a significant role in ensuring food security, particularly for small-scale farmers who relied on natural farming methods.

The presentation also covered land shaping and integrated farming techniques that had been historically practiced in the region. Dr. Das explained how local farmers had strategically used dykes and raised platforms to mitigate the risks of flooding and soil salinization. These techniques had allowed them to cultivate multiple crops simultaneously, optimizing land use efficiency. He described how traditional knowledge of air circulation and cloud cover had influenced farming decisions, helping farmers predict weather patterns and adapt their agricultural practices accordingly. This ecological knowledge had been invaluable in maintaining agricultural productivity in a challenging environment. Dr. Das also discussed the sustainable harvesting practices employed by Mouals (honey collectors), Bawalis (wood collectors), and Golpata harvesters. He explained how the Mouals had developed techniques to collect honey without destroying bee colonies. They had always cut only a specific section of the honeycomb, ensuring that young bees were not harmed, and reproduction continued. Additionally, they had never used metal tools, which could damage the hive and lead to colony collapse. The Bawalis, who depended on timber collection, had adopted a responsible approach by leaving at least one stem in each clump of trees after cutting. They had also followed a rotational harvesting system, ensuring that the same location was not used for wood collection every year. Similarly, Golpata (Nypa fruticans) harvesters had adhered to strict guidelines that prevented overexploitation. They had been prohibited from collecting Golpata during its growing period (June to September), allowing the plant to regenerate and sustain the ecosystem.

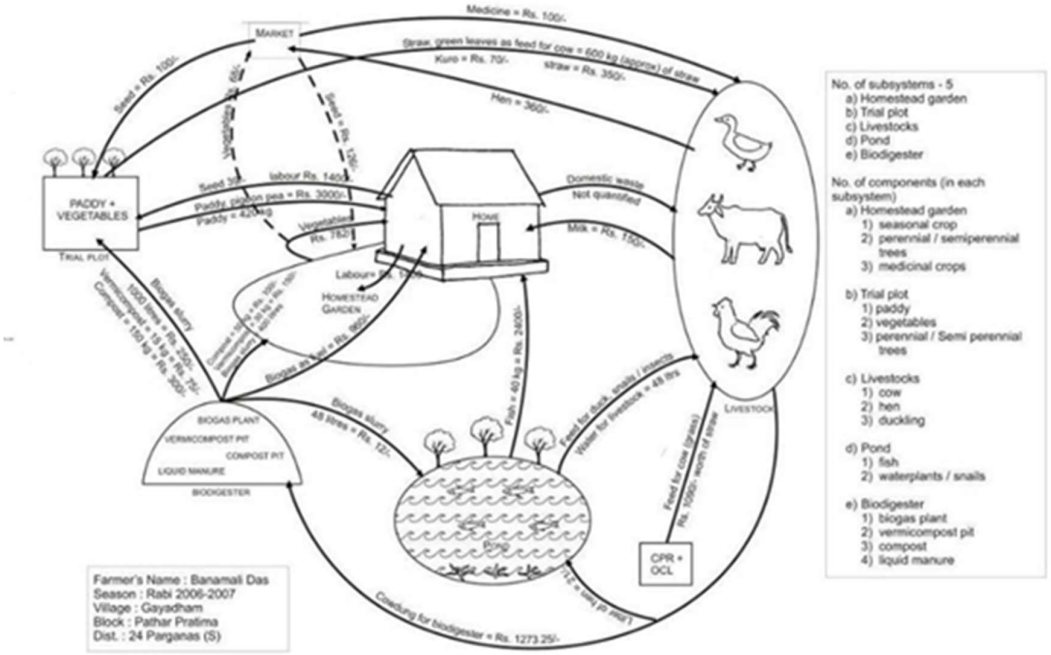


Figure: Integrated farming (from Dr. *Das'*s presentation)

The presentation also highlighted traditional boat-building techniques and navigation skills that had been passed down through generations. Dr. Das explained that various types of boats had been used for different purposes, each specifically designed for navigating the complex waterways of the Sundarbans. Fishermen had relied on oral traditions and dynamic learning methods to adapt their fishing techniques to changing river conditions. Over time, they had modified their nets, boats, and methods in response to environmental shifts. He mentioned how, in the 1990s, the Cox's Bazar model of boat-making had been adopted, illustrating how traditional knowledge had been flexible enough to incorporate useful external influences. He emphasized that the Betnai boat, traditionally used for carrying Golpata and Garan timber, had played an essential role in local trade and resource transport.

Dr. Das explained why traditional technology remained relevant and valuable in modern times. He pointed out that traditional practices had been time-tested, resilient, and need-based, often providing solutions that contrasted with conventional technological approaches. He argued that while top-down, externally imposed technologies had sometimes failed to address local challenges, traditional knowledge had evolved through direct experience and necessity. This had allowed communities to develop problem-solving techniques that were grounded in local logic and environmental awareness. Furthermore, he emphasized that traditional practices had not only been environmentally sustainable but had also helped strengthen social bonds and cultural identities within communities.

In his concluding section, Dr. Das proposed actionable steps to support and enhance traditional wisdom in the Sundarbans. He emphasized the need to understand the inherent scientific logic behind these practices rather than merely documenting them. He stressed that rather than blindly replicating traditional methods, researchers and policymakers should work to improve upon them by integrating modern scientific knowledge. He called for cross-disciplinary collaboration to bridge the gap between indigenous wisdom and contemporary science, advocating for a holistic approach that recognized the strengths of both fields. Additionally, he highlighted the importance of participatory research, where local communities played an active role in validating and refining traditional techniques rather than having external experts dictate solutions.

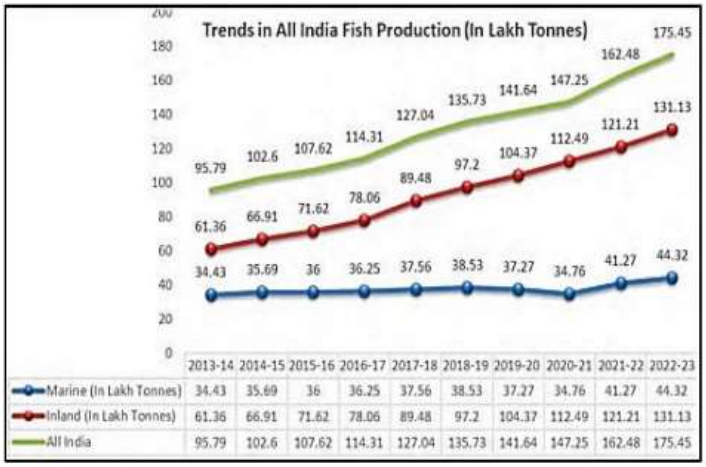
Dr. Das also underscored the importance of intellectual property rights (IPR) protection for indigenous knowledge. He cautioned that without proper legal safeguards, large corporations could exploit traditional techniques for commercial gain, leaving local communities without recognition or benefits. He stressed that traditional knowledge should be protected in a way that ensured equitable sharing of benefits among its rightful custodians. Finally, he emphasized the need for intergenerational knowledge transfer, particularly involving women, who had historically played a crucial role in preserving and passing down traditional agricultural and ecological wisdom.

Dr. Tapas Kumar Ghoshal, **Principal Scientist & Head ICAR- Central Institute of Fisheries Education, Kolkata Centre** delivered an extensive presentation on "*River, estuarine and marine fisheries: Challenges and opportunities*". He began by highlighting the significance of fisheries as a growing sector in India. He presented data showing the rise in

fish production and seafood exports, with revenue increasing from Rs. 46,662.85 crore in 2019-20 to Rs. 61,043.68 crore in 2023-24. He mentioned that the Department of Fisheries had received a budget allocation of Rs. 2,584.50 crore for 2024-25, marking a 15% increase from the previous year, demonstrating the government's commitment to the sector.

Dr. Ghoshal then described the riverine fisheries of India, noting that the country was endowed with 14 major, 44 medium, and numerous minor rivers spanning 0.28 million km. These water bodies supported a rich and diverse fish fauna comprising 930 species across 326 genera. He categorized Indian rivers into two major systems: the Himalayan river system, including the Ganga, Indus, and Brahmaputra, and the Peninsular river system, which encompassed both the east and west coast river networks. He emphasized that riverine fisheries contributed approximately 1 lakh tons of fish production annually but faced several challenges such as untreated sewage discharge, industrial effluents, excessive water withdrawal for agriculture, dam construction, and altered monsoon patterns leading to irregular flooding and droughts. To address these challenges, he recommended stricter environmental regulations, investment in sewage treatment plants, sustainable agricultural practices, integrated river basin management, and public awareness campaigns.

He moved on to discuss estuarine fisheries, defining estuaries as semi-enclosed coastal water bodies with a free connection to the open sea, where seawater was measurably diluted with freshwater from land drainage. He stated that India had a total estuarine area of 297,850 hectares, contributing to the inland fish yield of 139 lakh tonnes in 2023-24. He elaborated on Indian brackishwater aquaculture, which covered 1.2 million hectares of coastal areas and 8 million hectares of inland salt-affected lands. He noted that India had become a major shrimp-producing nation in Asia, exporting nearly 17 lakh metric tons of seafood valued at Rs. 60,000 crore. He provided a detailed breakdown of brackishwater aquaculture development across various states, listing the potential areas and the extent of development achieved in regions such as West Bengal, Andhra Pradesh, Tamil Nadu, and Kerala.



	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Marine (In Lakh Tonnes)	34.43	35.69	36	36.25	37.56	38.53	37.27	34.76	41.27	44.32
Inland (In Lakh Tonnes)	61.36	66.91	71.62	78.06	89.48	97.2	104.37	112.49	121.21	131.13
All India	95.79	102.6	107.62	114.31	127.04	135.73	141.64	147.25	162.48	175.45

Figure: Fish Production data of India (from Dr. Ghoshal's presentation)

Dr. Ghoshal provided insights into various fish and shellfish species used in brackishwater aquaculture, including sea bass, grey mullet, scats, milkfish, and pearl spot. He specifically highlighted the cultivation of shrimp species like Penaeus monodon, Penaeus indicus, and Pacific white shrimp (Penaeus vannamei). He elaborated on the characteristics of Asian seabass (Lates calcarifer), describing it as a euryhaline species with high adaptability to different salinity environments, a high growth rate, and suitability for pond and cage culture. He mentioned that the breakthrough in seabass seed production had been achieved by CIBA in 1997. Similarly, he discussed the milkfish (Chanos chanos), an herbivorous species with good market demand, whose seed production technology was standardized by CIBA in 2015.

He then shifted focus to shrimp culture practices, stating that Pacific white shrimp (Penaeus vannamei) had become the dominant cultured shrimp species, yielding 5.5 to 7.8 tons per hectare and significantly increasing farmers' income. He explained how bio-secured zero water exchange tiger shrimp farming had achieved production of 3.1 tons per hectare while maintaining sustainability. Additionally, he emphasized the importance of monosex culture in crab farming, which minimized aggressive behavior and improved survival rates. He detailed the use of cellular culture systems where small crabs were held in individual containers for controlled growth and fattening.

Dr. Ghoshal outlined several challenges facing estuarine fisheries, including pollution from industrial effluents, habitat destruction due to coastal development, destructive fishing practices, climate change impacts such as rising sea levels, and disruptions to water flow caused by dam construction. He recommended mitigation strategies such as stricter

environmental laws, integrated coastal zone management, sustainable fishing practices, mangrove conservation, and public awareness campaigns.

Figure: Indian brackishwater (0.5 to 30 ppt) aquaculture comprising of shell-fish and finfish farming is the economic engine of Indian aquafarming sector (from Dr. Ghoshal's presentation)

In discussing marine fisheries, he provided an overview of India's marine resources, stating that the country possessed an exclusive economic zone (EEZ) spanning 2.02 million square kilometers and a coastline of 8,118 km, with an annual capture fisheries potential of 5.31 million metric tons. He noted that capture fisheries had reached 44.95 lakh tons in 2023-24, with deep-sea and high-sea fishing offering further opportunities to harness India's marine potential. He described the achievements of marine fisheries, emphasizing that fish production had increased significantly from 5.34 lakh tons in 1950-51 to 44.95 lakh tons in 2023-24. He also highlighted the rapid growth of coastal aquaculture, particularly shrimp production, which had increased by 270% from 3.22 lakh tons in 2013-14 to 11.84 lakh tons in 2023-24.

Dr. Ghoshal then addressed the challenges associated with marine fisheries, which included overfishing, climate change impacts such as rising sea temperatures and ocean acidification, habitat destruction, pollution from plastic waste and oil spills, and illegal, unreported, and unregulated (IUU) fishing. He proposed various mitigation strategies, such as implementing

fishing regulations, establishing marine protected areas, combating IUU fishing, and controlling marine pollution. He stressed the importance of sustainable fishing practices, including setting catch limits, regulating fishing gear, and imposing closed seasons to manage fish populations effectively.

He concluded by discussing the major challenges of the blue economy, such as environmental degradation, overfishing, marine debris, and maritime security threats. He presented statistics showing that 65% of India's coral reefs were under stress and that 8.2% of the assessed fish stocks were overfished. He noted that India generated 9.46 million tons of plastic waste annually, contributing to marine pollution. He emphasized the need for promoting sustainable fishing in India by enforcing the National Policy on Marine Fisheries (NPMF, 2017) and implementing conservation measures such as uniform fishing bans, prohibition of destructive fishing methods, and installation of artificial reefs. He also highlighted budget allocations for 2025-26, which aimed to harness fisheries potential in the Andaman & Nicobar and Lakshadweep Islands, targeting an additional 2.5 lakh tons of untapped fisheries resources.

Dr. Ghoshal's presentation effectively underscored the challenges and opportunities in riverine, estuarine, and marine fisheries in India. He provided a thorough analysis of fisheries production trends, sustainable aquaculture practices, species-specific cultivation techniques, and policy interventions needed to ensure the long-term sustainability of the sector. His insights offered a roadmap for achieving the balance between economic growth and ecological conservation in India's fisheries industry.

Compiled by
Br. Soumitra Maity, PhD Scholar
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SESSION: 8
NATURE-BASED SOLUTIONS

This session was chaired by **Dr. Manas Ghosh Principal, ATC & Director, SAMETI**. He introduced key note speaker and other speakers to discuss on Nature-based solution - Sundarban.

Keynote Address:

Title: Natural climate solutions: As applicable to Sundarbans

Speaker: Dr. Debal Ray, Principal Chief Conservator of Forests, Government of West Bengal

Dr. Roy discussed the natural climate solution in the region of Sundarban. He stated that fifteen years ago, work began on assessing climate change vulnerabilities in West Bengal, including the Sundarbans, following the release of India's National Action Plan on Climate Change (NAPCC).

While progress has been made, vulnerabilities have worsened. The IPCC's confidence in dire predictions has strengthened, and greenhouse gas emissions continued on a high trajectory. The IPCC's fifth report identified three of the world's most vulnerable island regions, including the Sundarbans, confirming its high risk. The initial focus of the State Action Plan was on determining which islands could be saved in the short, medium, and long term. While vulnerability persists, a significant achievement over the past 15 years has been the mainstreaming of adaptation thinking into the planning process. Climate adaptation considerations are increasingly integrated, sometimes even unknowingly, into broader development strategies. Despite the growing risks, this shift in planning represents a crucial step forward in addressing climate change impacts in the region. Natural Climate Solutions (NCS) are considered "low-hanging fruits"—cost-effective interventions that can enhance resilience in vulnerable ecosystems like the Sundarbans. These solutions could help in mitigating climate change impacts while providing temporary relief by "buying time" until long-term measures, such as stabilizing carbon emissions and global temperatures, take effect.

The concept of "buying time" is inspired by a WWF book on species conservation, emphasizing that these solutions serve as interim measures rather than permanent fixes. While NCS play a crucial role in disaster risk reduction and adaptation, their effectiveness depends on broader efforts to curb emissions and address the root causes of climate change. Implementing NCS in areas like the Sundarbans involve restoring mangroves, conserving biodiversity, and adopting sustainable land-use practices. These strategies not only enhance ecosystem resilience but also provide socio-economic benefits to local communities. However, without stabilizing emissions and temperatures in the medium to long term, these efforts remain temporary buffers rather than lasting solutions. Ultimately, while NCS are valuable tools in climate adaptation and mitigation, they must be complemented by systemic changes to ensure long-term sustainability and resilience against climate threats.

In the face of climate change, carbon emissions must be reduced to stabilize temperatures in the medium term. One significant challenge is the increasing spread of saline blanks—barren, salt- affected lands that result from salt intrusion.

In the Sundarbans, 67 large saline blanks have emerged, growing at an alarming rate. The degradation process starts with salt intrusion, leading to soil dryness and the formation of barren patches. Over time, these patches coalesce into larger areas, exacerbating ecosystem damage. Though some sparse and stunted vegetation exists, the land remains largely unproductive. To combat this, restoration efforts began two years ago. Addressing such degradation is crucial for ecosystem recovery, biodiversity conservation, and climate resilience. By rehabilitating these saline blanks, it is possible to restore vegetation cover, improve soil health, and support local wildlife. Effective interventions could include salt-tolerant plant species, water management techniques, and sustainable land-use practices. These strategies will help mitigate climate impacts while enhancing the region's ecological stability.

Due to rapid soil salinization, exploration of different ways was carried out to restore affected areas. This analysis revealed that the top 30 cm of soil, where roots typically grow, had become too saline for most plant species to survive. To address, this research hypothesized that flushing the soil below this layer with fresh water could promote growth. To achieve this, the Sweet Water Pond was constructed at the head of the treatment area. The pond water flows through furrows, modelled after *alur bheri* (potato cultivation). This allows fresh water to percolate beneath the root zone and reduce salinity. This initiative is currently in its pilot

phase. While the methodology is yet to be improvised, it represents a promising and cost-effective approach to soil rehabilitation. Hence, this methodology was refined for restoring saline-affected areas using a low-cost approach. The focus is on introducing palatable plant species, such as *Aisia marina* and *Serius tagle* that can thrive in moderately high salinity while supporting herbivores. This strategy ensures the sustainability of ecosystems in these regions.

Vegetative barrier against storm surge:

The ecosystem services provided by the Sundarbans are valued in the millions of dollars, highlighting their importance in disaster risk reduction. Given their protective function, it is imperative to develop restoration and conservation strategies that are both effective and affordable. By prioritizing low-cost, sustainable vegetation solutions, this study can enhance the resilience of the Sundarbans while maintaining their ecological and economic value.

Between 2000 and 2018, 22 cyclones hit the region, with 16 classified as Category 4 or higher. The frequency and intensity of these storms are increasing, with three major cyclones occurring within just two years. Projections indicate an eastward shift in cyclone trajectories, moving from Odisha to West Bengal and further into Bangladesh's Sundarbans. Recognizing this trend, the West Bengal government has identified low-cost storm barriers as a crucial strategy to protect the hinterland. One such initiative involves extensive mangrove plantation in government-owned (Khas) lands.

Figure: Vegetative barrier as nature-based solution

These fast-growing mangroves serve as a natural barrier against storm surges, prioritizing rapid growth over biodiversity. This project represents a key nature-based solution,

demonstrating how ecological interventions can mitigate disaster risks. While many such solutions exist, this is one of three significant examples chosen for illustration.

Erosion control in Sundarbans:

The southern and western sides of the islands are experiencing rapid erosion, while accretion is mainly occurring in the upper zones, silting up channels. Over the past five decades, nearly 200 square kilometres of land have been lost, with the coastline retreating by approximately three kilometres between 1968 and 2014. Some islands have disappeared due to accelerated erosion and sediment shifts.

A striking example is Haliday Island, which has almost vanished. This island was a designated sanctuary, yet much of its land and biodiversity have been lost. Scientists even had to physically relocate certain molluscs from the area. This transformation is not solely due to sea-level rise. Rather, climate change has intensified sediment redistribution, shifting sediments from ecologically valuable regions to main channels. This process, driven by high-energy estuarine dynamics, has also led to severe navigational challenges. The study underscores the urgent need for nature-based solutions to mitigate the impact of such environmental changes.

Navigational problems in coastal areas are often caused by sediment accumulation, erosion, and shifting land masses, which are exacerbated by climate change. Traditionally, the Forest Department used “porcupine structures” to protect critical infrastructure. These structures, built in small administrative units (beats), facilitated sediment deposition around them. More recently, the World Wide Fund for Nature (WWF) introduced an innovative and cost-effective approach using terracotta rings to trap silt in erosion-prone islands. These rings placed strategically, capture silt during high tides. As water recedes, the sediment settles, creating a foundation for mangrove propagules to grow. Over time, these rings contribute to stabilizing the shoreline and fostering vegetation growth. WWF has implemented this method in eroded areas, refining the approach by leaving gaps between the seal traps and landmass boundaries. This modification allows for additional sediment deposition and natural recovery. However, while effective in regions with a gradual slope decline, this method is not universally applicable, especially where there is a significant height difference between land and water.

Despite its limitations, terracotta ring traps present a promising nature-based solution for

combating coastal erosion and fostering ecological restoration in suitable locations. Genetic diversity conservation is crucial for maintaining the adaptation potential of populations. As a forester, I emphasize that protecting species alone is not enough—genetic heterogeneity within populations must be preserved. When genetic diversity is lost, species lose their ability to adapt to changing environments, making conservation efforts less effective.

A gradual decline in slope can support nature-based solutions, but true resilience comes from safeguarding the genetic diversity of species across different locations. Field observations highlight that focusing solely on species conservation is often a last resort when little can be done. Instead, conservation strategies should prioritize genetic diversity to ensure long-term species survival. The key takeaway is that protecting diverse populations of the same species strengthens resilience against environmental challenges. Future generations must understand that true conservation means preserving genetic diversity, not just the presence of a species in a single location.

Title: Conserving bio-diversities for sustainable development

Speaker: Dr. Asok Sanyal, Former Chairman, West Bengal State Biodiversity Board

Biodiversity conservation is essential for sustainable development, a concept rooted in human history since the dawn of civilization. For over 2.5 million years, human progress has been driven by the quest for development, often impacting natural systems. However, many development models have proven unsustainable, leading to environmental challenges. The idea of sustainability gained prominence in 1972 during the Stockholm Conference on the Environment, where Indian Prime Minister Indira Gandhi emphasized the importance of biodiversity conservation for global peace and ecological balance. Subsequent global summits, including the 1992 United Nations Conference, the Johannesburg Summit, and Agenda 21 discussions, have consistently prioritized biodiversity conservation. These efforts address critical issues such as climate change and desertification.

The 2015 adoption of the UN's 2030 Agenda for Sustainable Development further reinforced

this commitment through 17 Sustainable Development Goals (SDGs). Biodiversity plays a crucial role in achieving these goals, ensuring food security, maintaining ecological balance, and mitigating climate change. Farmers have directly benefited from biodiversity conservation through improved agricultural diversity (agrobiodiversity), leading to better yields, and resilience to climate change, and sustainable livelihoods. Protecting biodiversity is essential for maintaining ecosystem services and securing a sustainable future for all.

Hunger remains a critical issue, with 850 million people suffering from malnutrition daily. Despite having nearly 7,000 edible plant species, only 200 are commonly used as food, and just four of them provide 80% of caloric intake. This highlights the untapped potential of plant and animal biodiversity for ensuring food security.

Sustainability and biodiversity:

Scientific and rational use of biodiversity can enhance food production, improve livelihoods, and support human well-being. Livelihoods, ecosystems, and overall human survival are intricately linked to biodiversity. It includes all living organisms, including humans, and plays a vital role in sustaining life. Proper conservation and sustainable utilization of biodiversity are crucial to achieving global well-being and long-term sustainability.

Biodiversity encompasses all forms of life, from microbes to humans, and is crucial for sustaining fundamental ecosystem services. These services, in turn, are essential for human well-being and survival. The relationship between biodiversity and ecosystem services is interdependent—biodiversity relies on ecosystem services, while ecosystem services depend on biodiversity. There are four main categories of ecosystem services, each playing a vital role in maintaining life on Earth.

Endangered biodiversity:

Biodiversity in the Sundarbans is incredibly rich, encompassing everything from microbes to mammals. However, it has declined over time, with many species already extinct. To ensure community resilience, sustainable livelihoods, and overall development, biodiversity must be the primary focus.

Conservation of biodiversity:

Three key elements contribute to conservation: access and benefit-sharing mechanisms, biodiversity protection, and sustainable resource management. These factors together help maintain the ecological balance of the Sundarbans. Human ecology, ecosystem services, and

technological advancements should be integrated into conservation efforts to strengthen biodiversity.

Erosion control in the Sundarbans depends on biodiversity, particularly the role of plant species. Conservation efforts should emphasize community awareness and education, focusing on biodiversity protection and sustainable practices. This includes providing high-quality aquaculture seeds, restoring degraded land, maintaining pollution-free wetlands, and improving communication and market access.

Macro- and micro-level studies are essential for understanding ecosystem dynamics and developing effective conservation strategies. Immediate action is needed to protect the Sundarbans' biodiversity, ensuring both environmental sustainability and the well-being of local communities.

Biodiversity and human ecology:

Biodiversity, ecosystems, and human ecology are crucial but often overlooked in development planning. Human ecology, in particular, plays a central role in sustainable progress, as people are at the core of all developmental processes. One important yet underutilized resource in this context is ‘Vetiver grass’, which has proven to be highly effective for embankment stabilization, helping to prevent erosion and manage water intrusion.

In the Sundarbans, one of the key challenges is housing sustainability amidst frequent inundation from rivers and the sea. This proposed solution involves constructing embankments using Vetiver grass, combined with a structural system of bamboo barricades. By placing two rows of bamboo with a gap in between and filling the space with mud blocks, water intrusion can be minimized. This method has been successfully applied in other regions and could be adapted for the Sundarbans.

Conclusion:

Additionally, biomass-based housing materials offer a viable approach for sustainable construction in flood-prone areas. Exploring these strategies further could lead to innovative start-ups focused on resilient infrastructure, ensuring both ecological balance and human security in vulnerable regions.

Conserving biodiversity through sustainable practices, community involvement, and technological innovation is vital for ecosystem health and human well-being, particularly in

vulnerable regions like the Sundarbans, where Vetiver grass and bamboo-based housing offer sustainable solutions.

Title: Enhancing nature-based livelihood opportunities

Speaker: Dr. S. K. Sarangi, Head, Division of Agricultural Technologies for Women, ICAR-Central Institute for Women in Agriculture, Odisha

Dr. Sarangi explained that climate change has a differential impact on men and women, particularly in the agriculture and food systems. While both genders contribute to biodiversity conservation, studies show that women face greater vulnerabilities due to climate change. Women engaged in agriculture are disproportionately affected by climate-related disasters such as floods and droughts, often experiencing higher levels of hunger compared to men. Additionally, women have limited access to essential resources like markets, credit, agricultural inputs, and extension services, making it harder for them to adapt. Addressing these disparities is crucial for building resilience among women in climate-affected regions.

Climate change and agriculture:

Climate change affects agriculture in three major ways: it reduces crop, livestock, and fisheries yields; lowers the quality of produce; and increases the incidence of pests and diseases. Given these challenges, targeted strategies must be developed to empower women and enhance their livelihoods. Identifying key areas where women need support can help create adaptive solutions, ensuring their participation in sustainable food production and climate resilience efforts. Climate change has led to an increased incidence of diseases and placed greater pressure on natural resources, particularly water and labour. This has significantly impacted women, increasing their workload as they manage essential resources. To address these challenges, adopting new technologies, improved crop varieties, and resilient agricultural practices is crucial. Additionally, climate change contributes to malnutrition, health issues, and mental stress, particularly during natural calamities.

Climate smart agricultural practices:

Recognizing these challenges, the Government of India has implemented various programs, such as the National Mission on Sustainable Agriculture and Paramparagat Krishi Vikas

Yojana, to promote sustainable farming. Over the past decade, climate-smart agricultural practices have been developed to enhance resilience in vulnerable regions like the Sundarbans. This study hypothesized, these practices need to be further encouraged, demonstrated, and propagated to ensure widespread adoption. By integrating climate-smart techniques, communities can mitigate climate risks, improve food security, and reduce the burden on women and marginalized groups.

Climate-smart agricultural practices address three key aspects:

Ensuring sustainable agricultural growth in terms of income and food security,

Adapting to changing climatic conditions,

Reducing greenhouse gas emissions.

Water efficient irrigation method:

Examples of climate-smart agricultural practices include natural resource management, such as water harvesting and efficient water management. This is particularly crucial in regions like the Sundarbans, where pond-based or ridge-based water management helps conserve rainfall and improve water storage. Reduced tillage or zero tillage practices are also essential to minimize the impact on soil resources while enhancing crop establishment. Water-efficient irrigation methods, such as drip irrigation and sprinkler irrigation, offer significant advantages over traditional flood irrigation by reducing water wastage.

Additionally, nutrient management plays a vital role in climate-smart agriculture. This includes both balanced chemical-based nutrient management and chemical-free approaches that promote the use of biofertilizers, organic manures, and beneficial microorganisms. By integrating these climate-smart practices, agriculture can become more resilient to climate change while improving productivity and sustainability.

Sustainable agriculture:

Sustainable agriculture requires a combination of improved practices, including proper residue management, mulching, and the adoption of climate-resilient crops. The development of flood- tolerant rice varieties with the sub1 gene, as well as drought- and salt-tolerant crops, enhances resilience. Crop diversification, including rotations and intercropping, ensures soil health and productivity. Adjusting sowing times in response to shifting seasonal patterns due to climate change is also crucial.

Additionally, integrated pest and livestock management, including improved manure storage,

can reduce greenhouse gas emissions by converting waste into biogas. Enhancing livelihood opportunities through agricultural entrepreneurship is essential. This includes the production of biofertilizers such as phosphate- and potassium-solubilizing bacteria and natural farming inputs like Jivamrit and Bijamrit.

Capacity-building and agriculture:

Capacity-building initiatives are vital for promoting microbial formulations tailored to specific crops. For example, jute cultivation benefits from microbial solutions like K Sona and Net Sati, which facilitate retting in conditions where water quality is declining. These innovations, combined with efficient resource management, can help farmers adapt to climate variability and maintain productivity while reducing environmental impacts. Training programs for farmers and entrepreneurs will be key in scaling up these sustainable agricultural practices.

Supporting needy farmers requires a multi-faceted approach that integrates plant growth mechanisms, quality seed production, and modern cultivation techniques. This study shows that the key focus should be on producing and multiplying plant growth hormones, ensuring healthier crop development. Additionally, the availability of high-quality seeds and planting materials, including tolerant varieties and endangered traditional crops, is crucial for sustainability. The use of green manure crops and high-quality vegetable seeds is essential, especially given concerns over private sector quality. A strong marketing strategy is needed to ensure fair returns for farmers. Livelihood options can be expanded through initiatives such as potato seed production, which meets the high demand for quality tubers. Nursery raising is another vital aspect, covering field crops, horticultural crops, and fruit plants like mango, guava, and papaya. The adoption of tissue culture for crops like banana and the use of mat nurseries for rice mechanization help address labour shortages. Entrepreneurship in agricultural tools and machinery is also necessary. Small-scale equipment like maize shellers, row makers, seed drills, and rice transplanters can significantly improve efficiency. Capacity building and training for farmers in mechanization and modern farming techniques will enhance productivity and sustainability. There is a gap between the availability of agricultural machines and their accessibility to farmers, the end users. To bridge this gap, entrepreneurship in the production and manufacturing of small implements needs to be promoted. Additionally, the concept of community custom hiring centres can be introduced by engaging farmers' interest groups or self-help groups. These centres would store essential

tools and implements, allowing farmers to either use them or rent them at a nominal price, ensuring affordability and accessibility.

Different sectors of climate smart agricultural practices:

Furthermore, the development and promotion of Farmers Producer Organizations (FPOs) can provide livelihood opportunities. Another crucial aspect is adding value to perishable crops like fruits and vegetables, as market access and fair pricing remain challenges. Encouraging self-help groups to engage in food processing—such as preserving vegetables, processing spices, and utilizing millets—can enhance income sources for communities. Beyond crop-based agriculture, other sectors like aquaculture are also vital, especially in regions like Sundarbans. Pisciculture, in particular, holds significant potential as an enterprise, contributing to economic resilience and sustainable livelihoods. Strengthening these initiatives can collectively empower farming communities, making agriculture more profitable and sustainable. The production of fingerlings and the promotion of hatcheries are crucial for enhancing fish farming, particularly for climate-resilient species. Scientific advancements have improved fingerling production for various fish species, including those for aquariums, which are in high demand. Capacity building is essential to help communities engage in aquaculture as a business, particularly in ornamental fisheries. Additionally, manufacturing modern fishing gear is critical, as manual harvesting is no longer advisable. Aquaculture presents a valuable livelihood option, with high-value species like alligator showing promise based on scientific evidence. Carp farming and export-oriented prawn culture can significantly boost farmers' incomes. In the animal husbandry sector, mechanized tools for feeding, waste collection, and general management are essential for improving efficiency. Allied enterprises like mushroom cultivation offer additional income opportunities, but the availability of quality spawn remains a major challenge. Training programs should focus on equipping communities with the skills needed to produce quality mushroom spawn. Promoting these livelihood options through scientific innovations and capacity-building initiatives can enhance economic resilience and sustainability for rural communities.

Title: Restoring ponds for rainwater harvesting

Speaker: Dr. Abhra Chanda, (Assistant Professor, School of Oceanographic Studies, Jadavpur University Kolkata)

Dr. Chanda emphasized on six key aspects: an introduction to rainwater harvesting, the types of ponds in the Sundarbans, available information on them, the potential for rainwater harvesting, associated challenges, and strategies to maximize its effectiveness. Implementing such systems can play a crucial role in addressing the water scarcity issues in the region, providing a more sustainable and resilient water management strategy for the future.

Restoring ponds for rainwater harvesting in the Indian Sundarbans is a critical solution to the region's freshwater crisis. The Sundarbans, primarily an agrarian economy, has historically relied on groundwater extraction to meet its freshwater demands. However, with increasing population density and prolonged groundwater use, there is growing concern about reaching a threshold where aquifers may no longer provide adequate water, potentially leading to land subsidence. Given these challenges, alternative freshwater sources are being explored, including the restoration of ponds for rainwater harvesting. This method, though ancient, has been successfully used by civilizations throughout history. The approach involves collecting and storing rainwater from surfaces such as rooftops or through surface runoff, ensuring a sustainable water supply.

The significance of rainwater harvesting extends beyond just providing an alternative freshwater source. It is essential for water conservation and has secondary benefits, such as flood control and soil erosion prevention. By capturing rainwater, sediments carried by runoff are also retained, reducing land degradation. Additionally, rainwater harvesting contributes to microclimate regulation, particularly in open ecosystems, by maintaining local humidity and temperature balance. Finally, it plays a vital role in recharging aquifers, ensuring long-term groundwater sustainability.

Ponds play a crucial role in aquifer recharge by allowing rainwater to seep into the ground, replenishing underground water reserves. In the Sundarbans, ponds have been integral to settlements since early colonization. Settlers would excavate land near their homes to construct houses, and these pits naturally turned into ponds. There are several types of ponds (Figure 1) in the Sundarbans. Domestic ponds support homestead gardening, subsistence

fishing, and household use. Agricultural ponds collect runoff from fields, ensuring water availability for arming. Crab fattening and aquaculture ponds are used for commercial fish and crab cultivation. Canal and irrigation ponds help regulate water flow and support agriculture. However, some ponds become abandoned, often turning into waste dumping sites, leading to water quality degradation.

Resort ponds are maintained for beautification, especially in tourism areas. Community ponds, often found near schools or village centres, serve as shared water sources for residents. Overall, ponds in the Sundarbans are essential for water management, agriculture, and local livelihoods (Fig.4a and b). Preserving them is crucial to sustaining both ecological balance and human settlements in the region.

A study in 2022 aimed to determine the number of ponds in the Indian Sundarbans, as no official data was available. This study focused on four blocks—Sagar, Patha Pratima, Gosaba, and Hingalgunj—using Sentinel-2 satellite data with a 10m resolution. They identified ponds larger than 100m², covering approximately 8 to 21.9 km² per block. The study revealed that the number of ponds is proportional to the block size, but their surface area does not follow a strict pattern. Most ponds fall within the 100–200m² range, with a significant portion exceeding 400m².

Regarding rainwater harvesting potential, previous studies by Mondol (2014) and Vadra et al. (2018) highlight a stark contrast in water demand. The potable water demand is 9 MCM, while agricultural demand is significantly higher at 2,780 MCM. The region receives substantial rainfall, ranging from 1,300 mm in low-rainfall years to 2,000 mm in high-rainfall years, generating runoff of approximately 2,100 MCM from the upper catchment and 1,800 MCM from within. These findings suggest significant potential for rainwater harvesting to address freshwater shortages, particularly for agricultural use, by utilizing the existing pond network more effectively. Theoretically, capturing runoff could help meet water demand, as the total available water (3,900) exceeds the demand (2,900). However, in practice, challenges like evaporation losses and other environmental factors make this difficult. In the Indian Sundarbans, scientific studies on this topic are limited, and most insights come from field observations.

Challenges:

One major issue is the lack of scientific intervention in pond design and management. There are no standardized guidelines on how deep a pond should be or where it should be

excavated. Another challenge is ensuring year-round water availability—harvested rainwater should be accessible even in dry periods, but current storage methods are inadequate.

The most crucial challenge is maintaining water quality. Ponds must support optimal primary productivity, functioning as net autotrophic ecosystems to regulate the microclimate and act as carbon sinks. Additionally, preventing eutrophication is vital to maintaining ecological balance. Without proper management, ponds risk becoming degraded and ineffective in supporting sustainable water conservation.

Absence of modelling structural design

Ponds in the Sundarbans are mostly man-made, with their volume determined by the investment in excavation. Their structure follows limnological principles, consisting of three layers: the epilimnion (where photosynthesis occurs), the thermocline, and the hypolimnion. If the pond is too deep, the bottom layer becomes anaerobic, leading to acidic water. Proper depth and volume management are often neglected.

Evaporation

Bank erosion is a major issue, especially during heavy monsoons, reducing pond depth and water retention. The region's silty, acid sulphate soil contributes to turbidity, limiting light penetration and photosynthesis. Another challenge is evaporation, which causes ponds to dry up completely by the summer (Zaid season), leaving no water for use.

Cultural eutrophication

Cultural eutrophication is the most severe threat, driven by excessive use of nitrogenous fertilizers and domestic activities like washing utensils in ponds. This accelerates nutrient buildup, turning aquatic ecosystems into terrestrial ones. Measuring the Trophic State Index (TSI) is essential for monitoring pond health, with oligotrophic conditions being ideal. However, most sampled ponds are eutrophic or even hypereutrophic due to uncontrolled pollution, posing a serious risk to water quality and ecosystem sustainability.

Uncontrolled GHG emission

To maximize rainwater harvesting and mitigate greenhouse gas emissions from ponds, a strategic approach is essential. Over time, ponds can transition from carbon sinks to greenhouse gas sources, releasing carbon dioxide, methane, and nitrous oxide. Therefore, new pond excavation should be guided by a multi-criteria analysis incorporating drainage density, slope, soil characteristics, and geomorphological attributes to ensure optimal site selection.

Plausible strategies to maximize rainwater harvesting potential:

Evaporation control is another key factor, particularly in regions like the Sundarbans, where high temperatures and wind velocity accelerate water loss. Techniques used in arid and semi-arid African countries, such as aqua caps that cover portions of the water's surface, can be effective. Similarly, floating "shade balls" can reduce water-air interaction, thereby minimizing evaporation. Beyond physical interventions, controlling anthropogenic activities is crucial. Littering, washing utensils, and dumping wastewater into ponds degrade water quality and must be addressed through proper waste management. Lastly, promoting citizen science can empower local communities to actively monitor and conserve pond ecosystems. In the Sundarbans, locals show keen interest in understanding water quality parameters like dissolved oxygen, pH, salinity, and turbidity. Engaging them in conservation efforts can enhance long-term sustainability and resilience of water resources.

Conclusion:

The speaker emphasizes the importance of simple, practical innovations for water management in the Sundarbans, such as using lime to regulate pH levels and automated rotators to maintain dissolved oxygen in ponds. These solutions fall under the broader umbrella of Natural Climate Solutions. For a comprehensive approach, the speaker highlights the need for geospatial modelling to assess the potential of rainwater harvesting as a long-term solution. Additionally, academic research is essential to establish a baseline for current water quality and storage capacity in the region. Citizen science should also be encouraged to engage local communities in monitoring and improving water resources. Finally, successful implementation requires collaboration between government and non-governmental organizations, integrating scientific research with community-driven interventions to ensure sustainable water management in the Sundarbans.

Topic: Eco-tourism in Sundarbans – Problems and prospects

Speaker: Dr. Chandrima Sinha, Programme Manager (Planning and Monitoring), Nature Environment and Wildlife Society, Kolkata

Dr Sinha has shed light on problems and prospects of eco-tourism in Sundarbans. The Sundarbans, the world's largest mangrove forest, holds immense ecological and economic significance. Spanning Bangladesh and India, it is the only mangrove habitat supporting a tiger population, making it unique for biodiversity conservation. Beyond its rich wildlife, the

Sundarbans is a critical buffer against climate change, shielding coastal communities from cyclones and storm surges. The dense mangroves act as a "green shield" reducing damage and enhancing resilience for the vulnerable populations living in the region.

Ecotourism in the Sundarbans presents both opportunities and challenges. On one hand, promoting sustainable tourism can create economic benefits, raise awareness about conservation, and support local livelihoods. However, balancing conservation with tourism is complex job. Increased human activity may disturb wildlife, lead to habitat degradation, and put additional pressure on fragile ecosystems. Hence, management strategies are essential to ensure that ecotourism contributes positively, without compromising the ecological integrity of the Sundarbans. Highlighting the forest's role in climate mitigation, biodiversity preservation, and sustainable livelihoods can attract responsible tourists who appreciate its unique value. A well-planned approach can make ecotourism a tool for both environmental protection and community development. The Sundarbans, a UNESCO World Heritage and Ramsar site, is home to one of the most significant blue carbon reserves, stored within its expansive mangrove ecosystem. These mangroves not only act as carbon sinks but also play a crucial role in water purification. The ecosystem is ecologically rich and visually stunning, attracting numerous visitors.

In 2021, tourist numbers dropped from 282,000 to 100,000, yet the impact remains significant. High tourist footfall demands vast amounts of water and generates considerable waste, with no comprehensive data available on its environmental effects. Most visitors enter through the Sajnekhali gate and primarily explore via river routes, leading to congestion

Tourists mainly seek tiger sightings, but such encounters are rare. This overreliance on tiger-based tourism is unsustainable, as the natural movement of tigers is disrupted by excessive boat traffic. Sustainable ecotourism strategies must be developed to preserve the fragile Sundarbans ecosystem while maintaining its appeal. Without intervention, uncontrolled tourism could jeopardize the very environment that attracts visitors, undermining the ecological balance of this globally significant mangrove forest. Tiger-based tourism has led to the rapid expansion of hotel infrastructure in areas like Pakhiralaya, transforming it from a

quiet village into a dense tourism hub. In contrast, nearby areas like Satjelia remain less developed. While tourism provides economic opportunities and educational experiences, it must be balanced with ecosystem conserva tourism provides economic opportunities and educational experiences, it must be balanced with ecosystem conservation and community well-being.

Challenges:

A major challenge is the lack of proper infrastructure, including jetties, large vessels, and waste disposal facilities. Additionally, human-wildlife conflict is prevalent, with numerous tiger attacks affecting local communities. Exploitation of local populations and resource scarcity further exacerbate the situation. Freshwater scarcity is a pressing issue, despite the surrounding abundance of water. In villages, clean water is hard to access, and groundwater is turning saline, particularly in northern regions like Hingalganj due to saltwater intrusion. However, there remains potential for responsible tourism, which, if managed well, could support both conservation and local livelihoods. Sundarban offers diverse tourism experiences, including wildlife safaris, bird watching, and village tours. Responsible tourism in Sundarbans should prioritize community involvement, eco-friendly accommodations, conservation efforts, and awareness programs. It is essential to regulate tourism to prevent environmental damage. Infrastructure should be built using natural materials that align with local culture rather than concrete structures that disrupt the ecosystem.

Scope:

An example of eco-tourism development is Kumirmari Village, where efforts were made to establish sustainable accommodations. Initially, the local community resisted using traditional mud or thatched houses due to concerns about storm resilience. Respecting their concerns, alternative eco-friendly solutions were explored. Overall, responsible tourism in Sundarbans must balance visitor experience with environmental conservation and local community welfare, ensuring sustainable growth.

For an example, the resort's development follows an eco-friendly approach. Initially, the first two cottages were constructed using concrete and fly ash bricks, which help conserve topsoil, the most fertile part of the land. For the third cottage, a modern mud structure with a thatched roof was introduced, blending traditional and contemporary methods. To enhance sustainability, the entire resort is powered by solar energy. Waste management is also a priority—plastic is strictly discouraged, and biodegradable waste is composted. The compost

is then utilized in the resort's organic kitchen garden, which the local community maintains. Additionally, the resort promotes local culture and livelihood opportunities. Through these efforts, the resort not only supports sustainable tourism but also empowers the local population by fostering eco- conscious practices and cultural preservation. Farm tourism is a model where visitors experience farming firsthand. In areas like Patharpratima and Kakdwip, farmers grow vegetables without harmful chemicals. City dwellers can visit these farms, observe farming practices, and enjoy fresh, organic produce. The government supports this initiative through homestay subsidies, encouraging farmers to accommodate visitors.

Farm tourism also benefits local communities by creating jobs, generating revenue, and preserving cultural heritage. It contributes to community revitalization and environmental stewardship, as farmers are motivated to maintain sustainable practices for additional income. This model not only enhances rural economies but also fosters a deeper connection between urban dwellers and agricultural life.

The Sundarbans, the world's largest mangrove forest, faces challenges balancing ecotourism with conservation. While tourism offers economic benefits and raises awareness, it also risks disturbing wildlife and degrading habitats. Over-reliance on tiger-centric tourism, coupled with inadequate infrastructure and waste management, strains the fragile ecosystem. Responsible tourism, prioritizing community involvement, eco-friendly practices, and conservation, is crucial. Initiatives like eco-lodges using local materials and solar power, handicraft development, and farm tourism offer sustainable alternatives. These initiatives promote local livelihoods while preserving the Sundarbans' unique biodiversity and mitigating climate change.

Compiled by
Diksa Kar, PhD Scholar
School of Environment and Disaster Management

SESSION-9:
STRATEGIC APPROACH FOR BUILDING RESILIENCE

The Sundarbans, a vast and fragile ecosystem, face an existential crisis due to climate change, extreme weather events, land degradation, and socio-economic vulnerabilities. In response to these pressing challenges, Session 9: Strategic Approach for Building Resilience **at the** International Symposium on Building Resilience of Communities in Sundarbans aims to explore comprehensive strategies for ensuring long-term sustainability and resilience in the region.

The session was chaired by **Prof. Jayanta Bandyopadhyay, Distinguished fellow at the Observer Research Foundation, Kolkata**. An internationally renowned professional in public interest research, mountain environment, and water governance in South Asia, Prof. Bandyopadhyay has authored sixteen critically acclaimed books and monographs and 150 papers and articles. Prof. Bandyopadhyay commenced this session by expressing his gratitude for the opportunity to chair such a significant discussion on resilience. He acknowledged Professor P.G. Dhar Chakrabarti for

inviting him to be the session chair and emphasized that the session was privileged to have an eminent keynote speaker, Shri Prabhat Kumar Mishra, Additional Chief Secretary, Finance Department, Government of West Bengal.

Shri Prabhat Kumar Mishra, Additional Chief Secretary, Finance Department, Government of West Bengal, his keynote address provided critical insights into the role of financial governance and strategic policy interventions in enhancing the resilience of Sundarbans communities. He emphasized the need for a ***multi-stakeholder approach,*** leveraging government policies, financial instruments, and community-driven initiatives to ensure sustainable development in the face of climate change and environmental uncertainties.


Prabhat Kumar Misra

He emphasized that the region's geomorphology was highly dynamic and continuously threatened by coastal erosion, sea-level rise, and high salinity levels and the inhabited part of the Sundarbans had been reclaimed from mangrove forests during colonial administration, leading to significant ecological changes. Mr Mishra further explained that over the last 200 years, the eastward migration of the Ganges had reduced freshwater inflow into the Sundarbans, causing increased salinity, which adversely impacted biodiversity. He noted that the relative change in sea level was about 7 mm per year, and sea surface temperatures had risen at a decadal rate of 0.5 degrees Celsius, well above the global average. Reduced sediment supply, land subsidence, and siltation of tidal rivers had intensified tidal amplification and coastal erosion, with 4.5 sq. km of land being lost annually.

Mr. Mishra discussed how the seven main tidal rivers - Hooghly, Muriganga, Saptamukhi, Thakuran, Matla, Bidyadhari, and Harinbhang - were becoming increasingly disconnected from wetlands, leading to siltation. He pointed out that large portions of wetlands had been converted into shrimp farms, disrupting the natural flow of tidal rivers. This led to rising salinity in agricultural lands and more frequent embankment breaches. He stressed that a basin-based approach was essential to maintaining the health of these rivers.

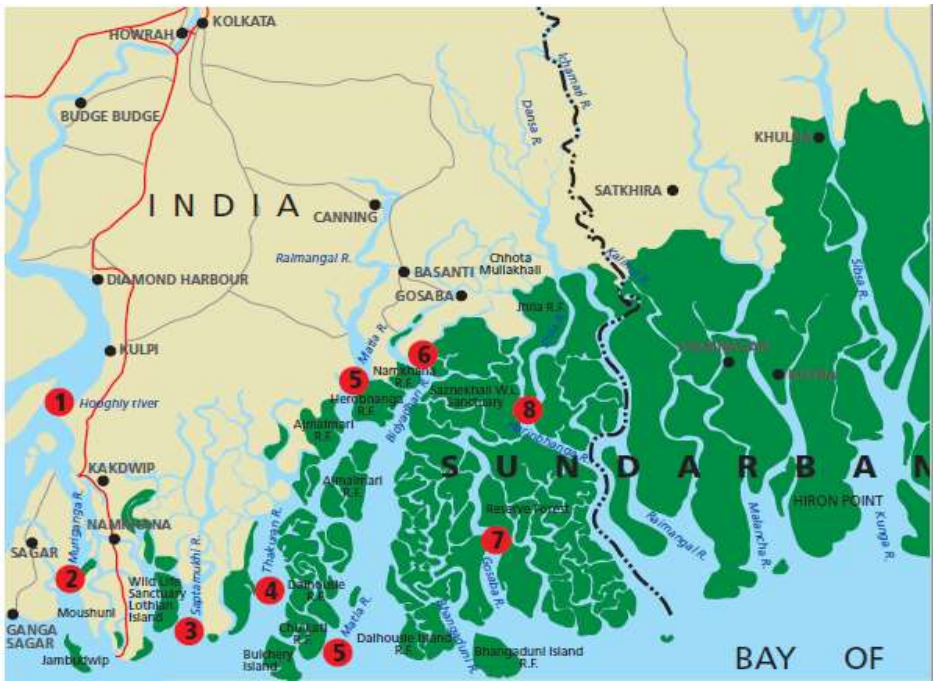


Figure: Tidal Rivers in Sundarbans (from Mr Mishra's presentation)

He presented alarming data on land loss, revealing that 250 sq. km had been lost between 1970 and 2015 due to tidal erosion. Many villagers had been forced to retreat, and ten sea-facing islands were most vulnerable to further erosion. He specifically mentioned that Lohachara Island was completely submerged, and 59% of Ghoramara Island had disappeared underwater. Shri Mishra elaborated on how rising salinity levels threatened mangroves, particularly species like *Nypa fruticans*. He cited a 2021 study by Robert J. Nicholls et al., which used satellite data to analyse mangrove health. The study found that 110 sq. km of mangrove forest had been lost due to erosion, while 81 sq. km had been regenerated through plantation efforts in inhabited areas. However, the shift toward salt-tolerant species indicated a decline in overall mangrove health.

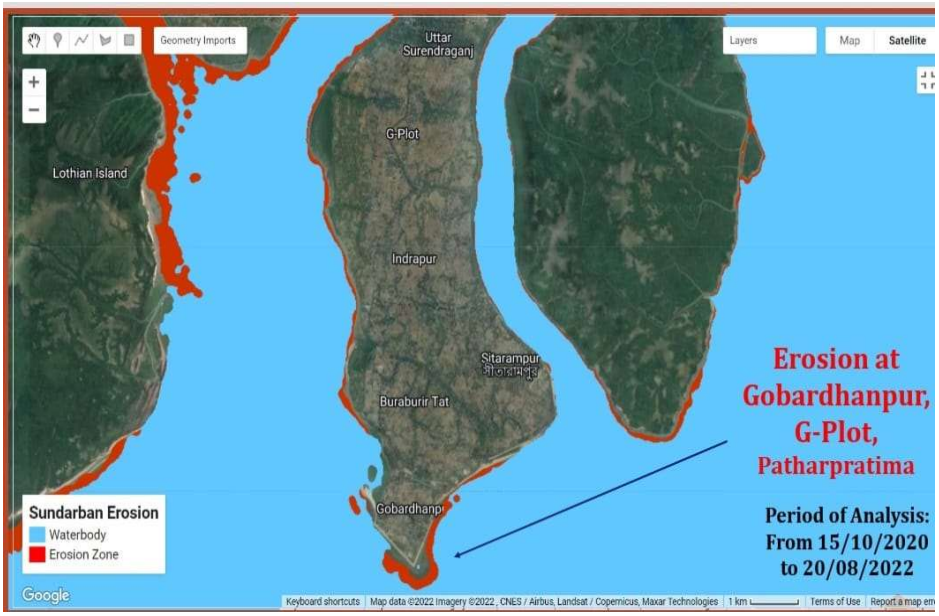


Figure: Erosion level (from Mr Mishra's presentation)

He advocated nature-based solutions such as sea-facing embankments and mangrove restoration efforts. He shared examples like Bankimnagar, where dwarf embankments had successfully facilitated healthy mangrove growth. However, he acknowledged that land acquisition for embankments remained a challenge, as most land was either vested or privately owned. He proposed a comprehensive rehabilitation policy to facilitate embankment construction. Mr Mishra highlighted the Govardhanpur mangrove plantation project, an exemplary effort led by women's self-help groups (SHGs). A sandbar had trapped silt, fostering natural mangrove regeneration, which in turn helped protect embankments and enhanced biodiversity. He emphasized the ecological services provided by mangroves, such as storm protection, flood control, saltwater intrusion prevention, and carbon sequestration, estimating their value at Rs. 1 million per hectare per year.

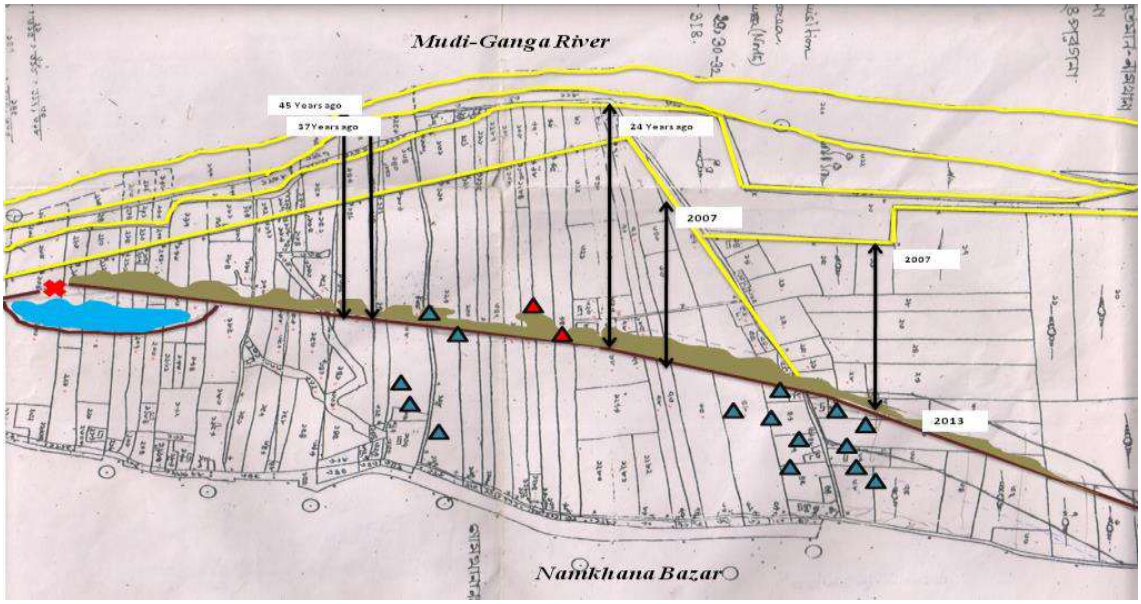


Figure: Muri Ganga river (from Mr Mishra's presentation)

He stressed the importance of community involvement in conservation efforts. He explained that local communities had a deeper understanding of mangrove benefits and should be primary stakeholders. He proposed creating mangrove nurseries managed by SHGs and maintenance programs involving local farmers. He also noted that paddy farmers had shifted to shrimp farming due to increased salinity and suggested forming farmer clusters to promote sustainable agricultural practices. He showcased West Bengal's Accelerated Development of Minor Irrigation Project (WBADMIP), which had successfully renovated creeks to improve water flow and reduce salinity. He also highlighted rainwater harvesting as a key strategy to expand freshwater availability in the Sundarbans. Mr Mishra discussed salt-tolerant crop options, such as watermelon, chillies, sunflower, spinach, bitter gourd, coriander, and capsicum, which had shown promising results. He recommended scaling up traditional salt-tolerant paddy varieties like *Swarna*, *Dudheswar*, *Matla*, and *Hamilton*. He also emphasized medicinal plant cultivation (*Brahmi*), the need for cold chain infrastructure, and the use of polyhouses and micro-irrigation to optimize water use.

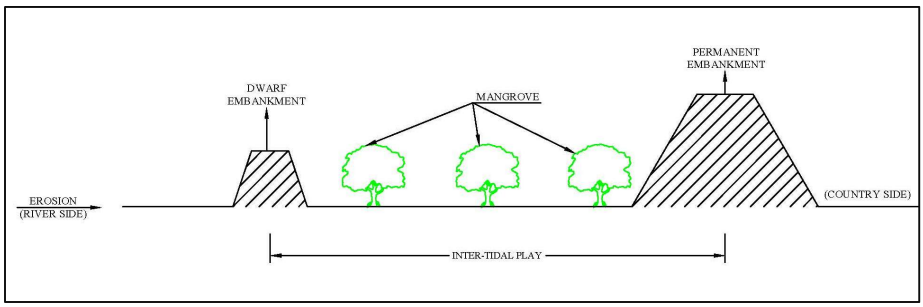


Figure: Nature-based solutions (from Mr Mishra's presentation)

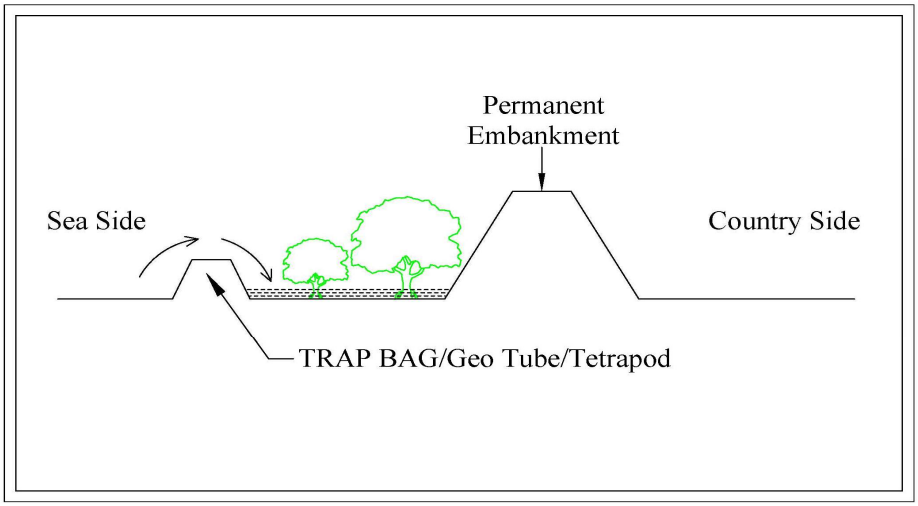


Figure: Sea Facing Embankment (from Mr Mishra's presentation)

He identified high-return aquaculture options, including salinity mapping for better planning. He suggested shifting from *Venami* shrimp to native *Tiger Prawn* in saline areas and *Scampi* in freshwater zones. He emphasized the importance of disease diagnostic centres, organic farming near water bodies, and cold chain infrastructure to support shrimp farming. He also highlighted integrated mangrove shrimp farming as a sustainable model. He introduced value-chain models for Scampi farming, outlining different stages of hatchery, juvenile rearing, and market-ready shrimp production. He also emphasized the potential of rearing Garole sheep, an indigenous breed well-adapted to the Sundarbans' conditions. He stressed the need for pontoon-based jetties, link roads, electricity-based cold chains, and storage spaces to facilitate access to markets. He suggested targeting Kolkata's organic produce market for Sundarban farmers. Mr Mishra explained how mangrove conservation could be monetized through carbon credit instruments. He acknowledged a market failure in developing carbon offset projects and called for government-backed initiatives to quantify

and trade carbon credits under the Green Credit Rules, 2023. He proposed a dual strategy for Sundarbans's resilience, first, one is the Upper Delta: Rejuvenate River basins and restore wetlands, and the second one is the Lower Delta: Implement nature-based solutions like mangrove plantations and embankments, and improve freshwater availability by re-excavating creeks, form farmers' and fishers' groups to promote sustainable livelihoods and Enhance transport infrastructure, including water-based transport and eco-tourism.

Mr Mishra concluded by reiterating the importance of nature-based solutions, community participation, and strategic policy interventions. He emphasized that engineering solutions should complement ecological restoration to create a self-sustaining and resilient Sundarbans. He ended with a call to action, urging policymakers, researchers, and local communities to work together in building a sustainable future for the Sundarbans.

The very first theme lecture of season 9 was delivered by **Mr *Md. Abdul Gani*, Former Special Secretary, Department of Sundarban Affairs, Government of West Bengal**. His presentation, titled "*Development Plans in Indian Sundarbans: Achievements and Shortcomings*", examined the historical, institutional, and policy-driven aspects of the region's development. His extensive experience in policy formulation and administration provided valuable insights into the historical and contemporary development challenges in the Sundarbans region of India.

Mr Gani began his talk by exploring the Dampier & Hodges Line, which once demarcated the Sundarbans' boundary. In his presentation, he said the region was classified into stable (Includes human settlements, agricultural land, and development areas), transition (A buffer between protected and inhabited regions, where controlled human activities like sustainable fishing and tourism are permitted), and core zones (A strictly protected area with no human interference, meant for wildlife conservation), each with varying degrees of human-wildlife conflict and forest use regulations. He explained that during **British colonial rule**, land use policies in the Sundarbans were primarily revenue-driven. Mr Gani also mentioned in his talk that the historical perspective detailed the premature land reclamation by the colonial

authorities under the Permanent Settlement Act of 1793 which prioritized land revenue over ecological concerns.

He discussed the Bengal Embankment Act of 1882, which was the first structured attempt at regulating embankment construction but later contributed to siltation and flood risks. Mr. Gani elaborated on the agrarian struggles of this era, particularly the Tebhaga Movement, which sought land rights for cultivators. The presentation then moved on to the Government of India Act of 1935, which granted provincial governments control over land policies, and this led to the establishment of the Floud Commission in 1938, tasked with assessing land revenue issues and recommending reforms for agrarian distress. The session addressed how government policies introduced high-yielding crop varieties and irrigation schemes to combat food insecurity. However, the unintended consequences, such as groundwater depletion and the loss of indigenous fish species, were also highlighted. The establishment of the Sundarbans Development Board in 1973 was noted as a crucial step in organizing development initiatives in the region.

Figure: Dampier & Hodges Line (from Mr Gani's presentation)

Mr. Gani pointed out that after independence, India had adopted the Universal Declaration of Human Rights as a guiding principle. The refugee crisis had become a major issue for the state government. To support farmers, two key acts were passed: one is the Estates

Acquisition Act of 1955, which abolished the Zamindari system, and the other one is the Land Reforms Act of 1956, which introduced land ceilings and land redistribution policies. Mr. Gani explained that while the colonial forest regulations had continued, revenue settlements had changed. Seasonal unemployment and corruption in the public distribution system have led to food crises. The introduction of high-yielding varieties and Boro cultivation had resolved food shortages but had also caused environmental issues by eliminating native fish and other species also mentioned. He noted that the Sundarbans population, which had depended on water, forests, and land, had suffered from pollution and declining productivity. He also mentioned that the Sundarbans region included 13 blocks in South 24 Parganas and 6 blocks in North 24 Parganas. The Sundarban Development Board (SDB) was formed in 1973, and a UNESCO resolution led to the declaration of the Sundarban Biosphere Reserve, covering 4,200 sq. km of reserve forest and 5,400 sq. km of non-forest human habitation areas. He noted that in 1978, the three-tier Panchayati Raj system had been institutionalized, and in 1994, the Department of Sundarban Affairs had been created. Dr Gani listed major employment and self-employment programs introduced over the years such as JRY, IJRY, EAS, IRDP, SESRU, and PMRY give employment schemes for unskilled, semi-skilled, and skilled labourers, implemented through Panchayati Raj Institutions and self-employment schemes, which, according to him, had been implemented without proper assessment and had led to mistrust between institutions and stakeholders.

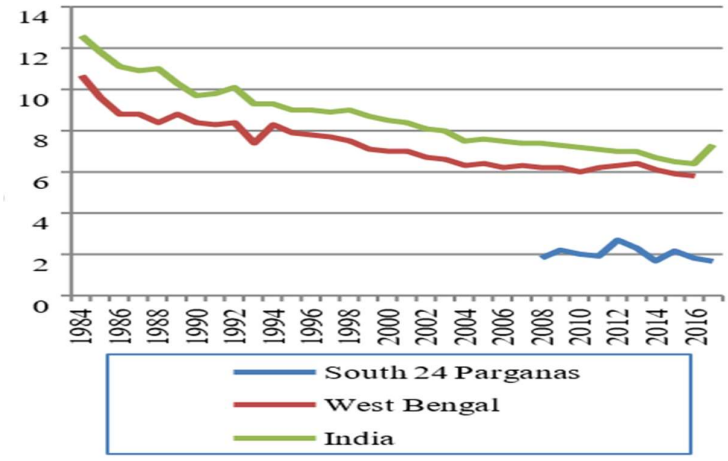


Figure: Trends of crude death rate (from Mr Gani's presentation)

Mr Gani stated that various departments had operated with secrecy, leading to a lack of transparency. The SDB, under the Planning and Development Department from 1973 to 1994, had received limited funds and had focused mainly on building communication networks. This had caused conflicts with PRIs, the Irrigation and Waterways Authority, PWD, and WRDD. Mr Gani also highlighted those different categories of reserved areas that had been established to protect the biodiversity and ecological balance of the Sundarbans. He presented data on the crude death rate in South 24 Parganas between 2008 and 2017, comparing it with the overall trend in West Bengal from 1984 to 2017.

Mr Gani emphasized the need for institutional changes, poverty reduction, vulnerability reduction, and biodiversity conservation. He insisted that administrative coordination needed to be tangible and vibrant. Mr. Goni concluded that the Sundarbans had overlapping jurisdictions of multiple institutions, leading to ineffective coordination. Mr. Gani recommended that all institutional functions be brought under direct control and supervision through appropriate statutory and regulatory mechanisms. He suggested redesigning the SDB as a full-fledged directorate with officials from all relevant institutions of the West Bengal government. His presentation raised awareness about the historical and ongoing development challenges in the Indian Sundarbans. Attendees gained insights into the evolution of land and resource management in the region.

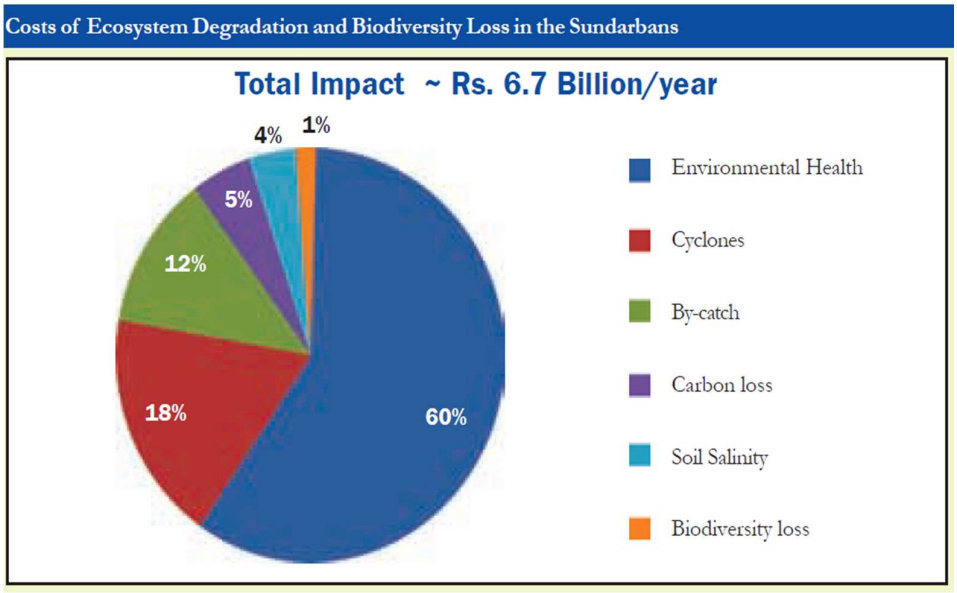


Figure: Costs of ecosystem degradation and biodiversity loss in the Sundarbans (from Mr Gani's presentation)

The second theme talk was delivered by **Dr. Rajarshi Dasgupta, Assistant Professor, School of Public Policy, IIT, Delhi** spoke on "*Strategic Interventions for Building Resilience to Climate Change and Disasters*". He stated that the purpose of his presentation was to discuss strategic interventions for building resilience to climate change and disasters in the Sundarbans. He mentioned that the symposium aimed to bring together experts to address critical issues related to resilience in the region.

Dr Dasgupta shared that a Scopus search using specific keywords had yielded 1,798 plus research papers related to the Sundarbans. These papers had spanned across 28 academic disciplines and had contributions from over 180 authors. He highlighted the vast amount of knowledge available and emphasized its significance in policy planning. Dr. Dasgupta quoted Charles Kettering's famous statement: "A problem well stated is a problem half solved." He then posed critical questions about resilience, such as who benefits from it, who bears the cost, and whose narrative shapes the policies. He had questioned whether resilience efforts had been inclusive and whether they had focused on short-term or long-term solutions. He explained different resilience theories like Ecosystem Resilience (Holling, 1973) had been described as the ability of a system to absorb disturbances while maintaining its core functions, Adaptive Resilience Theory (Walker et al., 2004) has been discussed as a model emphasizing flexibility and adaptation to future uncertainties, Panarchy Theory (Gunderson & Holling, 2002) was introduced as a framework highlighting the cyclic phases of growth, conservation, collapse, and reorganization in systems, and Critical Resilience Theory or Community Resilience Theory (Pelling, 2011) has been noted for its focus on addressing injustices and structural barriers to adaptation.

He stated that resilience needed to be measured effectively to be improved. He referenced the Human Development Index (HDI) as a useful starting point, although it had limitations in directly measuring disaster resilience. He also discussed alternative indices such as the Notre Dame Global Adaptation Initiative and the World Risk Index. Dr Dasgupta outlined the limitations of existing resilience frameworks, noting issues such as data granularity, proxy

indicators, and the focus on short-term events like Cyclone Aila. He also emphasized the lack of transformative indicators in resilience planning.

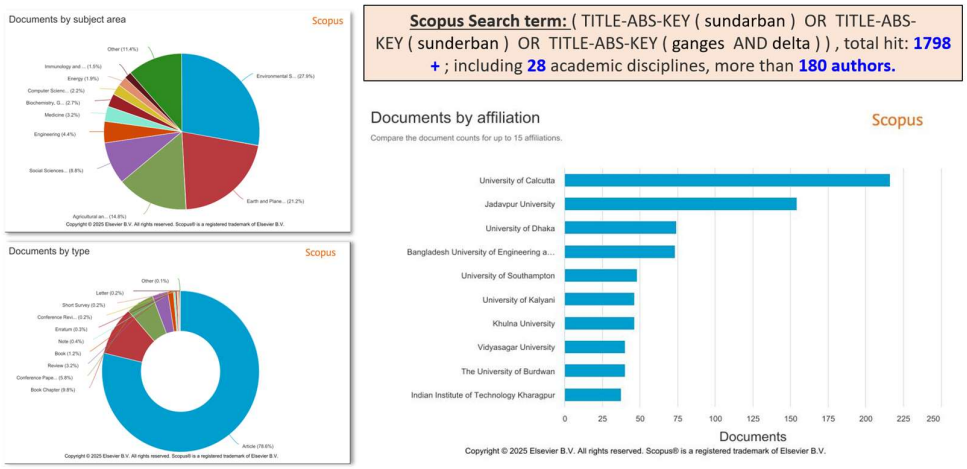
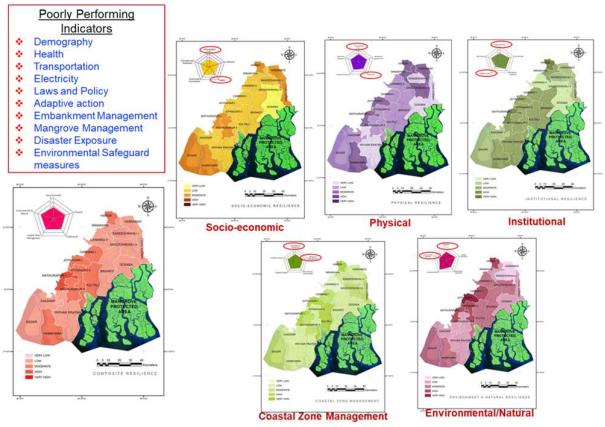


Figure: A glimpse of research on Sundarbans (from Dr Dasgupta's presentation)

Socio-economical	Physical (Infrastructural)	Institutional	Coastal Zone Management (Ecological)	Environmental & Natural
Demography (SE-1)	Transportation (PH-1)	Laws & Policies (IN-1)	Embankment & Shoreline Protection (CZM-1)	Frequency of Natural Disasters (EN-1)
Livelihood (SE-2)	Residential Infrastructure (PH-2)	Coordination (IN-2)	Mangrove Management (CZM-2)	Climatic Components (EN-2)
Health (SE-3)	Electricity (PH-3)	Emergency Response (IN-3)	Coastal Bio-diversity Conservation (CZM-3)	Geo-physical Components (EN-3)
Community Governance & Social Capital (SE-4)	Tele-communication (PH-4)	Adaptive Actions (IN-4)	Coastal Pollution (CZM-4)	Bio-geochemical Components (EN-4)
Education & Awareness (SE-5)	Water & Sanitation (PH-5)	Governance (IN-5)	Coastal Land use (CZM-5)	Environmental Safeguard Actions (EN-5)



Limitation: (a) Snap-sort view of resilience (b) Data granularity and availability (c) Proxy indicators (d) Contextual: Customed to Cyclone Aila (e) Lack of representation of transformative indicators

7

Figure: Five-dimensional resilience framework (from Dr Dasgupta's presentation)

Dr Dasgupta presented an embankment-centric model for disaster resilience in the Sundarbans, emphasizing the need to improve embankment management and agricultural strategies, particularly concerning soil salinity.

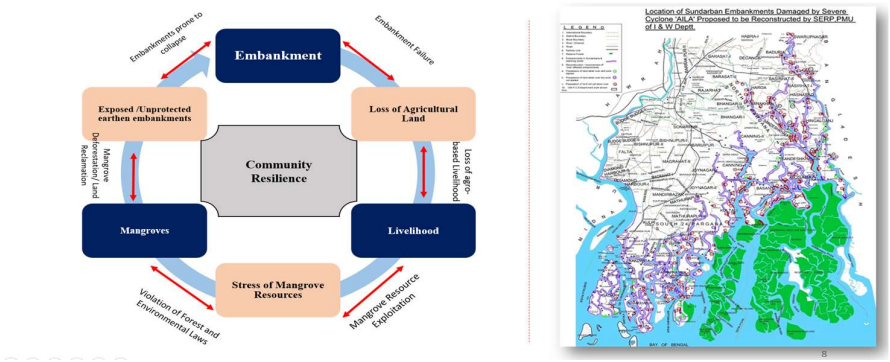


Figure: Embankment-centric resilience model of disaster and climate resilience in Sundarbans (from Dr Dasgupta's presentation)

Dr Dasgupta explained that the Sundarbans were not a homogeneous region, and thus, required zone-wise interventions for resilience. He referred to the World Bank's 2014 report, which had recommended 30 interventions across four key areas these are Vulnerability Reduction, Poverty Reduction, Biodiversity Conservation, and Institutional Changes. He discussed the IPCC's Climate Resilient Development Pathways, which promoted integrating mitigation, adaptation, and sustainable development for reducing climate risks. He emphasized the importance of considering equity, poverty reduction, and environmental sustainability in resilience planning. He had reviewed Bangladesh's Delta Plan 2100, which had outlined a 50-100-year planning horizon with short-term (2030), medium-term (2050), and long-term (2100) goals. He had highlighted that water management had been central to the plan and that it had accounted for multiple social and environmental goals. Dr Dasgupta introduced the socio-hydrological perspective as a valuable entry point for resilience planning. He mentioned ongoing research projects studying how hydrology and social structures interacted to shape climate resilience in the Sundarbans.

He explained that the Nature Futures Framework, developed by IPBES, had provided a new way to integrate different perspectives, including Indigenous knowledge, scientific research, and policy considerations. He described the three pathways within NFF, such as Nature for Nature (Intrinsic Value of Mangroves), Nature for Society (Instrumental Value, Ecosystem Services), and Nature as Culture (Relational Value, Equity, and Identity). He concluded by stressing the importance of collaboration between government agencies, academia, and local communities to build resilience. He had noted that most resilience frameworks had been reactive, responding to specific disasters, rather than focusing on transformative long-term

planning. He advocated for zone-based resilience strategies and the inclusion of newer frameworks like NFF. And finally, Dr Dasgupta ended his presentation with an AI-generated image of a resilient Sundarbans. He had left it open to interpretation, encouraging the audience to analyse the features that represented resilience in the region.

Figure: Resilient Sundarbans: Impression of Generative AI (from Dr Dasgupta's presentation)

The third lecture was delivered by **Dr. Anamitra Anurag Danda, Director, Sundarban Programme, WWF-India, Senior Visiting Fellow, Energy and Climate Change Programme, ORF, Kolkata** spoke on ***"Planned adaptation or managed retreat"***. Dr Danda began by introducing a multi-stakeholder workshop held in March 2009, which focused on climate change impacts and adaptation in the Sundarbans. The primary objective of the workshop had been to inform policy decisions to guide effective actions in response to anticipated changes in the region. He highlighted that policymakers needed to focus on strategies that would prevent the population from being exposed to

climate change impacts while simultaneously reducing their vulnerability. He also mentioned the WWF's suggestion of an alternative scenario to the existing business-as-usual approach. This proposal aimed to stimulate a well-informed public discussion by presenting a viable pathway that ensured human development continued while minimizing threats posed by extreme climate events. In the long run, this scenario sought to achieve the restoration of the mangrove ecosystem and the associated ecosystem services that provided natural resilience against climate change.

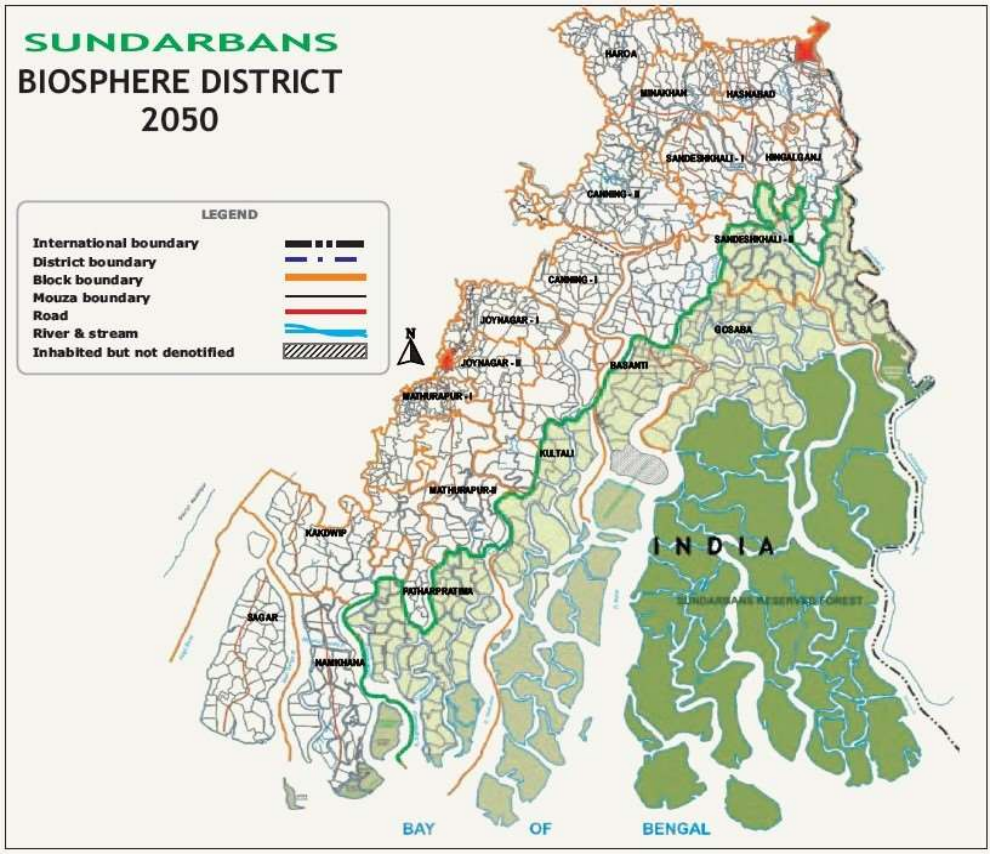


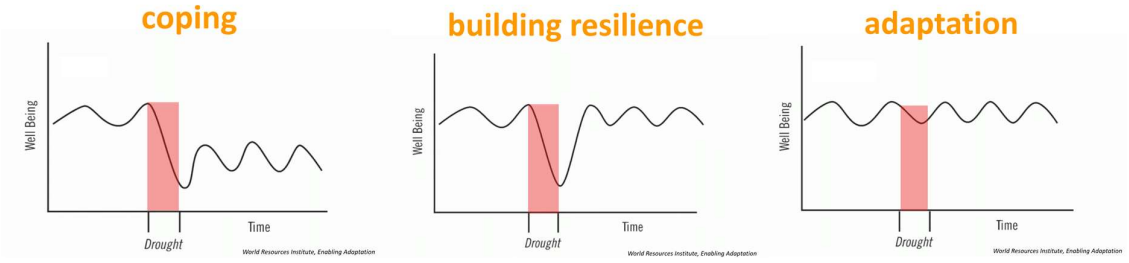
Figure: Sundarbans Biosphere District 2050 (from Dr Danda's presentation)

Dr Danda's presentation also referenced findings from the World Resources Institute (WRI), which contributed to the discussion on enabling adaptation. The author explored the concept of coping, emphasizing that short-term coping mechanisms were insufficient in addressing long-term climate threats. The communities in the Sundarbans had historically relied on reactive measures to deal with climate variability, but these strategies often proved to be unsustainable. Dr Danda suggested that a transition from mere coping to active resilience-building was necessary. Another key focus was on the theme of building resilience. Dr Danda

explained that resilience-building entailed proactive measures to ensure that communities were equipped to handle climate challenges without suffering irreversible damage. The emphasis was placed on ecosystem-based adaptation strategies, where the restoration of natural resources such as mangroves would play a crucial role in fortifying the Sundarbans against sea-level rise and extreme weather events.

Figure: Ecosystem-based adaptation strategies (from Dr Danda's presentation)

He further expanded on the concept of adaptation, as defined by the WRI. Adaptation was described as an ongoing process that required both structural and non-structural interventions. The author pointed out that planned adaptation efforts needed to be comprehensive, integrating scientific knowledge, traditional wisdom, and stakeholder participation to ensure long-term sustainability. Additionally, it was highlighted that managed retreat where communities were relocated away from vulnerable zones was not a preferred strategy due to socioeconomic and cultural constraints.



Picture: Aspects of coping, building resilience, and adaptation (from Dr Danda's presentation)

Dr Danda underscored the need for a balanced approach that did not solely rely on either planned adaptation or managed retreat but instead focused on a combination of human development and ecosystem restoration. The Sundarbans, as a unique ecological and socio-economic landscape, required innovative strategies that would protect both its communities and its biodiversity. The presentation emphasized that a forward-thinking, multi-stakeholder approach was essential to building resilience in the face of climate change challenges.

The fourth lecture was delivered by **Prof. Amites Mukhopadhaya**, **Professor, Department of Sociology, Jadavpur University, Kolkata** spoke on "*Conservation and conflict - Hopes and despair for the future*". Dr Mukhopadhaya delved into the historical evolution of conservation in India, particularly in the Sundarbans, by referencing a statement from Ronald Haring, made at a conference on the Commons in South Asia in Washington DC in 1987. He mentioned that, according to Haring, unlike tribal-inhabited forests where conflicts arose between traditional resource use and state-imposed conservation policies, the shrinking mangrove forests of the Sundarbans had become battlegrounds between livelihood-seeking communities and state-imposed restrictions.

Professor Mukhopadhaya argued that while Haring's statement was insightful, it overlooked the broader history of conservation in India. He explained that the principle of restriction and exclusion had been the foundation of most conservation policies, first under British colonial rule and later in post-independence India. In particular, he described how the Sundarbans' forests had been viewed through two opposing lenses over time. During the first 100 years of colonial rule**,** the forest was seen as an obstacle to economic development**.** Efforts were made to reclaim land for agriculture, leading to increased settlements and deforestation. After the passage of the Forest Act of 1878, the forest was seen as a valuable economic resource. The British administration sought

to control and commercialize forest resources while restricting native access to these lands. This shift in perspective laid the foundation for conservation conflicts, where state policies attempted to exclude local communities from lands that had historically been their source of sustenance.

Professor Mukhopadhaya explored the concept of *"The Tragedy of the Commons"*, explaining how colonial capitalism had redefined ownership and access to natural resources in South Asia. He emphasized that historically land and forest resources in India operated under a system of communitarian ownership, where multiple overlapping rights existed over the same physical space. He cited pre-colonial governance models, including the Delhi Sultanate and Mughal Empire, where agricultural lands, grazing areas, and forests were managed under a collective system. The emergence of Zamindari rights under British rule disrupted these traditional models, leading to displacement and loss of access for many tribal and rural communities. He suggested that this historical amnesia surrounding pre-colonial conservation models had shaped present-day conflicts in the Sundarbans.

Professor Mukhopadhaya also talked about the role of religious and cultural practices in shaping conservation ethics in the Sundarbans. He cited Richard's seminal work, *"The Rise of Islam and the Bengal Frontier"*, which described how Sufi saints played a role in organizing agricultural settlements in the Sundarbans. According to Eaton, these saints were seen as protectors of both the forests and the communities living within them. They facilitated a symbiotic relationship between people, forests, and wildlife. British gazetteers, such as Om Ali and Francis Banan, had documented these relationships, highlighting the existence of a moral ecology where humans coexisted with tigers, mangroves, and supernatural beliefs. He further argued that these traditional conservation ethics are still relevant today. He noted that while scientific conservation policies often dismissed these beliefs as superstitions, they nonetheless played a crucial role in shaping how local communities perceived the sanctity of forests and their responsibility toward environmental stewardship.

He highlighted the evolution of conservation policies in post-independence India. He explained how early conservation efforts were modelled after British colonial practices, which relied on top-down exclusionary policies. These policies often led to forced evictions and displacement of local communities, generating resistance and conflict. However, by the 1980s and 1990s, India witnessed a shift toward **a** Joint Forest Management (JFM) model, which sought to integrate local communities into conservation projects. Professor

Mukhopadhaya described this shift as an acknowledgement of past failures, where conservation efforts had been imposed without considering the realities of those living in and around protected areas. He highlighted how conservation projects, particularly in the Sundarbans, had gradually evolved to recognize the importance of local knowledge, participation, and sustainable livelihoods**.** He acknowledged that while displacement and exclusion had not entirely ceased, modern conservation policies increasingly sought to balance ecological preservation with human needs**.**

Professor Mukhopadhaya posed critical questions regarding the future of conservation in the Sundarbans. He identified some challenges: conservation restrictions had reduced traditional livelihood opportunities such as fishing, honey collection, and wood gathering**,** forcing many to migrate for alternative work. Increasing human settlements near protected areas has led to frequent tiger attacks, making conservation efforts a matter of survival for local communities. Large-scale conservation projects, including Project Tiger, had been associated with forced evictions, leading to tensions between conservation authorities and local populations. Rising sea levels, salinity intrusion, and cyclonic storms further complicated conservation efforts, making resilience-building a necessity. Despite these challenges, he argued that conservation in the Sundarbans could not be viewed as an exclusive effort separate from human needs. Instead, conservation must coexist with the lives and traditions of the people who had made the region their home for generations.

In his concluding remarks, Professor Mukhopadhaya emphasized that conservation efforts, no matter how well-intended, could not succeed without local community engagement**.** He argued that the people living in the Sundarbans were not merely passive recipients of conservation policies but active stakeholders who shaped and influenced conservation outcomes. He urged policymakers to adopt an inclusive conservation approach that acknowledged the complex socio-economic realities of the Sundarbans. He suggested that future conservation strategies should: Prioritize livelihood security by integrating sustainable economic activities with conservation goals. Promote participatory governance models that involve local communities in decision-making. Recognize and incorporate traditional ecological knowledge into formal conservation policies. Develop long-term resilience strategies to mitigate climate change impacts. Professor Mukhopadhaya concluded by posing a thought-provoking question: Should conservation continue as an exclusive, state-driven effort, or should it evolve into a collaborative, community-centred model? He left the

audience with this challenge, urging them to rethink conservation paradigms for a more sustainable and equitable future.

Discussion:

The panel discussion of session 9 at the symposium focused on the critical issues surrounding resilience, policy formulation, infrastructure development, and environmental conservation in the Sundarbans. Moderated by an expert panel, the discussion featured a diverse set of perspectives from researchers, policymakers, and community representatives. Several questions were raised by the participants, leading to insightful responses from the panellists.

The discussion began with a question posed by Sneha Biswas, who inquired about the necessity of quantitative data in policy formulation. He referenced various indices, such as the Resilience Index and Vulnerability Index, and highlighted ethnographic studies conducted in the Sundarbans. He questioned whether numerical data was always essential or if qualitative narratives could also play a role in shaping public policy. Dr. Rajashi Dasgupta responded by acknowledging that while qualitative insights were valuable, policymakers often preferred numerical data to formulate policies. He argued that metrics provided a reference point to measure progress, citing examples such as carbon sequestration targets. He also emphasized that a combination of qualitative and quantitative methods would be ideal for a comprehensive understanding of resilience.

The second question revolved around infrastructure development in the Sundarbans, particularly concerning tidal creek closures. The participant highlighted the impact of geomorphological changes and the lack of proper micro-level slope analysis before initiating government-funded projects. It was noted that embankments and road construction without proper drainage had exacerbated waterlogging and led to declining agricultural productivity. The panel responded by acknowledging the oversight in past infrastructure projects. They

emphasized the importance of conducting slope analysis before initiating construction to avoid disrupting natural drainage systems. One of the panellists noted that historically, residents had adapted to flooding by elevating land and digging ponds, but modern infrastructural changes, such as the concretization of pathways without culverts, had created unintended consequences.

A third question was directed to Dr. Dasgupta regarding the strategic implementation of the Blue Economy in the Sundarbans. The participant highlighted global issues such as overfishing, marine resource depletion, and the environmental impacts of bycatch and ghost fishing gear. The question sought to understand whether there were specific policies in India aimed at addressing these challenges in the Sundarbans. Dr. Dasgupta responded by outlining the need for carrying capacity assessments to determine the ecological sustainability of fishing activities. He cited global examples where excessive fishing had led to long-term depletion of resources. While specific Indian policies were not directly addressed, he emphasized the necessity of balancing economic benefits with ecological sustainability.

Another segment of the discussion addressed the technical aspects of tidal river closures. A participant asked whether the government had conducted studies on the long-term impacts of sealing tidal creeks and their effects on island inundation. It was noted that some paleo channels, which once played a role in freshwater storage, had silted up due to lack of maintenance. The panel acknowledged that while some closures were necessary for infrastructure projects, others had unintended consequences. The discussion pointed to the need for a re-excavation strategy to restore water flow and prevent salinity intrusion. The potential for freshwater storage through selective excavation was also discussed as a way to support livelihoods such as aquaculture.

A crucial question was raised about the political will behind the implementation of policies and frameworks for resilience-building. The participant expressed scepticism regarding the translation of well-documented policies into real-world action. In response, a panellist discussed the Multiple Streams Framework in public policy, which explains how problem identification, policy proposals, and political actions must align for effective policy implementation. He pointed out that policy shifts often occurred during **crisis events,** such as cyclones, when political and public attention was heightened. He also cited the framing of the Sundarbans Master Plan following Cyclone Yaash, which led to large-scale funding initiatives from the Asian Development Bank and the World Bank.

The final segment of the discussion focused on the measurement of resilience. A panellist noted that while resilience indicators had been established, the lack of updated data such as the Human Development Index for the Sundarbans hindered accurate assessment. He suggested that without regular data collection, it was difficult to evaluate long-term changes in community resilience. The discussion concluded with a collective acknowledgement that resilience-building in the Sundarbans required an integrated approach. The panellists emphasized that policies must be informed by both quantitative data and qualitative narratives, infrastructure projects should incorporate ecological considerations, and political will remain a key determinant in successful implementation. The session ended with a call for continuous dialogue and research to address the evolving challenges of the Sundarbans.

Compiled by
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Session-10:
Panel Discussion on
Draft Strategic Framework and Road Map to Resilience

This was the concluding session of the three day International Symposium on Building Resilience of Communities in Sundarbans. The Session was chaired by **Shri Prabhat Kumar Mishra Additional Chief Secretary, Finance Department Government of West Bengal**. He explained that the session will start with the presentation of the draft Strategic Framework and Road Map for Building Resilience of Communities in Sundarbans that has been developed based on the deliberations of the symposium. This will be followed by a panel discussion of a very distinguished panel that include Prof. Andy Large Director, Living Deltas Hub School of Geography, Politics and Sociology Newcastle University, UK, Shri Rajendra Ratnoo IAS Executive Director National Institute of Disaster Management Government of India, Shri Atri Bhattacharya IAS Additional Chief Secretary, Sundarban Affairs Department Government of West Bengal, Dr. Kalyan Rudra Chairman, West Bengal State Pollution Control Board, Dr. Jayanta Basu Environment Documentation and Communication Expert, Visiting Faculty, Calcutta University, and Shri Subhas Acharya Member Sundarban Development Board. Prof. Sugata Hazra Former Director, School of Oceanography Jadavpur University could not join the panel, but will send his comments separately.

After all the panelists have spoken the session will be open to the floor when anyone from the audience will be free to share their ideas, views, comments, perspectives and seek clarifications from the panelists.

Dr. P G Dhar Chakrabarti Swami Vivekananda Chair Professor on Environment and Disaster Management, RKMVERI and Convenor of the International Symposium presented the draft Strategic Framework and Road Map for Building Resilience of Communities in Sundarbans which is based on the three day long deliberations of the symposium spread out in eight thematic sessions. This policy document is structured in ten sections, as follows:

1) Contexts,
2) Challenges,
3) Strategic Approach
4) Estuary Management
5) Mangrove Regeneration
6) Livelihood Generation
7) Disaster Risk Reduction
8) Implementation Mechanism
9) Road Map
10) Monitoring and Evaluation.

This document has been circulated to the panelists present here as well as those joining online from London, Delhi and Kolkata. After the panelists have given their comments, this will be thrown open for discussion in the house. The document shall thereafter be circulated to all speakers and delegates who are not present today and further posted on the symposium website for inviting comments from the public. Based on the comments received, the draft will be finalized and submitted to all concerned for necessary follow up action.

Dr. Chakrabarti explained that the document is based on evidences from scientific knowledge across a wide range of disciplines as well as indigenous knowledge of communities, as presented in the symposium. The focus of the document is building resilience of local communities who are facing very serious existential crises that must be addressed through multi-prone interventions in a time bound manner.

Sundarban is administratively organised in 19 development blocks in the twin districts of North and South 24 Paraganas, but not all these blocks are facing similar crises. It is the isolated 9 predominantly island blocks of Hingalganj, Sandeshkhali-II, Basanti, Gosaba, Kultali, Mathurapur-II, Namkhana, Pathar Pratima and Sagar, inhabited by over 2.5 million people that are facing the brunt of the cumulative impacts of physiographic (land subsidence,

river sedimentation and island erosion), climatic (seal level rise, salinization, storm surges) and socio-economic challenges (poverty, livelihood crisis, distress migration). The WWF-India and the World Bank had recommended evacuation of people from these blocks to safer places in the districts, which is humanly impossible due to non-availability of land and absence of livelihood opportunities in the hinterland. These communities have been living in Sundarbans for generations and have developed capacity to live with harsh climatic conditions, which need to be further enhanced through well planned and coordinated initiatives for reducing risks of disasters and adapting to climate change.

The strategic approach for building resilience of local communities will require various structural, non-structural and nature based solutions across multiple sectors that can be broadly categorized in four pillars of interventions: Estuary Management, Mangrove Regeneration, Livelihood Generation, and Disaster Risk Reduction. The projects, programmes and activities required to be undertaken under each of these four pillars of interventions and the time line for their implementation were detailed in the road map.

It was pointed out that a strong, efficient and effective mechanism for implementation, monitoring and evaluation shall be necessary for building resilience of communities in a time bound manner before the problems are further compounded to create very serious humanitarian crisis that may be difficult to be addressed.

The presentation of the draft Strategic Framework and Road Map for Building Resilience of Communities in Sundarbans was followed by a lively panel discussion. **Prof. Andy Large Director Living Deltas Hub, School of Geography Politics and Sociology, Newcastle University, UK** expressed his regret for not being able to attend this important symposium physically due to his preoccupations and appreciation for the organisers for curating this symposium with participation of a large number of experts across disciplines and sectors and coming out with a draft strategic framework and road map for building resilience of communities in such a quick time. This framework resonates well with the work of Living

Delta Hub (LDH) on three rivers of South and South East Asia, namely Red River and Mekong in Vietnam and Ganga-Brahmaputra and Meghna in India and Bangladesh. The Five-Year long LDH project with funding from Global Challenge Research Fund of UK Research and Innovation is in its concluding phase. Prof Andy was happy to find that some of the stakeholders of LDH – School of Oceanography Kolkata, IIT Khargpur and AIT Bangkok – have actively participated in this symposium. In this context he referred to the forthcoming First UNCCRD Delta Summit 2025 in Bangkok next month which is likely to deliver a White Paper to the UN to operationalize the proposed UN Convention for Conserving River Deltas (UNCCRD) to address the challenges faced by these ecosystems.

The climate change and the associated challenges of sea level rise, salinization and livelihood are the key issues of the delta communities, and solutions must be location specific, community led and cultural heritage sensitive. We must understand the nexus of land water energy and food to analyze the drivers and spatial temporal dynamics of climate change, and again he was happy to see from the schedule and from the report that a lot of work has concentrated on these aspects.

Prof Andy referred to the importance of monitoring and evaluation, as mentioned in page 14 of the draft framework. The LDH established the first delta wide water quality baseline in India, Bangladesh and Vietnam which can be a good information base for planning and optimally utilizing the fresh water resources of the region which is critical for building resilience in the face of sea level rise and salinization.

Prof Andy underscored the importance of involving local communities for assessing their own risks of disasters. The participatory GIS can be a useful tool to empower the communities to select the layers of hazards vulnerabilities and exposures that they perceive as being the key drivers of their risks. In this context he referred to the risks of Covid-19 in driving reverse migration, which may be repeated in future, and should be factored in the strategic approach for building resilience of communities.

Prof Andy further underscored the importance of developing a strong data base of evidence to support policy decisions. We must also learn from the indigenous knowledge system of local communities who are adapting to harsh climate conditions on a daily basis. The traditional knowledge based on indigenous practices and cultures can provide solid support for many of the adaptive strategies that are advocated in the draft outcome document.

Shri Atri Bhattacharya IAS Additional Chief Secretary, Sundarban Affairs Department Government of West Bengal, commended the initiative of RKMVERI for organizing the first ever international symposium on Sundarbans covering a wide range of subjects and further coming out with a draft strategic framework and road map for building resilience of communities through a consultative process.

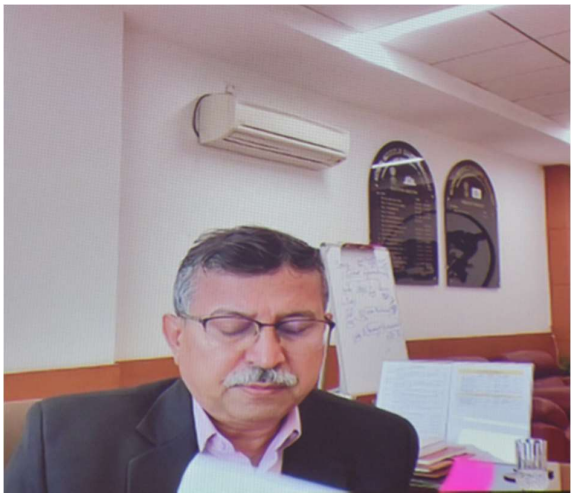
Shri Bhattacharya reiterated his statement during the opening session that we have to resolve dual conflict of nature versus man and man versus nature and develop a holistic framework in which nature will sustain itself and further provide solution to many of the challenges facing the communities including the critical issues of livelihood. Nature has also its carrying capacity and therefore all our activities must ensure that we are not exceeding the limits of such capacities.

In this context the most important issue is to stabilize the population of Sundarbans at its present level and therefore skill development of local youth for their gainful employment outside the delta should be an important agenda for reducing the pressure of population on the fragile ecosystem of the region.

Shri Bhattacharya suggested that once the draft strategic framework and road map is finalized a presentation can be made to the senior officers of the concerned departments of Government of West Bengal to discuss further course of action for taking it forward for implementation in a time bound manner, if necessary, with support from Government of India and multi-lateral funding agencies. RK Mission and its sister organizations should be involved with the process of implementation of the plan due to their networks, credibility and past records of service for the poor and downtrodden people of Sundarbans.

Shri Rajendra Ratnoo IAS Executive Director National Institute of Disaster Management Government of India complimented the School of Environment and Disaster Management of RKMVERI for organising this International Symposium on Building Resilience of Communities in Sundarban in collaboration with the School of Oceanographic Studies of Jadavpur University and Department of Sundarban Affairs of Government of West

Bengal. Sunderban is an ecologically super sensitive zone that is facing multiple challenges - increasing sedimentation and decreasing depth of rivers, rising sea level, growing salinity of soil and rivers - which is having a cascading impact the lives and livelihood of people. Lohachara and Bedford Islands of the delta have already submerged and Ghoramara Island is at high risk of submergence. Landmass of many islands include reserved forests have eroded consistently.



Problems of Sunderban cannot be addressed by focusing only on Sunderbans because the issues of sedimentation, erosion and salinization are linked with the larger issues of river basin management. Therefore we need to have a more comprehensive and holistic solution to the problem which may be difficult and complicated as river water is committed to many upstream projects that cannot be abandoned. Hence we need to find innovative solutions for enhancing the flow of water into the estuary.

However there are many challenges that can be addressed locally. The most important is regeneration of mangrove which can build resilience of communities in multiple ways, such as protecting them from storm surge, providing them employment, rejuvenating the ecosystem including bio-diversity, and promoting eco-tourism which opens up further opportunities for employment. Mangrove regeneration should therefore occupy a central place in the strategic framework for building resilience of communities.

Shri Ratnoo highlighted the importance of last mile connectivity for Early Warning Systems and real time forecasting to predict the level of submergence due to storm surge or flood. Adoption of such technologies with suitable local adaptation can be helpful in preparing emergency response plans and saving lives.

Shri Ratnoo made a mention of the network of Indian universities and institutions for DRR hosted by the NIDM. A small grant can be provided for supporting collaborative research projects for risk assessment in Sundarban and also for innovative applications for addressing the problem. Human resource development and capacity building are another areas where

NIDM can provide support to the Government of West Bengal for organizing specialized training programs for the community leaders and local level functionaries.

Dr. Kalyan Rudra Chairman, West Bengal State Pollution Control Board complemented the efforts made for developing an excellent strategic framework and road map to resilience

in such a short time. He suggested that strengthening of embankment should be treated as a separate pillar for building resilience as embankments are the lifelines of Sundarbans. The embankments of Sundarbans may be classified in four types. The first is the narrow embankment with a crest of 1.5 M, having step edge on the river side and about 34° slope on the landside, looking like an equal angle triangle, which is also used as a walkway and hence a means of communication for the people. The second type has a crest of about 2 m with riverside slope of 26°and landside slope of 34° and the third one has a crest of 2.5 M with river side slope of 24° and landside slope of 27°. The last one which is popularly called Aila bund is supposed to be the most resistant as it has a width of about 4 M and river side slope of about 18° and the landside slope of 27°. This type of embankment has absorbed the thrust of the subsequent cyclones, but are hugely expensive, costing about 13 cr. for 1 kilometer. There is scope for innovating on the design of each type of embankment that can trap sediments on the river side and help regenerate the mangrove.

The most critical embankment is a stretch of about 324 km which are mostly east facing concave sides which should be protected with a vegetative buffer. A stretch of 30 km of sea facing embankments also need special treatment. IIT Chennai had come forward with a proposal of offshore intervention in Sagar Island, but these have not been very successful. Parallel sea facing dykes with cross dykes in between shall be useful to trap sediments to generate a natural vegetative buffer to protect the embankments and stop erosion of sea facing islands including the sea facing reserved forest islands.

Dr Kalyan Rudra suggested that this strategy document should have one paragraph that will recommend redefinition of Sundarbans to exclude the 10 blocks that are so fully integrated with the mainland by roads and railways that these can no longer be regarded as part of Sundarban delta. Dr Rudra further suggested that this policy document should recommend that all diesel operated ferry boats in Sundarbans should be converted into electric boats to reduce the pollution load from emission and oil spills and the noises generated by low cost fuel engines.

Dr. Jayanta Basu Environment Documentation and Communication Expert and Visiting Faculty, Calcutta University congratulated the organizers for coming up within a very short time a strategic framework for building resilience in Sundarban and flagged a few issues with which he has been involved. The first is the study on community based disaster management to explore how the school buildings located on high grounds can be used as temporary disaster shelter as the existing cyclone shelters of Sundarbans are not adequate to accommodate people evacuated during cyclones and floods. The study will be useful for strengthening disaster response in isolated islands who cannot be evacuated away from their islands for shelter. The second is the issue regarding loss and damage in Sundarban in the context of new global fund created to support communities that have suffered due to climate change. The deltaic communities of Sundarbans have suffered irreparable loss and damage, much more than the small island developing states, due to both extreme climate events like cyclonic storms and floods and slow onset climate process like sea level rise and salinization. We need to document such loss and damage in Sundarbans so that these poor communities can claim their shares from global funds for building their resilience.

Shri Subhas Acharya Member Sundarban Development Board recounted his long association with Sundarban both as a resident of one of the most vulnerable blocks of Pathar Pratima and as a member of Sundarban Development Board for over 35 years. He pointed

out that the strategy documented missed out an important issue and this is the critical issue of fresh water which is getting increasingly scarce due to salinization of river. The farming communities of Sundarbans have taken recourse to indiscriminate use of ground water for cultivation of Boro crops and this will have a disastrous consequence as the aquifer of Sundarbans do not get recharged easily due the non-porous nature of the soil. Therefore restrictions should be imposed on use of precious ground water for irrigation purposes as this will exhaust the only source of drinking water in the delta.

Shri Acharya raised the issue of construction and maintenance of embankments that are the lifelines of Sundarbans. Large areas of Sundarban islands are without proper embankments and there are breaches in many places that are not repaired. These have exposed the communities to the risk of saline water ingress into their agricultural fields. He has made a detailed study of the villages and hamlets that are not protected by embankments and these should be taken up in a phased manner if necessary with funding support from external agencies.

Shri Acharya further raised the issue of regeneration of mangroves which is gaining support from people who are convinced that these are the only effective frontline defence for their survival and livelihoods. Therefore the time is ripe for taking up massive community based mangrove regeneration programme in Sundarbans.

Shri Acharya felt that the problem of Sundarban is not of hunger or poverty as everyone has food to survive; the problem is existential as everyone is concerned about their future and their very existence which is threatened by the fury of sea and rivers. Therefore every effort should be made to secure the life and property of people by strengthening the embankments and raising green buffer to provide a shield to the embankments and human settlements. The time is running out and we must act fast before it is too late.

Session Chair Shri Prabhat Mishra summed up the discussion which he said was fascinating. He recalled his association with Sundarbans as Principal Secretary in charge of Environment Department and Irrigation and Waterways Department. The problems of Sundarban are complex and difficult, but these difficulties are not insurmountable. Recent advances in science have given us deep understanding of the factors and processes that have contributed to the problems and technological progress in many sectors have given us innovative ideas for solution. These new ideas and innovations combined with indigenous knowledge and traditional wisdom and the indomitable spirit of people will help us to overcome the crisis situations. He will be happy to contribute to the implementation of the strategic plan.

The panel discussion was followed by a lively interactive session with the audience for half an hour when many questions were asked, clarifications sought, perspectives shared and ideas advanced for building resilience of communities in Sundarbans. Chairman assured that the proceedings have been recorded and requested the audience to further share their views in writing to the Convenor.

Dr P G Dhar Chakrabarti, Convenor of the symposium announced that copy of the draft strategic framework and road map shall be mailed to all speakers and registered participants and further posted on the symposium website for two weeks for inviting comments, views and suggestions from all interested individuals and organisations.

The draft framework shall be revised and the final document circulated to all concerned for further follow up action. This will also be published as part of the proceedings of the symposium.

A copy of the final policy document titled **Strategic Approach for Building Resilience of Communities in Sundarbans 2025-2050** is appended with the report.

Compiled by
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Glimpses of the Concluding Session

STRATEGIC FRAMEWORK AND ROAD MAP FOR BUILDING RESILIENCE OF COMMUNITIES IN SUNDARBANS

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STRATEGIC FRAMEWORK AND ROAD MAP FOR BUILDING RESILIENCE OF COMMUNITIES IN SUNDARBANS

Contexts

1.1 Sundarban is the largest river delta in the world, spread over 200 islands, separated by nearly 400 interconnected tidal rivers and creeks, at the confluence of Ganga, Meghna and Brahmaputra in the Bay of Bengal, spanning across India and Bangladesh. It is the habitat of world's largest contiguous mangrove forest and abode for nearly 500 wildlife fauna including the enigmatic Royal Bengal Tiger. The Sundarban reserved forest areas of the two countries have been designated as Ramsar Wetland and further enlisted as World Heritage Sites in the late eighties and early nineties. The legal, institutional and operational frameworks for conservation of mangroves and bio-diversity and protection of wild life protection have been well established in both the countries with reasonable measures of success despite the adverse impacts of climate change and extreme climatic events.

1.2 Sundarbans is also the habitat of about 13 million people of which about 5 million people live in the 'Sundarban Biosphere Reserve' (established in 1989), comprising of 19 development blocks of the twin districts of North and South 24 Paraganas of West Bengal in India. Human settlements in the islands of Sundarbans had existed long before the advent of the British, but it was the British policy of leasing land to Zamindars and small cultivators that encouraged large scale migration of poor people from Orissa, Mednipore and Chota Nagpur who cleared the jungles for agriculture, raised embankments for protecting agricultural fields and dug ponds for conserving rain water for drinking. Such settlements took place on the west of Sundarbans towards Calcutta that were connected by new built road and railways. Gradually such settlements spread over towards the islands on the east, mainly after the partition of India and further after the emergence of Bangladesh. Population of Indian Sundarbans have multiplied from11.50 lakhs in 1951 to 44.86 lakhs in 2011 with average density of 987 per sq. km.

1.3 Although population of all the 19 blocks of Sundarbans are mostly marginal farmers and share croppers, many of them living below poverty line, there is marked disparity in the standard of living of the people of 3 million people living in the 10 development blocks that

are well connected by road and rail, and 2 million people living in isolated islands. The Human Development Reports of North and South 24 Paragana districts prepared in 2009 highlighted these 'layers of intra-district disparities in development' in terms of education, health, employment, connectivity, access to banking and income. While the connected 10 development blocks of Sundarbans are fully integrated with the mainland, the isolated 9 blocks are living in a different world altogether, struggling to survive daily in hostile environment marked by rising tides, sinking lands, intruding saline water, without the basic services of decent living, often migrating to other districts and States in search of livelihood. The cumulative impacts of these physiographic and climatic changes and the rising frequencies and intensities of extreme and slow onset natural hazards will make the conditions of these poor and marginal people living on the edge even more difficult in the coming years. This will create an existential crisis for about 2.5 million people with enormous human tragedies unless there are serious deliberations for building resilience of the communities of these isolated island blocks through well planned and coordinated initiatives for reducing risks of disasters and adapting to climate change.

1.4 In this context a three day international symposium was organized by the School of Environment and Disaster Management of Ramakrishna Mission Vivekananda Educational and Research Institute, in collaboration with the School of Oceanographic Studies of Jadavpur University and Department of Sundarban Affairs of Government of West Bengal, to bring together scientists and researchers from various disciplines, policy makers from various sectors and practitioners from the fields to discuss and develop a strategic framework and road map for building resilience of local communities during the next two and half decades - from 2025 to 2050.

Challenges

2.1 A strategic framework on future development of Sundarbans must respond to the multi-dimensional challenges faced by the isolated islands. There has been an upsurge of research on these challenges based on scientific evidences on the patterns, trends and likely scenarios in physiographic, climatic, socio-economic, environmental and other related areas in the isolated island blocks of Sundarbans.

2.2 **Physiographic challenges**: There are five clear trends in the physiographic changes of Sundarban delta and these include a consistent loss of landmass and mangroves in habited and forested islands, increase in land subsidence, rise in river sedimentation and salinization of soil and water.

a) **Loss of landmass:** Tidal waves, storm surges and massive volume of water drained into the Ganga-Bhagirathi-Hooghly channel during monsoon have combined to cause continuous erosion of landmass in Sundarbans, particularly on the western side. The rivers have also deposited silts at some location creating new landmass, but rate of land erosion has been more than three times that of land accretion. During 1993-2000 net land loss was 283.58 sq. km, averaging 2.85 sq. km per year. This has sharply increased to 4.5 sq. km a year after 2000, due largely to frequent breaches in embankments. A few islands – Bedford, Lohachara, Kabagadi and Suparibhanga – have been submerged completely, and a few others – Ghoramar, Jambudwip and Bhangaduani – are eroding at a rapid space. Unless the embankments are made strong enough to withstand tidal waves and storm surges through structural measures and bio-shields the rate of land loss will increase.

b) **Loss of mangroves:** Around 110 sq. km of mangroves have disappeared in reserve forest area in the last two decades due to erosion, and a large chunk of mangroves outside the forest areas have been lost due to encroachments, while 81 sq. km was gained in the inhabited area through plantation and regeneration, showing both the problems and prospects for mangroves in Sundarbans.

c) **Land subsidence:** Landmass of Sundarbans is sinking gradually due to the combined effects of the natural tectonic tilting of the Bengal basin towards the east and the anthropogenic process of compaction of loose deltaic deposits due to human settlement cultivation. Land subsidence in Sundarban is taking place at an average rate on 2.4 mm per year, with some areas showing much higher subsidence of 6.9 mm per year, making the area extremely vulnerable to flooding as well as sea lea level rise.

d) **River sedimentation:** Silt deposits in the river beds of Sundarbans have increased as most of the rivers are no longer connected to large upstream river sources due to river avulsion and the construction of Farakka barrage. This has simultaneously reduced the water holding capacity of the rivers and raised the water levels of rivers, making the habited islands more vulnerable to floods and sea level rise.

e) **Salinisation:** Sea level rise, rise in tidal waves and storm surges, breaches in embankments and reducing flow of sweet water in the rivers, particularly on the central and eastern side have combined to raise the level of salinity in soil and sub-soil in southern parts of Sundarbans. In some areas, salinity has increased beyond the safe threshold for agriculture. Soil tests carried out post cyclone Aila found saline infiltration beyond a depth of 1.5 meters in most areas.

2.3 **Climatic change:** Climate of Sundarbans is changing like in other parts of the country and the world, but such changes are much more pronounced in Sundarbans and are clearly visible in all four parameters – rise in temperature, uncertainties in precipitation, rise in sea levels, and increase in frequencies and intensities of extreme climatic events

a) **Rise in temperature:** Sea Surface Temperature (SST) in Bay of Bengal has been rising at the rate of 0.5^0C per decade since 1980, which is much higher than the global average. Warmer sea water causes more evaporation, condensation and depression leading to increasing frequencies of cyclonic storms. Warmer sea further causes thermal expansion of water, leading to sea level rise. Land temperature in

b) **Uncertainties in rainfall:** Various studies have indicated that increase in SST beyond a threshold impacts rainfall negatively. This is leading to longer but drier monsoons where single rainfall events are becoming more intense. Such erratic rainfalls are not distributed evenly through the monsoon season leading to patches of dry monsoon during Kharif season which is affecting agriculture in Sundarban which depends almost entirely on monsoon.

c) **Sea Level Rise:** Sea Level Rise in Sundarban has also been higher than the global average – 5 mm/year compared to 4.4mm/ year globally. This is due to the combined effect of thermal expansion of sea water due to rise in SST, river sedimentation at the confluence due to silt load and land subsidence due to compaction of loose deltaic deposits. Geological Survey of India has estimated that one meter rise of sea level may inundate about 1,000 sq. km area of Sundarban delta. The islands of on the seaward side are most vulnerable to seal level rise. Other islands are also vulnerable as sea level rise will make tidal waves and storm surges even higher, posing higher risks to embankments and human settlements.

d) **Cyclonic storms:** Rise in sea surface temperature has resulted in increasing frequencies and intensities of cyclonic storms in northern Bay of Bengal. Historical average of one cyclonic storm in a year and one severe cyclonic storms in five years has given way to five cyclonic storms and one severe cyclonic storm every year. Sea level rise and river sedimentation has compounded the impacts of cyclones in Sundarban delta.

2.4 **Socio-economic challenges:** The cumulative impacts of the physiographic and climatic changes have adversely impacted on the life and economy of Sundarbans and these are clearly

visible in the declining income from agriculture and fisheries, loss of livelihoods, rise in level of poverty, rise in distressed migrations, and worsening conditions of women and children.

a) **Dwindling agriculture:** Nearly 70 percent of population of Sundarbans primarily depends on agriculture for their livelihood. Agriculture in the deltaic islands is inherently constrained by marginal landholdings of the farmers, near absence of irrigation facilities, and low-lying fields with poor infiltration capacity of soil, resulting in prolonged water stagnation during monsoon and near absence of freshwater in winter and summer seasons. All these factors make multi-cropping to be practiced extensively. Agriculture is further constrained by lack of institutional support of credit and essential inputs and infrastructural support of storage, transportation and marketing. Climate change and its associated parameters of rise in temperature and uncertainties in rainfall is adversely impacting on agriculture. Extreme climatic events like cyclonic storms and slow onset events like seal level rise and salinization are further precipitating the crisis of agriculture.

b) **Declining fisheries:** Fishing is the main source of protein for the islanders and is the primary occupation of about 17 percent of the population of Sundarban. Diminishing returns from agriculture has prompted many farmers to shift to fishing. Over exploitation, increasing level of salinity in estuaries and unsustainable fishing practices are the main causes of the dwindling fisheries resources of the delta. Prawn aquaculture (*bhedis*) in paddy fields that had flourished in some islands have collapsed in most places, and *bhedis* converted into illegal brick kilns. Inland fisheries have suffered setback due to saline water ingress and poor state of maintenance of ponds.

c) **Loss of livelihoods:** Declining agriculture and dwindling fisheries have forced people to look for alternate avenues of livelihoods such as collection of honey, bees wax, tannin bark and fuel wood from the mangroves at grave risks to their lives. Collection of tiger prawn seedlings from their breeding zones in river banks and mangrove fringes is another alternate source of livelihood due to high demand of such seedlings. Unscientific harvesting of such seedlings, especially during the breeding seasons, have led to the dwindling stocks of fries.

d) **Distress migration:** Migration has emerged an important option for alternate livelihood and coping with distresses caused by failure of crops and fisheries. Various studies have established that post-Aila more than 75 percent of the households in Sundarban had one or more male member who migrate every year for working in construction and other sectors in various parts of South and West India and some of

them have managed to migrate to West Asia, Singapore and Indonesia to work as labourers in various projects. The remittances sent by them have significantly boosted the income of the families. The migration has also it flip side in child labour, semi-bonded labour and trafficking of women and children. Covid-19 caused reverse migration of thousands of workers back to Sundarban raising doubts on the efficacy of migration as an effective tool for livelihood and adaptation.

e) **Unequal burden of works of women:** Migration of male workers have had discriminatory impact on women as their burden on work increased immensely. In addition to their normal household work of cooking, looking after children and elders they have also to cultivate the fields, look after cattle, and go for fishing for sustenance. These additional burdens of works have adversely impacted on their health and wellbeing. More than 50 percent women of Sundarbans are anaemic, about 58 percent girls are underweight and 18 percent malnourished.

f) **Rising levels of poverty:** Poverty in Sundarbans is multi-dimensional. More than 47 percent of the households do not own any land; more than 95 percent of those who own land are marginal farmers; about 52 percent households are landless agricultural workers, surviving on wages earned on their labour. An overwhelming 87 percent of population have no food security; close to 21 percent do not get food even once a day. Fragmentation of land holding is further accentuating marginalization of the work force. More than 50 percent population of the island blocks are living below poverty line; in some of the blocks like Basanti more than 68 percent of the households live in abject poverty.

g) **Loss of cultural continuity:** A resultant of all these factors have put the cultural landscape of the Sundarbans at risk. The community-based, inclusive, participatory, syncretic, indigenous mechanisms of living with the hazards of nature, based on traditional knowledge and rich folk culture, are getting diluted. This has created new layers of social vulnerabilities - based on religion, politics and wealth - that have stressed the ecosystem, the livelihood and the social fabric of the Sundarbans.

Opportunities

3.1 Every challenge provides an opportunity for innovative thinking and action for finding solutions. The multifarious challenges faced by the deltaic communities of Sundarbans have similarly created opportunities for finding solutions, based on the expanding scientific knowledge across various disciplines, rich traditional wisdom of the local communities, and

wide range of lessons learnt from experiences and experiments on the ground. During the past two decades the Sundarban delta has acquired the attention of scientists and scholars across earth, environmental, climatic, agricultural, social, and other sciences and their applications that probably very few regions of the world has had. This has widened our understanding of the challenges across the spectrum, even though there are uncertainties about the future, and it is difficult to predict the future developments with any precision. We have a good knowledge of the physiographic changes of the Sundarban delta, the dynamics of climate change and their probable impacts, the resilience of the eco-system and its services, and the strengths and weaknesses of the local communities. Our existing knowledge and understanding on all these areas can be put together for finding solutions to the challenges.

3.2 Over the years various government, semi-government, non-government and community based organisations have experimented with many innovative and out of box solution to the problems of Sundarbans with encouraging results that have been demonstrated through pilot projects. These provide opportunities for evaluating lessons learnt from these projects for replication in larger scales for transformative changes.

3.3 The greatest asset of Sundarbans is its natural environment and ecology. Apart from the large expanse of the mangroves and rich bio-diversity, and the varied eco-system services these provide, including the pristine beauty and tranquility, natural environment of Sundarbans has great regenerative capacity that may provide low cost solutions to many challenges, including risk mitigation and livelihood generation. Innovative nature based solutions may be the key to the building resilience of Sundarbans.

3.4 The second most important asset of Sundarbans is its community that have developed adaptive capacity of living with harsh nature. They have intimate knowledge about the nature, its resources and hazards, and have learnt the skills to harness its resources and adjust with its hazards for sustaining life and livelihoods. Sometimes the hungry tides and stormy winds have created havocs, causing irreparable damage and losses, but the resilient communities have bounced back. The inherent capacity of resilience of communities need to be further strengthened so that they can get over the current crisis and deal with more severe existential crises threatening them in near future.

Strategic approach

4.1 The geographical isolation, ecological sensitivity and socio-economic backwardness of the region called for an area specific strategic approach for development of the region. Unfortunately, such strategic thinking for development of the region has been missing altogether. The constitution of the Sundarban Development Board (SDB) in 1973 under the aegis of Development and Planning Department, with specific mandates of formulating integrated development programmes for the region and coordinating implementation of such programmes, provided opportunities for developing such long-term development plan for Sundarban region. This does not seem to have been ever done; on the contrary, the coordinating role of SDB was slowly given up, allowing line Departments to function independently with their own plans, projects and activities, often leading to avoidable duplication of activities and resources. SDB practically lost its role of planning and coordination and monitoring in 1994 when it was placed directly under the newly created Sundarban Affairs Department (SAD) to function as its Directorate or implementation agency.

4.2 Almost every line department of the Government of West Bengal – Forest, Irrigation and Waterways, Public Works, Power, Public Health Engineering, Agriculture, Fisheries, Revenue, Tourism, Education, Environment, Panchayats and Rural Development – have their own programme and activities in Sundarban, often working at cross purposes, without the knowledge and intervention of SAD. The role of SAD has remained confined to implementation of a few minor projects on connectivity (culverts, jetties and bridges), agriculture, fisheries and social forestry that are not attended by other departments. During the financial year 2024-25 total budgetary allocation of SAD was Rs. 600 crores of which an amount of Rs. 76.32 crores could be utilized till ending December 2024. No consolidated information on budgetary allocation and expenditure of line departments on Sundarbans are available with any agency.

4.3 Cyclone Aila in May 2009 and the massive devastations it caused triggered strategic thinking on the future of Sundarbans. World Wide Fund for Nature-India pioneered the discussion with its *Indian Sundarbans Delta: A Vision.* Published in March 2011, the vision document provided a long-term perspective of 40 years in the future in four phases. In the Phase I, it was proposed that all the 19 CD Blocks of Sundarbans be identified as a single administrative unit instead of being part of two separate districts and people living in six island blocks of Patharpratima, Kultali, Basanti, Gosaba, Sandeshkhali II, and Hingulganj within the Sundarban

Biosphere Zone be supported to make a living from non-farm/secondary or tertiary production activities for their eventual shifting to non-biosphere zone of the districts. In phase-II, physical infrastructure shall be developed in these identified non-biosphere zone for absorption of the emigrating population. In Phase III, the emigrated population shall be provided counselling, and financial inducements including compensation for their resettlement in the new areas. The vacated 6 blocks shall be returned to nature for regeneration of mangroves and development of eco-tourism.

4.4 In 2014 the World Bank came up with its strategy report on *Building Resilience for Sustainable Development of the Sundarbans* through estuary management, poverty reduction and biodiversity conservation. The report classified the Sundarbans in three zones – Stable, Transition and Core – and recommended that 1.54 million people living in 9 blocks of transition zone should be shifted to the stable zone of remaining 10 blocks and beyond in Kolkata metropolitan region, as 'their best and safest prospects for improving their plight are outside this zone'. The report recommended four pillars of interventions – vulnerability reduction, poverty reduction, biodiversity conservation and institutional changes.

4.5 The twin reports of WWF and the World Bank generated some debates in the academic world, but unfortunately failed to trigger any serious thinking in policy making and governance circles, which continue to follow the business-as-usual approach to development. It is high time that a strategic framework is developed that factors all the physiographic, climatic and socio-economic challenges that will provide guidance for building the resilience of local communities in short, medium or long terms, in realistic, feasible, time bound and sustainable manner.

4.6 Communities should be placed at the centre of any discourse regarding their future. They have been living with the nature for generations, have intimate knowledge about the forces, its resources and hazards, and have developed indigenous capacities for coping with the adverse conditions of nature. Their lives and livelihoods, hopes and aspirations are organically connected with their lands and surroundings and every effort shall be made to find solutions to the challenges within their habitats.

4.7 Large scale evacuation of people from their habitats must be avoided at any cost as this will cause unimaginable human sufferings as there is hardly any land available in the hinterland or anywhere in the state of West Bengal for rehabilitation of about 2.5 million people, socially and economically. This will lead to social strife, communal tension and ethnic clashes and disturb peace and harmony of the region at grave cost of the life economy of the region.

4.8 Compulsory evacuation of people should be restricted as a last resort for only those hamlets that have the imminent danger of submergence. Such areas shall be identified through comprehensive assessment of risks, based on irrefutable scientific evidences. The process of resettlement of such population at risks shall be carefully planned in consultation with the affected communities to ensure that they are fully rehabilitated.

4.9 Voluntary migration of people, particularly of the young and aspirational generation, should be encouraged for better opportunities of livelihood, through an appropriate incentive structure, skill development, and facilitation, while strengthening necessary regulatory mechanism to ensure that migration does not lead to human trafficking and exploitation.

4.10 Resilience of the local communities can be developed through six pillars of interventions.

a) Estuary Management
b) Embankment Management
c) Mangrove Regeneration
d) Livelihood Generation
e) Human Development
f) Disaster Risk Reduction

Estuary Management

5.1 Seven main tidal river systems or estuaries flow through the Indian Sundarbans into the Bay of Bengal - *Hooghly, Ichamati, Muriganga, Saptamukhi, Thakuran, Matla, Bidyadhari and Harinbhanga.* Barring Hooghly and Ichamati, all other tidal rivers are getting disconnected from upstream supply of water. River beds are getting silted and channels are getting diverted breaching embankments and increasing salinity of soil and sub-soil.

5.2 In the upper delta, a basin wise approach may be adopted jointly with Bangladesh for rejuvenation of tidal rivers of Sundarbans that would be beneficial for both the countries. This will increase the flow of sweet water into tidal rivers, reduce the level of salinity in rivers and facilitate both agriculture and fisheries, while increasing flow of sediments that can partly neutralize overall loss of land due to sea level rise.

5.3 The options for re- establishing the links of the tidal rivers with upstream wetlands that have been encroached for human settlements or converted into shrimp farming should be

explored for enhancing the supply of fresh water into the rivers. A recent study has shown that 500 cusecs of water can be added to Sundarbans upper delta by reconnecting the tidal rivers with upstream wetlands.

5.3 In the lower delta, availability of fresh water may be expanded by excavation and rejuvenation of the silted creeks of Sundarbans and the excavated materials may be used for strengthening the embankments. Apart from augmenting the flow of water in the estuary, the rejuvenated creeks will improve the system of navigation and river transportation

Embankment Management

6.1 The islands of Sundarban delta are protected by embankments of various types, sizes, widths, and lengths that all together run approximately 3500 kilometers. Effective construction, maintenance and management of these embankments are key to the survival of the communities in the islands. 90% of these embankment are low-height earthen structures having crest width around 2.5 m. to 3.5 m. and elevation of 2.5 to 3 m. above existing ground level. Though constructed within intertidal space, these embankments can sustain the impact of normal tides but face overtopping in case of high waves during severe cyclones, often leading to breaches and total collapse. Often embankments also collapse due to under-scouring along the concave banks, particularly along banks that have no mangroves on inter-tidal spaces, to absorb a part of the kinetic energy of the rolling waves. Some of the frontal *char* islands are protected by deflectors and other anti-erosion devices, mostly bamboo cubicles with protrusions, known as porcupines, filled up with bricks to add weight. These types of embankments have successfully resisted overtopping and failure during cyclones in the entire area across Sundarban. After cyclone Aila about 364 km long armoured embankments have been built with crest width around 3.5 to 4.5 meters, height of about 4.5 m. to 5.0 m. and flat riverside slope at 18º or even less. The slope is protected /armoured by concrete or brick block pitching to resist the impact of the breaking waves. Such types of embankments are quite cost prohibitive and require at least 20m -25m of additional private land in the countryside. Construction of additional stretches of such embankments were held up due to non-availability of land.

6.2 The sea facing islands of Sundarbans are facing serious problems of erosion. In the 30km.long sea front of four inhabited islands (Sagar, Moushumi, Bakkhali-Namkhana and G-plot), reinforcement of the existing embankments with concrete and their protection with

vegetative buffers should work well to prevent overtopping of storm surges. It is also important to put two parallel dykes with cross-embankments at regular intervals to prevent widespread flooding of the interiors in the event of beaching or wave-overtopping of the outer embankments.

6.3 Based on the experiences gained, lessons learnt, and global best practices adjusted according to local conditions, long term comprehensive plans should be developed for effective strengthening of the entire stretch of embankments in Sundarbans. The Irrigation and Waterways Department has identified 378 stretches of different rivers having a total length of 559 km. as vulnerable, of which 207 stretches having a total length of 324 km. as extremely vulnerable. These are mostly east-facing concave banks which should be taken care of as top priority. The stalled projects on construction of new embankments and improvement of existing embankments can be completed through a rehabilitation policy that will compensate the villagers for acquiring land under occupation. Innovative design and technology for construction of embankments can be adopted, wherever possible, that will allow trapping of sediments between two layers of embankments facilitating natural growth of mangroves. Bio-fortification of embankments can also be considered through plantation of vetiver grasses that are acclimatized in saline conditions.

Mangrove Regeneration

7.1 Mangroves in forest areas affected by erosion and salinization and human ingress can be relatively secured by better management of estuaries to increase the flow of fresh water and supply of sediments; and innovative practices such as rainwater harvesting in areas affected by saline blanks and trapping of sediments through measures like terracotta rings and porcupine traps.

7.2 Mangroves outside the forest areas can be regenerated through active participation of local communities. There are successful models of community-based mangrove management that can be further improved through innovative practices. Communities understand and appreciate the ecological services of mangroves better than others and they can become the main stakeholders in new mangrove plantations and better management of existing mangroves outside the forest areas. MGNREGA and other funds can be used extensively for community-based mangrove plantations. Mangrove nurseries can be created involving women self-help groups, providing a regular source of income for such groups. The plantations can be

maintained and protected by the local community who can be trained for creating a value chain in such plantation. Integrated mangrove cum aquaculture farming can be practiced generating additional income for the community. Carbon sequestration capacity of such community-based mangroves can be estimated and these can be traded in the emerging carbon markets.

Livelihood Generation

8.1 Agriculture and pisciculture are the main occupations of the people of Sundarbans and both are badly affected by the physiographic and climatic changes. There are tested and successful models of climate resilient farming and fishing practices in Sundarbans and these should be promoted and replicated on a large scale through infrastructural, extension, credit and marketing support on a mission mode. A time bound integrated plan for development agriculture, inland fisheries and animal husbandry can be drawn up for each block for initial five year for creating value chains that can substantially augment income and livelihood opportunities for the people of Sundarbans. Based on the lessons learnt these plans can be revised and further improved on an ongoing basis.

8.2 Under the project of National Innovation in Climate Resilient Agriculture (NICRA), Indian Council of Agricultural Research (ICAR) through their research wing of CRIDA, application wing of ATARI- Kolkata, and extension wing of Ramkrishna Ashram KVK Nimpith, have demonstrated various innovative climate resilient agricultural technology and practices that can be adopted by the farmers of the entire Sundarban region after suitable adjustment according to their local conditions. These include land shaping and rain water harvesting, land embankment or *ail* cultivation, broad bed cum trench system, cultivation of submergence tolerant and salinity tolerant rice varieties, short duration green gram varieties, floating and staggered seebed of rice etc. A handful of enterprising farmers have adopted these technologies and practices with amazing results, but most the farmers with marginal landholdings are unable to follow due to constraints on initial capital investments. Though these technologies have been demonstrated through several Govt. schemes like, NAIP, IWMP, RKVY, etc., at pilot scale, further interventions of State Agriculture Department are needed to hand hold the farmers with support through existing or new schemes to facilitate large scale application of these new technologies and practices in a time bound manner. Cooperative farming can be encouraged to economise the cost of application of these technologies. Cultivation of cotton is another possibility in Sundarbans due to its salinity tolerance. Cotton can be an important second crop for the Rice-fallow crop sequence, where extensive areas are

kept fallow after the kharif rice due to increased soil salinity. RAKVK Nimpith has developed a guaranteed marketing system of where the entire harvest is procured by the Cotton Corporation of India Ltd. through a PPP mode.

8.3 Organic farming and nature farming can also be promoted for growing vegetables and fruits that have a captive market in Kolkata and other urban hinterland. Good quality of watermelon is already grown in Sagar and Kakdeep, chillies in Patherpratima, spinach, bitter gourd, coriander and capsicum that are salt tolerant are grown in most of the villages. Sunflower cultivation is also gaining momentum in many islands. Creation of cold chain for vegetables and fruits can boost the income of farmers from these crops.

8.4 There are incredible traditional knowledge on farming, which needs to be documented with full details regarding the science behind such knowledge. Traditionally grown salt tolerant varieties of paddy (e.g., *Swarna*, *Dudher swar*, *Matla*, *Hamilton*, *Baktulsi*, *Talmugur*, *Velki*, *Nonabokhra*, *Asfal*, *Najani*, *Tilak Kanchari*, *Getki*, *Kanasol etc.)* can be scaled up. Similarly, various local grown weeds that have medicinal values (e.g., *Kulekhara*, *Thankuni*, *Telakucho*, *Gime*, *Jolkolmi*, *Shushni*, *Brhami*, *Purul*, *Punarnaba*, *Gnadal*, *Malancha*, *Kalkasute*, *Giriya*, *Bathua*, *Gumukh*, *Chikni etc.)* can be scaled up.

8.5 Every household or a group of households in Sundarbans have a pond which were dug by the settlers for conserving rainwater for irrigation and drinking as well as for growing varieties of fishes for consumption. Over the years most of these ponds have decayed and natural slopes for draining rainwater to the ponds have also been blocked. These traditional rain water harvesting structures should be rejuvenated and new ponds excavated wherever required so that most of 1900 mm of rainfall that the island receives can be harvested for agriculture and fisheries. An appropriate scheme can be designed for rejuvenation of existing ponds and excavation of new ponds by way of providing technical guidelines and financial incentives to the farmers owning such ponds, and linking such ponds for development of agriculture and inland fisheries.

8.6 Central Institute of Freshwater Aquaculture of ICAR has successfully implemented a project on enhancement of pond aquaculture productivity through adoption of better technology and management practices in Chunakhali island of Basanti Block and Bali Island of Gosaba Block in Sundarbans. The project has successfully demonstrated that pond aquaculture productivity can be enhanced by three to four times with minimal investments thereby significantly boosting income and livelihood opportunities for farmers. This tested

project needs to be replicated throughout the Sundarbans in a time frame of 5 years. Drawing lessons from the project the Fisheries Department of Government of West Bengal may design a project for developing inland fisheries in Sundarbans whereby necessary infrastructural, technical, extension, credit and marketing support may be provided to the farmers for an initial period of three years till they are able to adopt it sustainably.

8.7 There are tremendous potentialities for development of canal, estuarine and marine fisheries in Sundarbans. Shrimp and crab farming that have very high returns may be promoted in a regulated and scientific manner through saline mapping to determine the appropriate varieties that can be reared. *Venami* rearing may be shifted to *Tiger prawn* in saline areas and *Scampy* in fresh water with polyculture. Box fishing is another innovative option that may have game changing potentialities. Organic farming should be encouraged in areas adjoining water bodies to preclude leaching of pesticides into shrimp tissues. Integrated mangrove-shrimp farming may be promoted in saline ponds near embankments. Disease diagnostic centres and related protocols needs to be developed, cold chain (e.g., refrigerated vans) needs to be established, value chain created with involvement of women self-help groups so that local communities are benefited. Fisheries Department may make arrangements for aggregation of produce and establishing linkages with exporters for maximum value addition to the local fishermen communities.

8.8 Estuarine fisheries are regulated by the archaic colonial practices of Boat Licence Certificates that are traded with a premium while genuine local fishermen are deprived of their traditional fishing rights. The entire system needs to be reviewed to make the system more transparent

8.9 Eco-tourism has opened up opportunities of livelihood generation in tertiary sector and marketing of locally produced agricultural and allied commodities and handicrafts, but such opportunities have been offset by unregulated tourist traffic and creation of unplanned tourist infrastructure that have adversely impacted on local environment and stressed critical local resources like safe drinking water etc. This calls for development of comprehensive guidelines on eco-tourism that would discourage large and unsustainable tourist resorts and focus on more on eco-friendly accommodations with involvement of local communities.

8.10 Increased flow of diesel powered motorboats - emitting fumes, spilling oils and creating noises - are polluting the serene environment of Sundarbans. WWF-India has been working on a pilot project to retrofit diesel operated ferry boats with an electric propulsion unit run by an

energy-efficient lithium-ion battery pack. This simple and cost effective technology has the potential of decarbonizing water transportation system in Sundarbans thereby reducing the adverse impact of diesel operated boats on aquatic and terrestrial life in the sensitive ecosystems.

Human Development

9.1 All the available Human Development Indicators of the deltaic islands of Sundarban – education, health, income, employment, gender - are much lower than the national, state and district average. Human Development Reports of the twin districts of North and South 24 Paraganas, published in 2009, have brought out these stark realities. There has not been any significant improvements in the situation since then. The disparities in the availability of basic services of primary education, primary health care, child and mother care, supply of drinking water and electricity, availability of essential inputs and credits for agriculture, minimum wage employment etc. must be bridged in a time bound manner. This is not difficult as such basic services are already covered under various development programmes of central and state governments.

9.2 Each line department offering these services may be asked to identify the gaps in these basic services in each village and prepare a plan of action for providing universal basic services along with related infrastructure within a period of 3 years.

9.3 Geographic isolation of the islands further demand that apart from these universal basic services, the deltaic communities are provided with additional facilities like higher secondary schools for boys and girls, maternity clinics for child delivery in each Gram Panchayat within affordable reach. Each Gram Panchayat must also have its banks and markets for disposal of surplus products with ancillary facilities like storage and refrigeration.

9.4 While these universal basic and additional services will improve the human development indices in Sundarbans, special efforts may be required for improving the social and economic conditions of women who are suffering more than men due the adverse impacts of climate change and disasters. Women who are the mainstay of agriculture and animal husbandry operations have no rights over the land and animals and as such they cannot easily access the facilities of bank credits and insurance. Non-land owning communities who comprise nearly half of the population of Sundarbans have no collaterals for securing bank credits for their small business or other activities. Suitable schemes should be drawn up for

providing sovereign guarantees for credits and insurance for women and marginalized communities of the islands.

Disaster Risk Reduction

10.1 Comprehensive Hazard Vulnerability Exposure and Risk Assessment (HVERA) of all development blocks and villages of Sundarbans may be developed on a dynamic GIS enabled platform. HVERA shall deliver the following products:

a) Hazard maps of Blocks, Gram Panchayats and Villages on various layers (cyclone, flood, earthquake, drought, river and coastal erosion, land subsidence, river sedimentation, sea level rise) based on latest available hazard zonation maps prepared by the concerned scientific and technical agencies superimposed on 1 cm resolution of maps captured through drone photography;
b) Vulnerability maps of similar resolution on Blocks, Gram Panchayats and Villages in different layers (housing, physical infrastructure, and social, economic and environmental conditions) based on data collected from authentic sources and field surveys;
c) Risk maps of Blocks, Gram Panchayats and Villages, integrating hazards, vulnerabilities and exposures (population and economy).
d) GIS enabled platform in vernacular which will enable communities and other stakeholders to select the layers of hazards, vulnerabilities and exposures for assessment of disasters and climate

10.2 Block, Gram Panchayat and Village Disaster Management Plans may be prepared with participatory approach in a comprehensive manner identifying the local level issues for risk prevention and risk mitigation and for disaster preparedness for response and recovery. While local level disaster prevention and mitigation plans may be integrated with the development plans of line departments, Community Based Disaster Preparedness Programmes (CBDP) may be designed to develop capacities of local communities to respond to disasters in to save lives and assets.

10.3 There should be paradigm shift in post-disaster reconstruction of houses and infrastructure with a focus on Building Back Better so that these withstand the shocks of climate change, inundation and cyclonic storms. Locally available building materials can be used to design climate and disaster resilient houses integrating scientific and scientific

knowledge. Location of cyclone shelters should be need based with access to surface communication.

10.4 Based on the multi-hazard risk zonation maps, the most critical risk zones shall be identified where structural and non-structural measures for disaster risk reduction and climate change adaptation programmes may not work and the communities may need to be resettled to safer places in a phased manner. A detailed long term settlement plan may be developed for such resettlement of the most vulnerable households through a consultative and participatory process.

Implementation Mechanism

11.1 The six pillars of interventions, outlined above, should be planned and implemented for the largely isolated island blocks of Sundarbans with a clear road map, definite resource allocation, and well defined institutional mechanism for implementation.

a) Operational Area

11.2 The Sundarban Development Board was established in 1973 under the aegis of Development and Planning Department of Government of West Bengal with jurisdiction over 15 Police Stations, namely Kakdip, Namkhana, Sagar, Patharprotima, Mathurapur, Joynagar, Kultoli, Canning, Basanti, Gosaba, Haroa, Minakhan, Sandeshkhali, Hasnabad and Hingalganj of the district of 24 Paraganas. In 1989 Ministry of Environment and Forests Government of India notified Sundarban Biosphere Reserve (SBR) over an area of 9,630 sq. km divided into core, buffer, and transition zones, as per the guidelines of UNESCO's Man and Biosphere Programme.. The core and buffer areas of the SBR form the Sundarban Reserved Forest, covering an area of 4,263 sq. km. and the transition area comprises of 19 densely populated development blocks (Kakdip, Namkhana, Sagar, Patharprotima, Mathurapur-1, Mathurapur-2, Joynagar-1, Joynagar-2, Kultoli, Canning-1, Canning-2, Basanti, Gosaba, Haroa, Minakhan, Sandeshkhali-1, Sandeshkhali-2, Hasnabad and Hingalganj), covering an area of 5,367 sq. km.

11.3 Over the years 10 out of 19 blocks of Sundarbans (Kakdip, Mathurapur-1, Joynagar-1, Joynagar-2, Canning-1, Canning-2, Haroa, Minakhan, Sandeshkhali-1 and Hasnabad), have been largely integrated with the mainland with development of surface transport of roads and railways and other infrastructural development. These blocks can no longer be considered as deltaic island facing existential crises of the type and magnitude faced by the remaining nine blocks, namely Namkhana, Sagar, Patharprotima, Mathurapur-2, Kultoli, Basanti, Gosaba,

Sandeshkhali-2 and Hingalganj. Therefore the operational area of this strategic framework and road map shall be limited to these nine blocks only.

b) Time Line

11.4 This strategic framework is prepared for a time horizon of twenty-five years - 2025-2050 to inform and guide designing of appropriate projects, programmes and activities in consultations with stakeholders for short (0-5 years), medium (0-15 years) and long-term period (0-25 years) depending on the mobilization of resources from state and central government and other sources.

11.5 The short term programmes shall broadly include all programmes related to livelihood generation, human development and disaster risk reduction. Medium term programmes shall include projects on mangrove regeneration and embankment management, while long term programmes shall be the more difficult programmes of estuary management. Short term projects can be broken up in annual programmes, while medium and long term projects can have rolling five yearly and annual cycles.

11.6 This does not mean that the programmes shall be limited to their respective time frames; these will continue beyond for stabilizing the gains made and further improving upon the same. The focus of livelihood generation, human development and disaster risk reduction programmes during the first five years will be to bridge the huge development deficits that exist in these sectors; thereafter these will carried on building on the gains made to address the evolving challenges and opportunities. Similarly, mangrove regeneration and embankment strengthening programmes will be taken up on a mission mode till it stabilizes within a time frame of 15 years and thereafter it will continue for regular maintenance and upkeep. Estuary management will be a long haul, necessitating relinking of the estuary with upper delta wetlands and further transfer of surplus water from Bangladesh to Indian estuaries, which will be not easy, but can be a win-win situation for both countries, if connected with other issues of common concern.

11.7 Specific programmes, projects and activities need to be drawn up on each of the six pillars of strategic interventions, through a participatory process involving both scientific and technical agencies and communities, with clear goals, objectives, time frames, targets, indicators, and above all, resource allocations.

c) Resource Mobilization

11.8 Many of the basic development deficits in Sundarbans can be bridged with available allocations of concerned line departments, as the existing programmes of central and state governments provide for funds for basic education, health, mother and child development, food security, employment guarantee etc. Poor implementation of the programmes on the ground over the years, for whatever reasons these could be, has created these deficits. Bridging the deficits within a time frame of five years may need additional resource allocation that may not be very substantial and should be provided by the line departments within the overall budgetary allocations of respective departments.

11.9 Budgetary allocations of all line departments and Sundarban Affairs Department for these nine development blocks can be pooled together and reallocated for the implementation of the short and medium term projects, following the principle of zero budgeting. Besides earmarked allocations of Finance Commission on disaster management, health, education etc. and special allocations under various centrally sponsored and central sector schemes can also be dovetailed, to the extent possible as per the guidelines of the programmes, for the implementation of the road map. For this purpose a study may be commissioned on the available allocations and expenditure of all line departments on all schemes, programmes and projects for these nine development blocks of Sundarbans and how these can be optimally utilized for the development of the road map. The study may also assess the requirement of additional of funds for implementation of the short and medium term projects of the road map and the possible sources for mobilization of additional funds.

11.10 Some of the medium term projects and the long term project of estuary management shall require intervention of the Government of India. Ministry of External Affairs may be approached for initiating discussion, especially under aegis of the Joint Rivers Commission set up in 1972, for management of the Trans Boundary Rivers with Bangladesh. Ministry of Finance may be approached for their assistance in mobilizing resources from multi-lateral sources like the Asian Development Bank and the World Bank for difficult project of estuary management.

d) Implementation Mechanism

11.11 Implementation of this strategic framework and road map shall not be possible without strong, coordinated, effective and efficient institutional arrangements. Over the years the

Sundarban Affairs Department (SAD), set up in 1994 for 'coordination of development schemes and projects' for 'social, economic and cultural advancement' of people of Sundarbans, have largely lost its planning and coordinating role. The SAD does not have any say on the core and buffer areas of Sundarban Biosphere Reserve that are looked after exclusively by the Forest Department. 10 out of 19 development blocks of the transitional area of Sundarbans can no longer be considered as part of Sundarban delta. The development, regulatory and other administrative functions of these 10 blocks take place largely outside the knowledge and intervention of SAD. Development and regulatory works of the line departments in the remaining 9 blocks also take place without any involvement of SAD. Therefore the rationale for continuation of a full-fledged department of the Government of West Bengal for running truncated residual functions of 9 blocks, with large administrative overheads, needs to be reviewed.

11.12 Either the SAD should be bestowed with full authority of planning, coordination, and monitoring of all developmental, regulatory and administrative functions over the entire Indian Sundarbans with appropriate field level support system to properly discharge its functions or the department may be made a unit of the Environment Department that has the nodal responsibility of implementation of State Action Plan on Climate Change.

11.13 The Sundarban Development Board (SDB), set up in 1973 under the aegis of Development and Planning Department, for 'integrated and accelerated development of Sundarban area' had been reduced as 'the Directorate' of SAD in 1994. SDB consists of Minister in charge of SAD in chair, MLAs of Sundarbans, District Magistrates of two districts, representatives of a few departments, noted social worker and NGO nominated by government, and a Member Secretary who also functions as Project Director. SDB performs no other function but to approve the work plan of SAD, which consists of small projects of roads and bridges, agriculture, forestry and fisheries that are already looked after by the concerned line departments on a larger scale. The Project Director and his team comprising of one technical officer each from agriculture, fisheries and forestry sectors and eight civil engineers headed by a Chief Engineer, are responsible for implementing the projects. SDB does not have block level offices and has no capacity to take up large and dispersed projects.

11.14 SDB needs to be reconstituted with Chief Minister in Chair and Principal Secretaries in charge of Forests, Irrigation and Waterways, Agriculture, Fisheries, Environment, Education, Health, Disaster Management departments, besides a few nominated experts and elected

representatives and a Chief Executive Officer as its Member Secretary with clear mandate for planning, coordination, implementation and monitoring of all small, medium and large projects as outlined in the strategic framework and road map. SDB must not be involved with direct implementation of the projects; it will get all the projects implemented through the concerned line departments. Further details on the organizational structure and functions of the reconstituted SDB may be worked out in consultation with concerned authorities.

Monitoring and Evaluation

12.1 A strong and effective monitoring and evaluation system will be crucial for the success of the implementation of the strategic framework and road map in a time bound manner. Comprehensive Management Information System shall be developed using ICT and AI to record every activity of each project for tracking the status of implementation and monitoring financial and physical progress, with a set of input, output, outcome and change indicators. A baseline data bank shall be developed on each household of these 9 blocks to track changes in the socio-economic status of the households on a continuing basis so that specific issues faced by them regarding their entitlements of education and health, food and nutrition, employment and income can be addressed to ensure that no one is left behind.

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