



"Surakshayanam 2023"

--Towards a Safer State--

**KERALA-NORWAY BILATERAL WORKSHOP ON DISASTER RISK
MITIGATION**

17th – 21st October 2023



KERALA - NORWAY BILATERAL WORKSHOP on DISASTER RISK MITIGATION
Organised by Kerala State Disaster Management Authority & Kerala State Planning Board
KOCHI, OCTOBER 17-21 2023



Jointly organised by

GOVERNMENT OF KERALA

KERALA STATE DISASTER MANAGEMENT AUTHORITY

KERALA STATE PLANNING BOARD

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Contents

EXECUTIVE SUMMARY.....	4
1. INTRODUCTION	5
2. INDIA-NORWAY.....	7
3. THE BILATERAL WORKSHOP	8
3.1 THE PRELUDE	8
3.2 SITES VISITED DURING THE NOVEMBER FIELD TRIP.....	10
3.3 INAUGURATION – 17 TH OCTOBER 2023.....	13
3.4 DAY 1 - 17 TH OCTOBER 2023 - TECHNICAL TOPIC 1: COASTAL EROSION AND SLOPE INTEGRITY ALONG THE COASTLINE.....	13
3.4.1 1 ST SESSION - COASTAL EROSION.....	13
3.4.2 2 ND SESSION - CONSEQUENCES OF SEA LEVEL RISE AND CLIMATE CHANGE.....	14
3.4.3 3 RD SESSION – STORM SURGES BY CYCLONES	14
3.4.4 FIELD VISIT TO CHELLANAM AND EROSION-PRONE AREAS	14
3.5 DAY 2 – 18 TH OCTOBER 2023 - TECHNICAL TOPIC 2: TUNNELLING TECHNOLOGY.....	15
3.5.1 1 ST SESSION - MITIGATION AND ADAPTION BY GREY AND GREEN SOLUTIONS	15
3.5.2 2 ND SESSION - NUMERICAL MODELLING OF COASTAL EROSION	15
3.5.3 3 RD SESSION – SALTWATER INTRUSION.....	15
3.5.4 4 TH SESSION – TSUNAMI.....	16
3.5.5 5 TH SESSION – NORWEGIAN METHOD OF TUNNELLING (NMT) PART 1	16
3.5.6 6 TH SESSION – NORWEGIAN METHOD OF TUNNELLING PART 2 (NUMERICAL TOOL FOR THE DESIGN AND OPTIMIZATION OF ROCK SUPPORT IN TUNNEL).....	16
3.6 DAY 3 – 19 TH OCTOBER 2023 - TECHNICAL TOPIC 3: SLOPE STABILITY AND LANDSLIDES ALONG ROAD CORRIDORS	16
3.6.1 FIELD VISIT TO KOOTTICKAL LANDSLIDE SITES AND VAGAMON ROAD CUT FAILURE SITES (KOTTAYAM DISTRICT)	17
3.7 DAY 4 – 20 TH OCTOBER 2023 - TECHNICAL TOPIC 3: SLOPE STABILITY AND LANDSLIDES ALONG ROAD CORRIDORS	18
3.7.1 1 ST SESSION – LANDSLIDE CLASSIFICATIONS, PREDISPOSING AND TRIGGERING FACTORS.....	18
3.7.2 2 ND SESSION – SUSCEPTIBILITY, HAZARD, AND RISK MAPPING.....	18
3.7.3 3 RD SESSION – LANDSLIDE MONITORING AND EARLY WARNING	19
3.7.4 4 TH SESSION – NUMERICAL MODELLING OF LANDSLIDES	19
3.7.5 5 TH SESSION – CONSTRUCTION OF TETRAPOD BASED COASTAL PROTECTION WALL AT CHELLANAM	19
3.7.6 FEEDBACK	19
4. LECTURES IN THE WORKSHOP	20
5. FEEDBACK OF PARTICIPANTS.....	23



6. WHAT WAS LEARNED	31
6.1 SLOPE STABILITY	31
6.2 COASTAL EROSION.....	32
6.3 TUNNELLING	33
7. FUTURE	34
8. EXPENSES	36
APPENDIX.....	37



Executive Summary

Kerala, a state celebrated for its phenomenal natural landscapes, is grappling with far-reaching consequences of natural disasters and climate change-induced perils such as landslides and coastal erosion. In addition to these challenges, Kerala experiences increasingly intricate geotechnical problems that demand specialized solutions. The SENDAI Framework - Target 6 highlights the necessity to boost international cooperation by 2030 for Disaster Risk Reduction

Recognizing the imperative need for expertise tailored to these specific challenges, the Kerala State Disaster Management Authority (KSDMA) joined hands with the Norwegian Geotechnical Institute (NGI)¹ to conduct an extensive 5-day workshop for building institutional capacities in key departments in the State in reducing risks through resilient infrastructure designs. This collaborative effort assembled a consortium of experts from NGI and KSDMA, along with participants representing various government organizations within Kerala.

The overarching objective of this workshop is to facilitate the transfer of state-of-the-art knowledge and skills honed over time by NGI while drawing upon real-life instances from Kerala as illustrative case studies. This immersive learning experience aspires to cultivate a problem-solving perspective among participants, uniquely attuned to the region's idiosyncratic challenges.

Hence, this workshop represents a pivotal convergence of Norwegian geotechnical expertise and Kerala's pressing geotechnical challenges. It is envisioned as a dynamic platform where knowledge transcends boundaries and is meticulously tailored to address the State's distinct and pressing concerns.

By harnessing the synergy of NGI's technical prowess and KSDMA's local insights, the workshop endeavours to equip participants with the requisite tools and strategies essential for navigating and mitigating the intricate geotechnical challenges that Kerala confronts on its journey towards sustainable development and resilience.

¹ NGI was formally founded as a research institute on January 1, 1953, under the Royal Norwegian Council for Scientific and Industrial Research (NTNF), and in 1985, transitioned into an autonomous commercial foundation. This research hub specializing in the domains of geotechnical engineering harness the synergy of geotechnical expertise and advanced technology to craft intelligent and sustainable solutions for land and maritime infrastructure, environmental technology, contaminated soil management, and mitigating natural threats such as landslides and avalanches. They contributes valuable knowledge that aids in addressing critical global challenges related to climate, the environment, energy, and societal security.



1. Introduction

The Bilateral Workshop on Disaster Risk Mitigation for the State of Kerala marks the second phase of the Surkashayanam initiative that started in 2012 (<https://sdma.kerala.gov.in/surkashayanam-2012/>), which stands as a pioneering milestone in the domain of disaster risk reduction in Kerala.

On a global scale, disaster management has become an integral component of comprehensive planning efforts aimed at fostering societal and ecological resilience in the presence of extreme events, whether they stem from natural occurrences or societal factors. Within this context, the 14th Five-Year Plan of KSDMA working group promotes a Social-ecological framework², which views social and ecological systems as interconnected and mutually influential. Gaining an understanding of the functioning of both systems and how they mutually adapt and strengthen each other provides vital insights for developing effective management approaches.³

Moreover, in line with this objective and considering the future vision of KSDMA to integrate “Science and Technological considerations in Disaster Risk Reduction,”⁴ the technical visit by NGI and subsequent discussions with state departments have led to the determination to organize a five-day capacity-building workshop. The decision to host a Bilateral Workshop on Disaster Risk Mitigation for the State is also underpinned by a thorough examination of the international, national, and regional agendas and strategies outlined in KSDMA’s Annual and Five-Year plans.

These include:

² Government of Kerala (2022), Formulation of Fourteenth Five Year Plan 2022-2027 “Report of the Working Group on Disaster Management,” *Box.2: Social-ecological framework*, State Planning Board, Thiruvananthapuram, pg.12.

³ Government of Kerala (2022), Formulation of Fourteenth Five Year Plan 2022-2027 “Report of the Working Group on Disaster Management,” State Planning Board, Thiruvananthapuram, pg.11.

⁴ Government of Kerala (2022), Formulation of Fourteenth Five Year Plan 2022-2027 “Report of the Working Group on Disaster Management,” *Chapter III-Future Perspectives and Critical Issues, 3.1. Science and Technological Considerations for Disaster Risk Reduction (DRR)*, State Planning Board, Thiruvananthapuram, pg.28.



1. In the 14th Five-Year Plan⁵ of the Government of Kerala, a key initiative echoes “the prioritization of achieving the seven objectives set forth in the SENDAI framework, as informed by the AR6 report.⁶
2. This initiative aligns with the proposal of the establishment of “creating anticipatory action hubs, creating risk transfer mechanisms, mainstreaming risk informed planning and rapid adaptation of advance science and technological solutions.”⁷
3. In alignment with the proposal, the bilateral workshop conducted in collaboration with NGI is rooted in the fourth priority of the SENDAI framework, which emphasizes “Investing in disaster risk reduction for resilience.” And the workshop serves as a pivotal milestone in working toward accomplishing the sixth target, “INTERNATIONAL COOPERATION BY 2030.”⁸
4. Further it upheld the fifth point of the Prime Minister’s Ten Point Agenda for Disaster Risk Reduction, which advocates for “Leverage technology to enhance the efficiency of disaster risk management efforts.”⁹
5. The workshop also coheres 2030 Agenda for Sustainable Development,¹⁰
 - “SDG 9: Building resilient infrastructure, promoting inclusive and sustainable industrialization and foster innovation and
 - SDG 11: Making cities and human settlements inclusive, safe, resilient, and sustainable.”

The primary aim of this workshop was to create an enriched platform for interaction and fellowship between Kerala and distinguished scientists and experts specializing in hazards and

⁵ Reference: Order No. SPB/437/2021/PPD/W (5) dated 7-9-2021.

⁶ Disaster Management Annual Work Plan 2023 – 2024, Kerala Disaster Management Authority, Government of Kerala, pg.05.

⁷ Government of Kerala (2022), Formulation of Fourteenth Five Year Plan 2022-2027 “Report of the Working Group on Disaster Management,” State Planning Board, Thiruvananthapuram, pg.07.

⁸ Government of Kerala (2022), Formulation of Fourteenth Five Year Plan 2022-2027 “Report of the Working Group on Disaster Management,” *Box.1: Sendai Framework: Priorities and targets*, State Planning Board, Thiruvananthapuram, pg.10.

* Disaster Management Annual Work Plan 2023 – 2024, Kerala Disaster Management Authority, Government of Kerala, pg.05.

⁹ Disaster Management Annual Work Plan 2023 – 2024, Kerala Disaster Management Authority, Government of Kerala, pg.06.

¹⁰ Government of Kerala (2022), Formulation of Fourteenth Five Year Plan 2022-2027 “Report of the Working Group on Disaster Management – State Planning Board, Thiruvananthapuram, pg.11.



disaster risk management from across the globe. Its overarching goal was to gather global insights and contributions to inform the development of world-class scientific frameworks and policies geared toward effectively managing and reducing future disaster risks and threats.

In essence, Surkashayanam series of workshops represents a pivotal stride toward a future for the State of Kerala that is safer and more resilient, firmly rooted in global collaboration and expertise.

2. India-Norway

The historical ties between India and Norway have deep and enduring origins, tracing back to the 1600s and official cooperative ties were initiated in 1952 through fishery projects undertaken in Kerala.¹¹ In recent years India's geopolitical pertinence, its substantial population, extensive coastline, and its rapidly growing economy contributing to its growing influence on both regional and global scales has expanded Norway's notably presence in India.¹²

In December 2018, the Norwegian government introduced the 'India Strategy,' outlining specific priorities for their government's initiatives until 2030. This strategy aims to rejuvenate and enhance bilateral cooperation between Norway and India. By fostering political discourse and cooperation among authorities, promoting business partnerships, and the facilitation of research collaborations. It focuses on five key thematic priorities: Democracy and rules-based world order; The Oceans; Climate and Environment; Research, Higher Education and Global Health. The Memorandum of Understanding (MoU) establishing a structured and strategic cooperation on the oceans in 2019¹³ and MoU between the National Highways and Infrastructure Development Corporation Ltd. (NHIDCL) and Norwegian Geotechnical Institute (NGI) are some of the interventions under the fellowship.¹⁴

¹¹ John Kurien, (1985), Technical Assistance Projects and Socio-Economic Change: Norwegian Intervention in Kerala's Fisheries Development, Economic and Political Weekly, Vol.20, No25/26, pp. A70-A88.

¹² Norway – India 2030, The Norwegian Government's strategy for cooperation with India, Ministry of Foreign Affairs – Strategy Report, Publication: Published by: Norwegian Ministry of Defence and Norwegian Ministry of Justice and Public Security.

¹³ Refer:https://www.pmindia.gov.in/en/news_updates/cabinet-approves-mou-between-india-and-norway-on-india-norway-ocean-dialogue/

*Ministry of Earth Sciences, <https://pib.gov.in/PressReleasePage.aspx?PRID=1702137>

¹⁴ Government of India, MoU between India and Norway for undertaking non-intrusive Geological Surveys and Investigations, <https://pib.gov.in/Pressreleaseshare.aspx?PRID=1566767>



3. The Bilateral Workshop

3.1 The prelude

Driven by the vision to enhance the State's resilience, a high-level delegation led by Hon'ble Chief Minister visited Norway on 5th October 2022. As a follow-up Dr. Dominick Lang, Director, Natural Hazards of Norwegian Geotechnical Institute visited Kerala from November 10th to 13th, 2023. The aim of this 3-day field trip was exploring selected sites and projects where local authorities face various challenges, either posed by natural/climate change-induced hazards (e.g. landslides, coastal erosion) or where NGI's unique competence might be of assistance in solving these (e.g. tunnelling technology, instrumental/remote sensing monitoring).

He along with State Planning Board Members, Mr. V. Namasivayam and Dr. Ravi Raman, Member Secretary, KSDMA and State Planning Board Chiefs, Dr. V. Santhosh and Dr. S.S Nagesh visited the following sites to understand the resilient infrastructure development challenges that Kerala faces:

1. Maripuzha, Kozhikode – starting point of Wayanad Tunnel: Tunnelling challenges
2. Munnar Gap Road, Idukki: cut slope induced landslide challenges
3. Varkala, Thiruvananthapuram: Cliff failure and water way tunnel

Representatives from relevant government departments, including Public Works, Irrigation, Soil Conservation, and Local Self-Government also attended.

During the November field visit it became obvious that most of the addressed challenges fall into NGI's core competence and would also be of significant interest to NGI in assisting local authorities with special consultancy. However, to better understand these various challenges and how to address these properly, the involved parties suggested the organization of a first workshop (3 days) followed by a 2-day field visit. The purposes of the workshop would be:

- Establish institutional relationship between public authorities and NGI
- Expose engineers and earth scientists in the Government of Kerala to advanced geo-engineering techniques
- Identify challenges related to the technical areas and develop strategies on how to tackle these



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- Figure out a model how NGI can be directly contracted and receive compensation for potential consultancy works for authorities in Kerala
 - Create the basis for parallel activities such as the joint development of research proposal to funding institutions in India (DST), Norway (NFR), and internationally (e.g. World Bank, UNDP)

To conduct the workshop and field visit most efficiently, also with respect to numbers of experts from NGI, and hence keep the costs reasonable, it is suggested that the following technical areas are addressed. These represent those challenges authorities in Kerala had flagged as being most relevant when it comes to NGI's expertise:

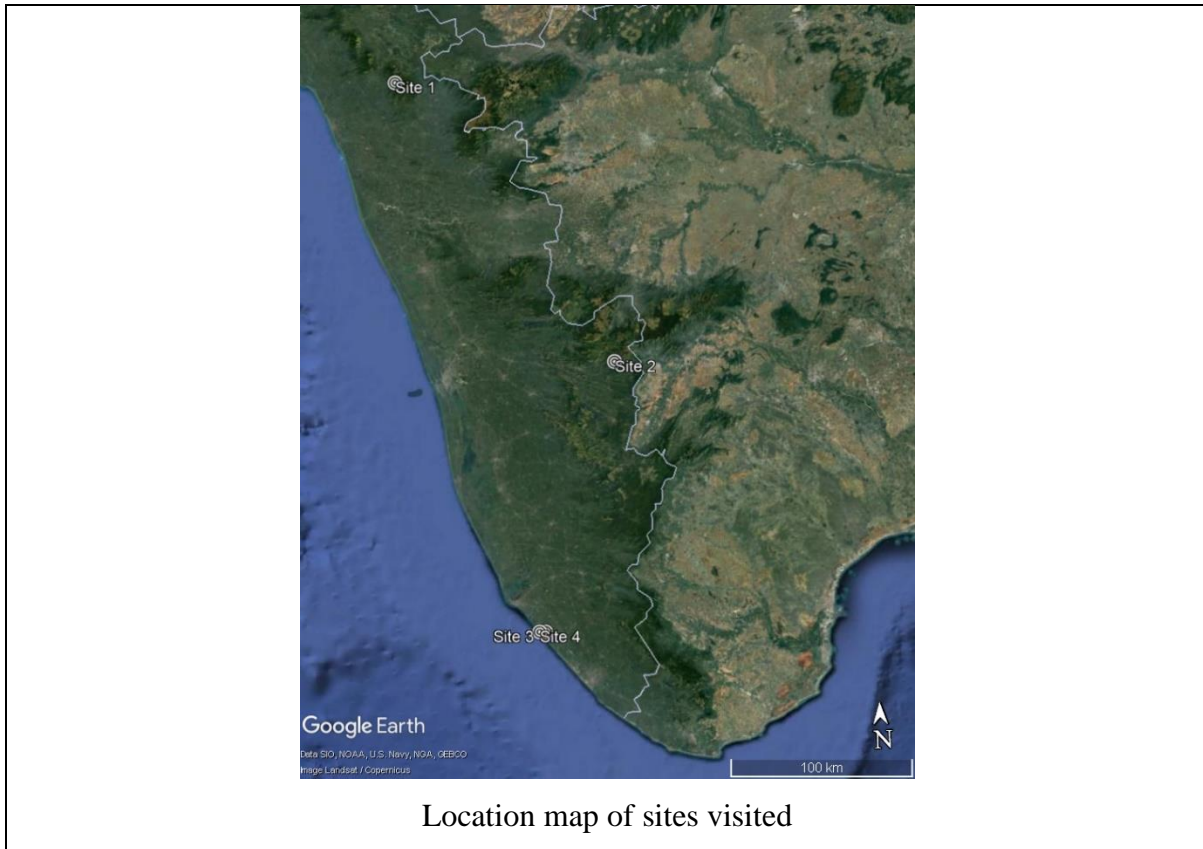
- Tunnelling technology (life-cycle approach for safe and sustainable tunnelling)
- Slope stability/landslides along road corridors
- Coastal erosion and related integrity of slopes along the coastline

In addition to these technical areas, various remediation methodologies could be addressed that cover more than one of these technical areas, such as:

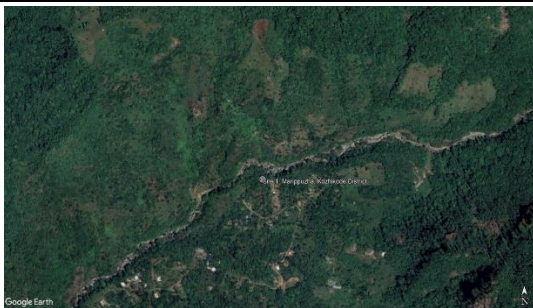
- Holistic monitoring such as the implementation of instrumentation solutions for early warning systems (EWS), drone-based scanning, or satellite-based remote sensing (e.g. InSAR)
- Protection measures using classical (grey) solutions as well as nature-based solutions (NBS)
- Exposure to the use of new technologies such as machine learning techniques



3.2 Sites visited during the November field trip



Location map of sites visited



Site 1: Marippuzha, Kozhikode District


Proposed tunnel from Kozhikode to Wayanad district. Possible consultancy for a life-cycle approach to tunnel for reducing tunnelling-induced landslides in the tunnelled rock massive



Site 2: Idukki Gap Road, Idukki District

Currently severely landslide affected national highway segment at 1400 m above MSL along the Western Ghats of Idukki. Possible consultancy for a life-cycle approach to map and identify potential landslide-triggering zones and engineering design consultancy for slope stabilisation



	<p>Site 3: Varkala Water Way Tunnel, Thiruvananthapuram District</p> <p>A century old water way tunnel in the national water way which state desires to make motorable and dig another tunnel to facilitate goods transport</p> <p>Site 4: Varkala Cliff, Thiruvananthapuram District</p> <p>A tertiary coastal cliff that is failing rapidly owing to severe anthropogenic interventions in the cliff top. The cliff itself is naturally susceptibility owing to its fragile sedimentary composition. Possible consultancy for designing slope stabilization measures and monitoring.</p>
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The academic discussions related to large infrastructure projects in India predominantly centers on concerns such as environmental challenges, displacement of individuals and communities, and the erosion of livelihoods.¹⁵ The workshop’s three themes, referred to as technical topics, are structured to bring an anthropocentric perspective of nature and a positivist approach to knowledge and science, both of which underlie substantial significance in tackling the issues confronted by the state of Kerala in managing large infrastructure projects.

The KSDMA and KSPB in collaboration with NGI prepared a detailed programme for the conduct of the workshop. The Member Secretary, KSDMA scouted various locations for the conduct of the workshop and finally agreed on Ernakulam as the location of the conduct of


¹⁵ Gadgil, M., & Guha, R. (1995). Ecology and equity: The use and abuse of nature in contemporary India. Psychology Press.
* Guha, R., & Alier, J. M. (2013). Varieties of environmentalism: Essays North and South. Routledge.
* Thakkar, H. (2007). Water Pollution Control: Role of Community and Public Action. In M. Rangarajan (Ed.), Environmental Issues in India: A Reader (pp. 247–274). Pearson Education India.
* Guha, R. (2000). The unquiet woods: Ecological change and peasant resistance in the Himalaya. Unit of California Press.





the workshop. Sites were examined for the field visit such as Varkala, Chellanam, Baypoor (Coastal Erosion), Koottickal, Amboori and Pauthumala (Slope Stabilisation), Marippuzha, Kuthiran and Varkala (Tunnelling). The sites were evaluated carefully and finally, it was decided to host the workshop in M/S Saj Resorts, Nedumbassery and accommodation for participants in nearby hotels. Sites were selected for the field work, they being Chellanam, Koottickal and Vagamon. Direct visit to a tunnel was not feasible given the distances and the available time.

KERALA - NORWAY BILATERAL WORKSHOP ON DISASTER RISK MITIGATION

KOCHI, OCT 17-21, 2023



Inauguration
Hon. Chief Minister. Sri Pinarayi Vijayan

Workshop Themes

Technical topic 1: Coastal Erosion and Slope Integrity along the Coastline

Coastal erosion poses significant challenges to the region's infrastructure and environment. The workshop will explore cutting-edge solutions to combat erosion and preserve the integrity of coastal slopes. Experts will discuss coastal engineering methodologies, nature-based solutions, and sustainable coastal management practices.

Technical topic 2: Tunnelling Technology

The workshop will emphasize a comprehensive life-cycle approach to ensure the implementation of safe and sustainable tunnelling practices. Expert from NGI will share insights and best practices to optimize tunnel design, construction, and maintenance, considering the unique geological and environmental conditions of the region.

Technical topic 3: Slope Stability and Landslides along Road Corridors

This topic will delve into effective measures and strategies to mitigate risks and enhance stability along road corridors prone to landslides. Participants will gain valuable knowledge on geotechnical solutions, monitoring techniques, and innovative approaches to prevent and manage slope instabilities.

"Towards a Safer State"



Program Schedule

Day 1: 17-10-2023		Day 2: 18-10-2023		Day 3: 19-10-2023		Day 4: 20-10-2023		Day 5: 21-10-2023			
Welcome session / Coastal Erosion / Field Visit		Coastal Erosion/ Tunnelling technology		Field Visit		Landslides		Landslides / Closure			
9:00 – 10:30	Opening ceremony	09:30 – 10:00	Mitigation and Adaption by Grey and Green solutions	07:30 – 18:30	Field trip to Koottikkal Landslide Sites and Vagamon Road Cut failure sites (Kottayam district)	10:00 – 10:30	Landslide classifications, predisposing and triggering factors	09:30 – 10:30	Mitigation Measures		
		10:00-10:30	Numerical Modelling of Coastal Erosion								
10:30 – 11:00	Coffee Break	10:30 – 11:00	Coffee break					10:30 – 11:00	Coffee break		
11:00 – 12:00	Workshop Introduction	11:00 – 11:30	Saltwater intrusion					11:00 – 12:00	Susceptibility, Hazard and Risk Mapping	10:30 – 11:00	Coffee break
12:00 – 12:30	Coastal Erosion	11:30 – 12:00	Tsunamis					12:00 – 12:30	Feedback session	11:00 – 12:30	Path ahead & group for mitigation proposals by team KSDMA
		12:00-12:30	Feedback session								
12:30 – 13:30	Lunch	12:30 – 13:30	Lunch					12:30 – 13:30	Lunch	12:30 – 13:30	Lunch
13:30 – 14:00	Consequences of Sea Level Rise and Climate Change	13:30 – 14:30	Norwegian Method of Tunnelling Part 1					13:30 – 14:30	Monitoring and Early Warning	13:30 – 15:00	Closing ceremony - Feedback by participants and certificate distribution
14:00 – 14:30	Storm Surges by Cyclones							14:30 – 15:00	Coffee break		
14:30 – 15:00	Feedback session										
15:00 – 15:30	Coffee Break	14:30 – 15:00	Coffee break			15:00 – 16:00	Numerical Modelling of Landslides				
15:30 – 18:00	Field trip to Chellanam and erosion prone areas	15:00 – 16:00	Norwegian Method of Tunnelling Part 2			16:00 – 16:30	Feedback session and wrapping up day 4.				
		16:00 – 16:30	Open Discussion and wrapping up day 2.								

"Towards a Safer State"



3.3 Inauguration – 17th October 2023

Dr. Sekhar L. Kuriakose, Member Secretary, KSDMA and Chief Resilience Officer of Kerala presided over the inaugural ceremony. Dr. V. Venu, Chief Secretary of Kerala and Chief Executive Officer of KSDMA inaugurate the workshop. He highlighted the importance of such specialised trainings and the need to upskill the technical staff of the State, particularly focusing on Climate Change Adaptation, Resilience Building and Disaster Risk Reduction. Dr. V.K Ramachandran, Vice Chairman of Kerala State Planning Board delivered the keynote address (online). He reiterated State's commitment to building back better by fostering expertise from across the world. Dr. Dominick Lang, Director, Natural Hazards of NGI offered continued support to Kerala in upskilling the State in its mission towards resilience building. Dr. A. Kowsigan, Commissioner Disaster Management and Mr. N.S.K Umesh, District Collector Ernakulam gave felicitation speeches. Ms. Usha Bindhumol, Deputy Collector and Chief Executive Officer, DDMA, Ernakulam delivered the vote of thanks on behalf of the State.

3.4 Day 1 - 17th October 2023 - Technical topic 1: Coastal Erosion and Slope Integrity along the Coastline

In recent times, coastal areas have garnered growing interest from the scientific and engineering community. This surge in attention is primarily driven by the imperatives of economic development, necessitating a more profound comprehension and efficient utilization of the coastal regions.

Between 1990 and 2016, the National Centre for Coastal Research conducted a survey along India's 7,517-kilometer coastline, covering 6,031 kilometres. The results revealed that 33 percent of the coastline has experienced erosion, primarily concentrated along the eastern coast facing the Bay of Bengal, with West Bengal reporting the most significant erosion.

According to the report, out of the surveyed coastline in the country, approximately 2,156.43 kilometres experienced erosion, while about 1,941.24 kilometres witnessed accretion. Notably, Kerala exhibited more pronounced erosion compared to other western states, despite being situated on the west coast. This is attributed to the challenging conditions in the southern Arabian Sea, characterized by rough seas and strong tidal movements.

3.4.1 1st Session - Coastal Erosion

The session delved into the multifaceted challenges posed by coastal erosion to regional infrastructure and the environment. The discussion covered sediment budgets, sediment



transport systems, contributing factors, and their consequential effects on coastal hydrodynamics. The Coastal Vulnerability Index and initiatives like the MERRIC project were explored. Modelling techniques, supported by case studies, were highlighted as valuable tools for predicting and mitigating the adverse impacts of coastal erosion.

3.4.2 2nd Session - Consequences of Sea Level Rise and Climate Change

The discussion centred around the implications of rising sea levels and climate change, providing insights into how these phenomena affect coastal communities, biodiversity, and infrastructure. It explored consequences across economic, health, and cultural dimensions, addressing strategies for adaptation to these evolving challenges.

3.4.3 3rd Session – Storm Surges by Cyclones

This session covered the effects and outcomes of storm surges caused by cyclones. It provided an in-depth examination of the generation and trajectory of storm surges, explaining the changes they instigate. The session also underscored the array of disasters arising from storm surges, utilizing various case studies to exemplify real-world situations.

3.4.4 Field Visit to Chellanam and Erosion-Prone Areas

A field trip was conducted to Chellanam and areas susceptible to erosion to understand sustainable coastal management practices. An Irrigation Department and ULCCS official elucidated the construction processes for sea walls and groynes, outlining procedural aspects. The goal was to gain a first-hand understanding of infrastructure projects in these vulnerable coastal areas.

DISCUSSION:

- To harness the full potential of the coastal zone while simultaneously preserving its resources, a comprehensive understanding of this intricate ecosystem is imperative for geologists, engineers, oceanographers, and coastal planners involved in the management of coastal areas.
- Coastal sediment cells exert a significant influence on coastal erosion. Therefore, it is essential to enhance our understanding and explore potential methods for analyzing sediment transport patterns.
- There is an urgent need to monitor the cyclonic circulation
- Upon inspection in Chellanam, specific attention was drawn to the construction of the sea wall.



3.5 Day 2 – 18th October 2023 - Technical topic 2: Tunnelling Technology, Coastal Erosion and Slope Integrity along the coastline

The constant shift of urbanization is causing land values to rise precisely when there is a growing demand for larger public spaces. Over 50 per cent of the world population residing in urban areas, it has been established that an estimated 61 per cent will be living in urbanized regions by 2030, and this number is expected to increase to 70 per cent by 2050.¹⁶ Given these circumstances, there is a growing demand for tunnelling in various projects related to mass transit, railways, road and highway development, water supply, and sewerage, leading an acceleration in tunnel construction within the nation. Concomitantly it is crucial to acknowledge and address the significant challenges posed by the ecological transition in such structures.

On this note the technical session emphasis on multifunctionality, resilience, and adaptability, with a primary focus on ensuring that the ecological transition is central to the design, construction, and operation of underground structures. By involving reduced carbon footprint and by minimizing the consumption of natural and energy resources.

3.5.1 1st Session - Mitigation and Adaption by Grey and Green Solutions

This session detailed strategies to prevent coastal erosion, drawing upon case studies showcasing grey and green solutions. Insights into early warning systems and their monitoring mechanisms were also provided.

3.5.2 2nd Session - Numerical Modelling of Coastal Erosion

The presentation on Numerical Modelling of Coastal Erosion elucidated the process through case studies, demonstrating how numerical modelling is conducted for coastal erosion, storm surges, cyclone tracks, and tsunamis. The discussion emphasized using various modelling tools to guide the selection of appropriate mitigation measures.

3.5.3 3rd Session – Saltwater Intrusion

This session focused on saltwater intrusion, covering causes, consequences, potential solutions, and adaptation strategies, explicitly mentioning how NGI (Norwegian Geotechnical Institute) can contribute.

¹⁶ ITA-AITES (2012), *Report on Underground Solutions For Urban Problems*, ITA Working Group , Urban Problems – Underground Solutions.



3.5.4 4th Session – Tsunami

The session provided a comprehensive overview of tsunamis, covering their sources, types, and return periods. It delved into global tsunami modelling and detailed various tsunami hazard assessments, supported by relevant case studies.

3.5.5 5th Session – Norwegian Method of Tunnelling (NMT) Part 1

This session introduced NMT (Norwegian Method of Tunneling) and highlighted its distinctions from NATM (New Austrian Tunneling Method). The presentation focused on the Q system for rock support by NGI, covering various ground investigation techniques, tunnel mapping, and construction methodologies.

3.5.6 6th Session – Norwegian Method of Tunnelling Part 2 (Numerical Tool for the Design and Optimization of Rock Support in Tunnel)

The session provided insights into numerical tools for designing and optimising rock support, demonstrating their application through case studies.

DISCUSSION:

- Are tunnels a more suitable for Kerala?
- What is the core capacity in the State to undertake such complex projects?
- Do Kerala have institutional memory of transportation tunnelling in Kerala?
- What are the SOPs for tunnelling?
- Is there an observational system for measuring salt water intrusion?
- What are the various mitigation measures?
- Is Green Solutions for Coastal Erosion Mitigation more appropriate than Grey Solutions?

3.6 Day 3 – 19th October 2023 - Technical topic 3: Slope Stability and Landslides along Road Corridors

The occurrence of devastating landslides has become a frequent occurrence during the monsoon season in the southwestern state of Kerala, India, situated in the foothills of the renowned mountain range, the Western Ghats. Except for the coastal district of Alappuzha, all 13 districts in Kerala are susceptible to landslides. Approximately 8% of the Western Ghats in



Kerala, covering an area of 1,400 square kilometres, is designated as a critical zone for mass movements.¹⁷

3.6.1 Field Visit to Kootickal Landslide Sites and Vagamon Road Cut Failure Sites (Kottayam District)

The trip started at 8 am and included visits to various locations with specific questions regarding debris flow prevention, rock stability, and stabilization measures for weathered rock formations.

Location 1 (Teekoy)

- Arrived by 11:30 am
- The first location along the Vagamon road cut at Teekoy is a frequent debris slide point.
- The site undergoes debris removal thrice a year, incurring substantial costs.

Questions that were discussed included

1. How can we prevent such debris flows? – Routine cleaning of streams that intersect roads, boulder catchers, catch drains etc. were discussed as options
2. How to reduce the time of blockage of roads due to such debris flows? – Locally hired ERTs for road block clearing under Local Self Governments, possibility of using MGNREG workers.

Location 2 (Karikadu watchtower Point 1)

- Along Vagamon cut road
- The presence of hard rock cliffs along the roadside poses a potential threat in the form of rockfall.

Questions that were discussed included

1. How can we prevent rockfall? – netting, bolting, jet concreting, blasting and removing, chipping
2. Is tunnelling a viable option in this location? – Tunnels ensure transportation continuity even during extreme weather. Norway has the largest number of tunnels in the world.

Location 3 (Karikadu watchtower Point 2)

- Adjacent to site 2

¹⁷ Kuriakose, Sekhar L., Sanjaya Devkota, D. G. Rossiter, and V. G. Jetten, (2009), "Prediction of soil depth using environmental variables in an anthropogenic landscape, a case study in the Western Ghats of Kerala, India," *Catena* 79, no. 1: 27-38



- The area comprises highly weathered rock formations, mainly laterite.

Questions that were discussed included

1. What measures are possible for stabilizing this formation? – this formation fails every year. Many a times this has cause obstruction to road traffic. Soil nailing and jet concreting is a solution with provision for soil nailing

Location 4 (Kootickal)

Questions:

1. During landslides, several bridges are destroyed. How can we prevent this, and what modifications can be made to construction? – In light of climate change, ungauged design of bridges is bound to fail. Therefore, bridge designs, even if they are for small rivulets should conducted for a 25 years higher return probability than the standard ungauged designs.
2. There are numerous boulders in the river course. Can they be used as construction material? – Smoothing the river course has pros and cons. The boulders are entrapments of sediment and prevent under cutting and bank erosion of streams by dissipating the flow velocity and impact. However, in a flooding situation, many of the large boulders will act as obstacles to stream flow and will result in upstream flooding and flow path diversion. Therefore, it is essential that a study is conducted on the size of boulders to be retained in the streams and the potential of using larger boulders for construction purposes in the state.
3. What type of early warning systems can be developed to mitigate flash floods in hilly upstream rivers? – the quick flowing rivers of Kerala requires a non-conventional early warning system. Instrument driven EWDS alone will not cater to the needs of Kerala. Therefore, it is appropriate to orient a startup to develop such an EWDS.

3.7 Day 4 – 20th October 2023 - Technical topic 3: Slope Stability and Landslides along Road Corridors

3.7.1 1st session – landslide classifications, predisposing and triggering factors

This session introduced various landslide classifications and discussed predisposing and triggering factors associated with landslides.

3.7.2 2nd session – susceptibility, hazard, and risk mapping

The session covered a broad spectrum of concepts and techniques related to landslide risk assessment and mapping. It included discussions on the risk formula, landslide



susceptibility and hazard zoning methods, and various analysis approaches such as heuristic versus statistical methods.

3.7.3 3rd session – landslide monitoring and early warning

The session comprehensively covered various aspects of landslide early warning systems and monitoring techniques. It included an introduction to remote sensing and the utilization of monitoring tools such as inclinometers, piezometers, tensiometers, and rain gauges.

3.7.4 4th session – numerical modelling of landslides

The session covered diverse landslide modelling and ground investigation topics, emphasizing the importance of regional-scale soil strength. It highlighted the significance of building models based on ground investigation data and underscored the use of modelling tools like GEO-Studio, SEEP/W, and SLOPE/W.

3.7.5 5th session – Mitigation of landslides

Mitigation measures for landslides including both grey and green strategies were discussed. Grey measures involving engineering solutions like slope stabilization, retaining walls, and drainage systems and flexible barriers specifically meant for debris flows were introduced. Green measures focus on nature-based approaches such as afforestation, soil bioengineering, and sustainable land-use planning.

3.7.6 5th session – construction of tetrapod based coastal protection wall at Chellanam

This session provided a summary of the Kerala coastline, highlighted the effects of climate change on shoreline changes, and focused on the Chellanam project, detailing the construction of a seawall structure in two reaches, Reach A and Reach B.

3.7.7 Feedback

The agenda covered a wide range of topics related to disaster risk reduction, including coastal erosion, tunnelling methods, slope stability, and landslides along road corridors. Including speakers from various backgrounds and expertise levels enhanced the overall quality and perspective of the workshop.

Upon successful completion of this bilateral workshop, the initiation of various innovative proposals for the benefit of every participant needs to be considered.

DISCUSSION:

- Following the field visit to the Koottickal Landslide Sites and Vagamon Road Cut failure sites in Kottayam District, several critical concerns emerged:



- How can we mitigate the risk of debris flow, and is stream widening a viable solution? If we opt for stream widening, what measures can be implemented to prevent debris blockage?
- Is it feasible to remove the hard rock through methods such as blasting or other techniques? Can techniques like rock bolting or rock nailing be employed to stabilize the rock formations?
- What construction modifications can be implemented in the design of bridges to safeguard against landslides and flash floods?
- Within the river course, an abundance of boulders is present. Can these boulders be utilized as construction materials?
- Is the removal of these boulders from the riverbed likely to trigger riverbank scouring, subsequently increasing undercutting and erosion? Are there any preventive measures for this?
- What types of early warning systems can be devised for mitigating landslides of this nature?

4. Lectures in the workshop

Sl. No	Title	Lecturer	Link
1	About Norwegian Geotechnical Institute	Dr. Dominick Lang, Director, Natural Hazards	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/2.-About-NGI.pdf
2	Consequences of Sea Level Rise and Climate Change	Mr. Carl B. Harbitz, Mr. Sylfest Glimsdal, and Ms. Elisabeth H. Reutz	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/3.-Climate-Change.pdf
3	Coastal Erosion	Ms. Sylfest Glimsdal and Mr. Carl B. Harbitz	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/4.-Coastal-Mitigation.pdf
4	Coastal erosion - mitigation and adaption		https://sdma.kerala.gov.in/wp-content/uploads/2024/01/8.-Mitigation-Coastal-Erosion.pdf



5	Numerical modelling of coastal erosion		https://sdma.kerala.gov.in/wp-content/uploads/2024/01/13.-Numerical-Modelling-Coastal-Erosion.pdf
6	Saltwater Intrusion	Mr. Sylfest Glimsdal and Mr. Thomas Pabst	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/14.-Saltwater-Intrusion.pdf
7	Storm surges by Cyclones	Mr. Sylfest Glimsdal, Mr. Carl B. Harbitz and Ms. Gunilla Kaiser	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/15.-Storm-Surge-Cyclons.pdf
8	Tsunami Modelling	Mr. Carl B. Harbitz, Mr. Sylfest Glimsdal, and Mr. Finn Løvholt	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/16.-Tsunami.pdf
9	Landslide classifications, predisposing and triggering factors	Prof. Luca Piciullo	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/5.-Landslide-classifications.pdf
10	Susceptibility, hazard, and risk mapping		https://sdma.kerala.gov.in/wp-content/uploads/2024/01/6.-Mapping.pdf
11	Landslide monitoring, and early warning		https://sdma.kerala.gov.in/wp-content/uploads/2024/01/9.-Monitoring-and-early-warning.pdf
12	Mitigation Measures for Landslides	Dr. Ing. Sparsha Nagula, Dr. Farrokh Nadim &	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/7.-Mitigation-Measures-for-Landslides.pdf



		Dr. Anders Solheim	
13	Numerical Modelling of Landslides	Dr. Ing. Sparsha Nagula, Dr. Zhongqiang Liu & Dr. Hans Petter Jostad	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/12.-Numerical-Modelling-of-Landslides.pdf
14	Norwegian Method of Tunnelling (NMT)	Dr. Rajinder Bhasin	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/10.-Norwegian-Method-of-Tunnelling-Part-1.pdf
15	Numerical tools for the design and optimization of rock support in tunnels		https://sdma.kerala.gov.in/wp-content/uploads/2024/01/11.-Norwegian-Method-of-Tunnelling-Part-2.pdf
16	Construction of Sea wall at Chellanam: An overview	Mr. Aswin Subhan, Assistant Engineer, PMU ASE Chellanam	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/Chellanam-Irrigation-work-.pdf
17	Rubber Check Dams	Mr. Sudhakaran A.P, Assistant Engineer, Irrigation (Minor)	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/Mitigation-Rubber-check-dam.pdf
18	Disaster Risk Reduction in Kerala: Towards a Safer State	Dr. Sekhar L. Kuriakose, Member Secretary, KSDMA	https://sdma.kerala.gov.in/wp-content/uploads/2024/01/2022-Current-Status-612023.pdf



5. Feedback of participants



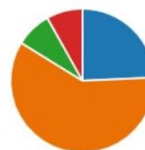
India-Norway Bilateral Workshop Feedback

Coastal Erosion-Tunnelling-Landslides

Overview of Background of 37 Participants



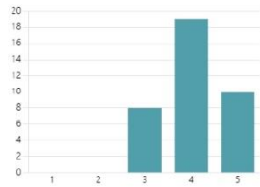
Bachelor (Bsc, Btech)	9
Masters (Msc, MTech)	22
PhD	3
Other	3





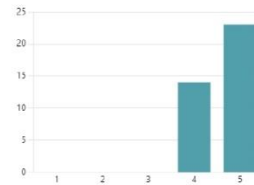
Overall rating of the technical quality of workshop

4.05
Average rating



Overall rating of the workshop

4.62
Average rating



Would you recommend such workshops to others

Very likely	28
Somewhat likely	8
Neither likely nor unlikely	1
Somewhat unlikely	0
Very unlikely	0





Useful to connect with colleagues from other departments and extension of your professional network



NGI

NGI



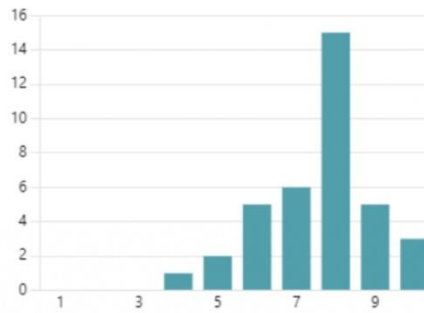
Coastal Erosion





Overall effectiveness

7.59
Average rating



NGI

Meeting overall expectations and needs

Yes	18
No	7
yes, but	10
Other	4



Topics presented in clear and easy way regardless of background

Yes	27
No	1
To some extend	10
Other	0



NGI

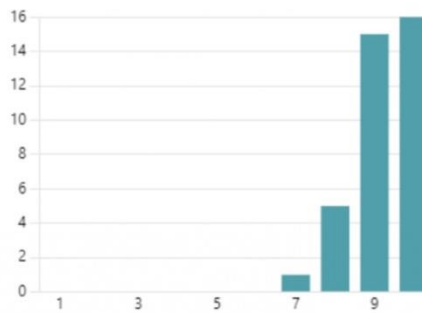


Tunnelling



Overall effectiveness

9.24
Average rating





Meeting overall expectations and needs

Yes	32
No	0
yes, but	5
Other	2



Topics presented in clear and easy way regardless of background

Yes	37
No	0
To some extend	0
Other	0



NGI

NGI



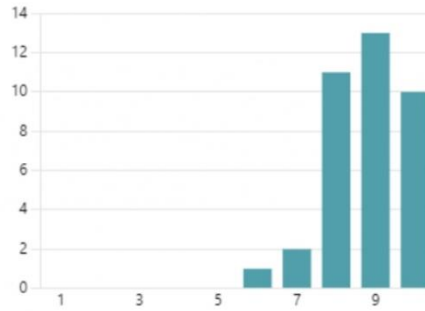
Landslides





Overall effectiveness

8.78
Average rating



NGI

Meeting overall expectations and needs

Yes	29
No	0
yes, but	7
Other	1



Topics presented in clear and easy way regardless of background

Yes	32
No	0
To some extent	4
Other	1



NGI



Overall, did you have a good time?

● Yes	37
● No	0
● Sort of	0





6. What was learned

6.1 Slope Stability

- Importance and timeliness of the workshop, noting its relevance in the context of Rebuild Kerala was well understood by the participants. The workshop was designed to help build partnerships and to facilitate the exchange of best practices and the sharing of lessons learned. 18 presentations and two field works were organised as part of the workshop.
- The lack of harmonized methodology and protocol came out very strongly in all aspects of landslide risk management, particularly in the treatment of susceptible slopes when infrastructure development is carried out – Slope stability along rural roads, district roads and state roads are not seen adequately attended with a long-term resilience building perspective.
- The need for capacity building featured prominently in all the technical sessions. Multi-level engagement was favoured, and having policy, legislation, and institutional mechanisms in place were deemed imperative to facilitating ground-level interventions. Experiences from Norway highlighted the importance of community engagement in all aspects of landslide risk management for the success of interventions. Rebuilding the livelihoods of local communities and enhancing food security by adopting indigenous species to build resilience for sustaining recovery was noted as essential. Lack of awareness about modern construction methods, geoenvironmental solutions and relevant BIS codes were evident.
- Experiences showed that the use of civil engineering structures together with bioengineering measures has a high rate of success, rather than depending on one type of intervention.
- The provision of actionable information resonated strongly with participants. The need to develop hazard and risk maps at the local government level (at scales of 1:10,000 or 1:25,000) was proposed. There was strong preference for combining top-down (traditional) and bottom-up (community) approaches to integrate technological input and community engagement for more effective interventions.
- Lack of very high resolution and accurate terrain models (LiDAR based) was well noted. This is a major limiting factor in micro-zonation of landslide susceptibility and preparing high resolution susceptibility maps



- It was seen that it is essential to have harmonized methodologies and protocols for landslide inventory, hazard and risk assessments, and data sharing
- All cases of landslide investigations need not be referred to Geological Survey of India. Only when it comes to areas where critical assets or more than 10 houses are involved that matters should be referred to GSI. In case of areas with less than 10 houses, possibility of applying susceptibility-based relocation should be examined. In cases where mitigation measure is costlier than relocation, relocation may be preferred.
- Longterm approach towards landslide risk informed land use planning, particularly for residential area planning and road network planning is essential
- Management of Tertiary Formation Cliffs such as the Varkala Cliff requires careful micro planning of the land use, on the cliff summit
- Minor roads and infrastructure, particularly of local self-governments are not structurally designed considering risks. However, considering climate change impacts and disaster risks, it is essential that such structures also need to be designed considering relevant IS codes and with a life cycle-based approach of maintenance.

6.2 Coastal Erosion

- The state-of-the-art of hard infrastructure (Tetrapod) based solution implemented at Chellanam, Ernakulam District was highly appreciated. It was an eye opener to majority of the participants that Kerala could undertake such an engineering measure on its own.
- Complete hardening of the coast is not ideal and essential.
- An assessment of the Kerala coast in the context of hard solutions vs soft solutions is not seen. Relative prioritisation of assets/areas for implementing expensive solutions hard solutions as against the soft approaches including ‘retreat approach’ recommended by IPCC is not clear. This requires a detailed study by the Coastal Zone Management Authority
- Offshore coastal erosion protection measures such as offshore breakwater may be more intensely explored for implementation along the coastline of Kerala.
- Hybrid solutions involving hard and soft solutions may be explored.
- Maintaining the quality of estuarian mangrove forests shall be a priority.
- Creation of coastal sand dunes landward, beyond the hightide line along with vegetative protection is an ideal measure



-
- Continuous coastal erosion monitoring and mapping mechanism is essential for which in-sea and on land wave and wind monitoring systems are essential
 - High resolution and high-quality bathymetric data of the coastal area of Kerala, including of intertidal zones are required for improved designing

6.3 Tunnelling

- Tunnels are an ideal resilient solution for reducing disaster impacts on transportation sector in the hilly terrain
- They are also ideal for reducing distances and thereby reducing carbon emissions
- There is a lack of Standard Operating Procedure for identifying and prioritizing the transportation corridors that needs tunnelling
- Standard Operating Procedures for site investigation requirements and their strengths and limitations for tunnel design and construction in soils and rock needs to be derived for the State specific conditions
- Standard Operating Procedures for understanding and selecting the appropriate tunnelling method and tunnel lining system for a given combination of soils, groundwater, tunnel diameter and depths needs to be derived
- Safety protocols must be prepared for the operations of tunnel, both inside the tunnel and for the slope stability aspects of the tunnels
- There is a lack of institutional knowhow on tunnelling project management principles and experience. It is appropriate to provide training for selected young engineers, engineering geologists, geologists and hazard analysts by and at the Norwegian Geotechnical Institute in collaboration with various ongoing projects therein. A special training programme of 1 month may be created by KSDMA for the purpose.



7. Future

1. KSDMA and NGI:

- KSDMA and NGI may collaborate to establish a Centre for Geohazards and Climate related hazards management as was proposed during the visit of Hon'ble Chief Minister to NGI. The Centre may be technically supported by NGI and financially supported by KSDMA. Possibility of associating with other Norwegian agencies such as NERSC may also be considered in further strengthening and institutionalizing the collaboration under SENDAI Target 6. The centre can enable the following roles/tasks:
 - Regular training courses on more concrete problems/topics.
 - Building up a stipend for students of Kerala to be trained (Msc, PhD) in Norway.
 - Joint R&D proposals to national (DST India, RCN Norway) and international funding agencies (European Commission).
 - Joint tender works to World Bank, UN funded works focusing on Kerala.
 - Annual workshop involving decision-makers to plan for potential collaborations and initiatives and evaluate past activities.
 - The Centre may focus on Capacity building of engineering departments of Kerala in adopting appropriate design solutions for building resilient infrastructure and support them in following [Annexure 11 of the State Disaster Management Plan](#)
- The Centre may focus on capacity building of engineering departments of Kerala in adopting appropriate design solutions for building resilient infrastructure and support them in following [Annexure 11 of the State Disaster Management Plan](#)

2. Collaborative Training Program:

During the opening session, Chief Secretary examined how many of the participants in their service period received any specialised training of 3 days or more. The number of participants who received such training was only 3 in the entire group.

- The Technical/Engineering Departments in the State requires global exposure in modern engineering techniques and project management.
- It will be appropriate to identify engineers and technical officers from various departments (PWD, Local Self Government Engineering, KSEB, Irrigation, KWA, Mining and Geology, Soil Conservation, Local Self Government Planning, Project Implementation and Monitoring, KIIFB, KSDMA, KSCCAM and Dept. of Environment)





APPENDIX



Dr. V.K Ramachandran

Dr. V. Venu



Dr. Dominick Lang



Dr. A. Kowsigan



Mr. N.S.K Umesh



Ms. Usha Bindhumol



Prof. Luca Piciullo



Mr. Sylfest Glimsdal



Mr. Carl B. Harbitz



Dr. Rajinder Bhasin



Dr. Ing. Sparsha Nagula



Dr. Sekhar L. Kuriakose



Participants at Chellanam





Participants at Kottayam-Vagamon Route

