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25

YEARS IN SCIENCE

Dedicated to advancing science for a sustainable and resilient future

ANNUAL REPORT 2024

NANSEN ENVIRONMENTAL RESEARCH CENTRE (INDIA)

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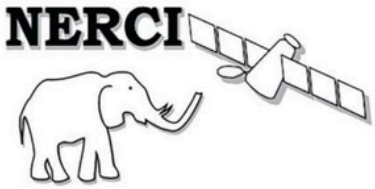

NANSEN ENVIRONMENTAL RESEARCH CENTRE (INDIA)
A non-profit environmental and climate research centre recognised by the Department of Scientific and Industrial Research (DSIR) Govt. of India.

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http://nzc.iap.ac.cn

Nansen-Tutu Centre
Nansen-Tutu Centre for Marine Environmental Research
Cape Town, South Africa

Nansen Scientific Society
Nansen Scientific Society
Bergen, Norway

NABIC
Nansen-Bangladesh International Centre for Coastal, Ocean and Climate Studies
Dhaka, Bangladesh

NANSEN ENVIRONMENTAL RESEARCH CENTRE (INDIA)

The Nansen Environmental Research Centre India (NERCI) was established in 1999 as a non-profit research centre in India, as one of the six international Nansen research centres. The Centre is registered with Department of Scientific and Industrial Research (DSIR) of Ministry of Science and Technology, Govt. of India as a Scientific and Industrial Research Organization (SIRO) (www.nerci.in). NERCI is also an approved research centre of Kerala University of Fisheries and Ocean Studies (KUFOS) http://kufos.ac.in/research-centers/ in the Faculty of Ocean Science and Technology and Faculty of Fisheries Engineering. The Centre conducts basic and applied research in ocean and atmospheric sciences as well as in coastal zone management with core staff strength of four senior scientists, two administrative staff, 16 researchers and intern students.

The Centre co-operates scientifically, particularly with the other five Nansen Centers and its international associate partners Plymouth Marine Laboratory (PML), UK; Nansen Scientific Society, Norway. The Centre has an extensive national and international network of research project cooperation, including several public Indian MoU research and educational partners.

NERCI promotes Ph.D. scholars and master students from India and abroad. We provide research and internship guidance through our distinguished scientists and partners. In 2024, Four full-time and five part-time doctoral students affiliated to Kerala University of Fisheries and Ocean Studies (KUFOS) and Bharathidasan University did their research at NERCI with funding from Department of Science and Technology (DST), Government of India Ministry of Earth Sciences, Research Council of Norway and Nansen Scientific Society (Norway). During 2024, Eleven MSc. students completed their degree dissertations under the guidance of NERCI scientists and one Ph.D part time student submitted his doctoral thesis to Bharathidasan University.

VISION

To serve the society through advancing knowledge on Monsoon, Ocean Variability and

Coastal Marine Ecosystem for sustainable development by promoting interdisciplinary research and education cooperation programmes in the spirit of Nobel laureate Fridtjof Nansen.

MISSION

The Centre conducts basic and applied research in ocean, atmospheric sciences, marine ecology and coastal zone management using observations, remote sensing, and GIS applications and numerical simulations for achieving the UN sustainable development goals.

OUR RESEARCH AREAS

- **Regional sea- level variations-** present and future, coastel circulation including upwelling.
- **Marine ecology and pollution** of coastal waters and estuaries using *in-situ* and remote sensing methods.
- **Ocean biogeochemistry** - focusing on primary production, harmful algae blooms and deoxygenation (eutrophication).
- **Climate change impact studies** on coastal habitats like coral reefs, carbon cycle, ecosystem and human health using remote sensing and GIS. Monsoon variability and its global teleconnections
- **Water quality and health –** how the deterioration of water quality of estuaries and coastal waters influence the pathogen dynamics and the water associated diseases in the context of One Health.
- **Carbon dynamics and carbon impact studies –** of both terrestrial and marine carbon dynamics and carbon credit estimation.
- **Sustainable development -** focusing on urban sustainable development and energy resources as well as the UN-SDGs.

The research that we do in these areas have a socio-economic component that cater to the needs of the society in the field of interest. We also focus on capacity building

activities in all our research works, either through training or through citizen science activities. Employing satellite remote sensing and AI/ML methods, we enhance observational data and develop models with good precision.

BOARD OF DIRECTORS

- Mr. Lasse H. Pettersson (Chairman), Research Coordinator & Senior scientist, Nansen Environmental and Remote Sensing Center (NERSC), Norway
- Dr. Tore Furevik, Director, NERSC, Norway.
- Dr. Annette Samuelsson, Research Leader, NERSC, Norway.
- Dr. K. Ajith Joseph, Executive Director, NERCI.
- Dr. N. Nandini Menon, Deputy Director, NERCI.
- Dr. Shubha Sathyendranath, Merit Scientist, Plymouth Marine Laboratory (PML), UK as observer.
- Dr. Roshin P Raj, Senior Researcher, NERSC and representative from Nansen Scientific Society as observer.

SCIENTIFIC RESEARCH ADVISORY BOARD

- Dr. Shailesh Nayak, former Secretary, Ministry of Earth Sciences, Govt. of India &Director, NIAS, Bengaluru.
- Prof. Dr. B. Madhusoodana Kurup, former Vice Chancellor, Kerala University of Fisheries and Ocean Studies.
- Lasse H. Pettersson, Leading scientist, NERSC, Bergen, Norway.
- Dr. Laurent Bertino, Research Director, Mohn-Sverdrup Centre for Global Ocean Studies and Operational oceanography, NERSC
- Prof. S. T. Balasubramanian, Vice Chancellor, Chettinad University of Health Sciences, Chennai
- Dr. N. Nandini Menon, Member Secretary

FROM THE BOARD OF DIRECTORS

NERCI celebrated its 25 years in Science in November 2024 and NERCI´s scientific contribution during this period 1999-2024 reached 100 publications in referred journals. Four peer-reviewed publications in 2024 and six oral or poster presentations in international conferences were also published jointly with other Indian and international research scientists and institutions in the current year. In addition, seven papers with scientists from partner institutions as co-authors are under review. In addition, NERCI scientists provided invited talks at conferences and gave webinars at various national and international fora.

The published scientific results have emerged from major projects related to the Indian Ocean ecosystem, coral reef bleaching, HABs and seagrass; urban and lake pollution related to human health and access to energy in cities. NERCI has 11 ongoing externally funded projects in 2024. New consultancy activities have been developed with some major tea and coffee plantations to assess their carbon emissions and uptake, following international protocols and standards. Currently, four full-time and four part-time Ph.D students are continuing their research at NERCI in collaboration with KUFOS and six project fellows are working under different projects. The number of Indian master students under co-supervision by NERCI scientists has increased significantly and eleven students completed their B.Sc. or M.Sc. thesis during 2024.

The centre has a core staff strength of four full-time core scientists, one associate scientist, two administrative staff as well as 16 researchers including project fellows and eleven intern students working on current projects. Two doctoral students of NERCI are co- supervised by NERSC scientists – Dr. Roshin P. Raj for Mr. Ullas M Pillai working on Sea level changes in the North Indian Ocean and Dr. Annette Samuelsen for Mr. Akash S working on Oxygen Minimum Zone variability in the North Indian Ocean. Both are supported financially by the Nansen Scientific Society, Bergen.

REFLECTIONS ON OUR ACTIVITIES - 2024

1. URSA MAJOR Hackathon 2024: Sustainable City Development – Environmental Scenarios in the Global South

A five day hackathon was organized by NERCI/NERSC as part of the INTPART-2020 funded project 'URban Sustainability in Action Multidisciplinary Approach through Jointly Organized Research schools'(URSA MAJOR) in Kochi from 11-15 November 2024.

The Hackathon was planned in three stages: Pre Hackathon, Hackathon and post hackathon. Pre hackathon was conducted two weeks prior to the hackathon during which work flow was discussed and study materials were distributed online to the participants. 22 young researchers from Institutions and universities in India and abroad participated in the event. During hackathon, internationally reputed scientists provided lectures, hands-on training and guided small scale research projects (SSRP) that simulated real-world challenges. The three projects that the participants worked on were:

i) Assessing Urban Growth and its impacts on Surface Urban Heat Island in the Kochi City, Kerala

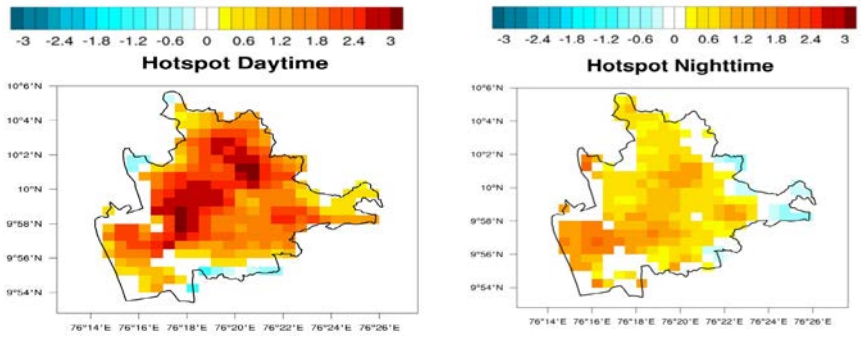

Figure 1: Urban heat island of Kochi city

The central region of Kochi exhibited the highest UHI index during the day (fig. 1), highlighting the intensity of urban heat due to dense infrastructure and reduced vegetation. Land Use and Land Cover changes from 2003 to 2023 revealed significant transformations in Kochi's landscape driven by urbanization with a substantial 48.38% increase in built-up area.

ii) Assessing Urban Air Quality: A Comparative Study of Pollutant Trends in Delhi and Kochi (2019-2023)

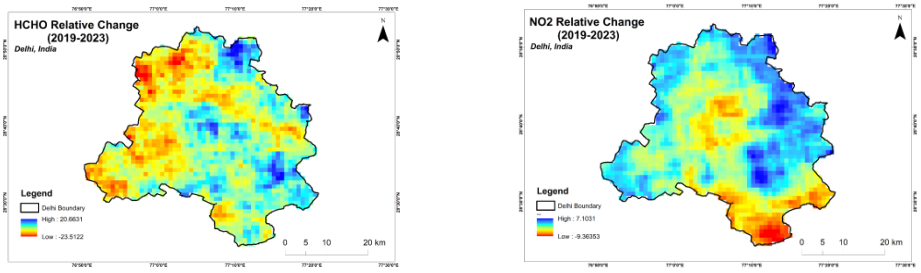

Figure 2: Relative change of pollutants over Delhi

The comparative analysis of air pollutants in Delhi and Kochi from 2019 to 2023 showed that Delhi had notable reduction of most pollutants, including aerosols, AOD, CO, NO_2, and SO_2, reflecting the effectiveness of targeted pollution control measures and improved traffic management. However, the rising levels of formaldehyde (HCHO) in Delhi (fig. 2) highlighted the persistent challenge posed by industrial and vehicular emissions in central and eastern regions.

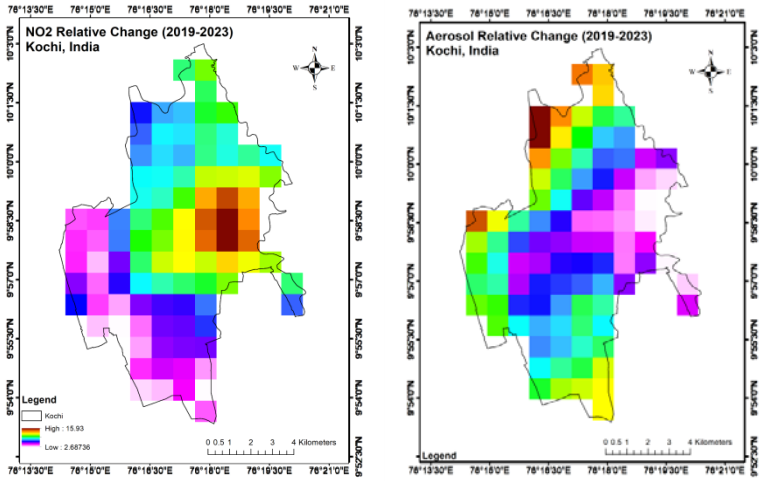

Figure 3: Relative change of pollutants over Kochi

In contrast, Kochi presented a more varied picture, with improvements in CO, SO_2, and HCHO levels in specific regions, but increases in NO_2 and aerosols, particularly in urbanized central areas (fig. 3). The city's seasonal pollutant patterns, such as winter peaks and monsoon-associated reductions, paralleled those of Delhi but were influenced by its unique coastal and meteorological conditions.

Both cities reveal the importance of localized interventions tailored to regional characteristics. While Delhi benefits from stricter emission controls, Kochi requires targeted strategies to address its rising NO_2 and aerosol levels, which could impede further improvements in air quality.

iii) Analysing Kochi's SMART city initiatives its challenges and solutions.

The study focusing on identifying barriers to smart city development found that while the smart city vision for Kochi holds promise, it requires recalibration from a tourism-driven, data-centric model to one that caters to local societal voices and needs. By adopting a bottom-up approach and prioritizing community consultation, smart city initiatives in Kochi could achieve sustainable development that is not only technologically advanced but also socially inclusive.

Post hackathon activity was to produce publications out of the mini projects.

Hackathon provided an opportunity to gain practical research experience, contribute solutions to urban issues, collaborate with international experts and other participants.

Figure 4: Glimpses from the URSA-MAJOR Hackathon 2024

2. *NERCI 25 Yr Colloquium and Anniversary Celebrations*

Nansen Environmental Research Centre (India) (NERCI) was established in April, 1999 under the provision of section 25 of the Companies Act, 1956, jointly by the Nansen Centre, Bergen and the Norinco company (now Varya Tech Pvt. Ltd), Mumbai, with George and Thomas Mathew as partners, with the vision 'to improve our understanding of the climate change, its impact on monsoon and Indian Ocean ecosystems and their influence on the coastal zone and the resulting social problems'.

Under the leadership of Dr. Ajith Joseph, and with the scientific stewardship of late Prof. (Dr) N. R. Menon, NERCI has successfully implemented numerous international research projects, producing high-impact publications, postgraduate and doctoral degrees, and sustained capacity building in remote sensing and GIS. The Centre has also benefited immensely from the mentorship and support of distinguished scientists such as Prof. P. V. Joseph and late Prof. Trevor Platt, as well as the strategic guidance of Board Member Mr. Thomas Mathew. Under such efficient guidance, NERCI has secured competitive research funding from national and international agencies, contributed meaningfully to several UN Sustainable Development Goals, and built a robust network of scientific collaborations. The national partners include ICAR-CMFRI, CSIR-NIO, MoES-INCOIS, MoES-NCPOR, CUSAT, Sathyabama University, Anna University and Trevor Platt Science Foundation. International partners like NERSC, PML, Alterra, IFREMER, CMCC, and INPE have provided scientific and financial support, enhancing our visibility and exposure in international marine research.

The efforts of NERCI's scientists and scholars have not only strengthened the ties between the Nansen Group and NERCI but have also played a pivotal role in strengthening scientific cooperation between India and Norway, aligning closely with the Norwegian government's bilateral research strategy launched in 2018. Its sustained presence has enabled the participation of numerous scientists and institutions from Norway, Europe and beyond, including the training of several hundred young researchers through international research schools held across India and at Svalbard.

These enduring achievements, built on strong personal and institutional partnerships over a quarter-century, were fittingly celebrated during the anniversary event attended by leading national and international scientific dignitaries.

One day colloquium and anniversary celebrations were conducted on the 16 November 2024 at Renai Blue Waters resort, Cherai, Kerala, India. The morning session included a formal meeting with Dr. M. Ravichandran, Hon. Secretary, MoES, Govt. of India inaugurating the colloquium. He also released the Book of abstracts of NERCI publications in the last 25 years. Dr. T.M .Balakrishnan Nair, Director, INCOIS opened the new website of NERCI. Felicitations were given by Prof. Dinesh Kaippilly (Registrar, KUFOS), Shri. A. Jayakumar, Special Advisor, Vijnana Bharati, Dr. G.V. M. Gupta, Director, CMLRE, Dr. Grinson George, Director, CMFRI and Dr. Chiranjivi Jayaram, Scientist, ISRO-RRSC (NERCI Alumni representative). The founding members and the other Board members of NERCI were honoured at the function.

Afternoon session had two scientific panel discussions:

1. Inter-disciplinary and collaborative research on climate change impacts

   Moderator: Dr. S. S. C. Shenoi, former director, INCOIS.

Panelists-

1. Dr. T. M. Balakrishnan Nair, Director, INCOIS
2. Dr. Grinson George, Director, CMFRI
3. Prof. Dr. Suresh Kumar, Director of Research, KUFOS
4. Dr. Anas Abdulaziz, Principal Scientist, NIO Regional Centre, Kochi
5. Lasse H. Pettersson, Research Coordinator, NERSCI, Norway
6. Dr. Nandini Menon, N., Principal Scientist & Deputy Director, NERCI

Dr. S. S. C. Shenoi, former Director of INCOIS and moderator of the discussion, kick-started the importance of collaborative interdisciplinary research, highlighting how the impacts of climate change are deeply interconnected.

The discussion began with the question raised by Dr. Balakrishnan Nair - What can we

do about climate change? He highlighted the Ocean Climate Change Advisories issued by INCOIS and emphasized the need for integrated approaches to address key challenges such as rising mean sea levels, increasing cyclone intensity and frequency, and storm surges. Dr. Balakrishnan Nair also stressed the importance of modeling for phenomena like Kalla Kadal and coral reef bleaching. He discussed the need to build climate-resilient communities and suggested ocean literacy programs to enhance climate hazard preparedness among local communities.

Dr. Suresh Kumar shared the details of climate-related projects and studies underway at KUFOS. These included analyses of climate extremes, monitoring of greenhouse gas emissions, development of a mobile app to support disaster management, and research on carbon pools within mangrove ecosystems. Dr. Suresh Kumar emphasized the need for region-specific climate change predictions, particularly tailored to the needs of the fishing community.

Dr. Anas Abdulaziz discussed the connection between climate change and public health in coastal regions. He highlighted the vulnerability of these areas to pathogens such as *Vibrio cholerae* and Leptospira, noting that temperature and salinity are key factors influencing their spread in wetlands. Dr. Abdulaziz also identified challenges such as inadequate databases and the limitations of current microbiological technologies. He called for active inter-disciplinary collaboration in pathogen surveillance and risk mapping to address these issues effectively.

Lasse H. Petterson highlighted the critical importance of the marine ecosystem and its significant societal impacts, including sea level changes. He emphasized the need for collaborative efforts in the Arctic Ocean Observatory System as well as on climate projection models. He also underscored the value of satellite data acquisition, urban management, smart city development, and carbon footprint assessment in addressing climate-related challenges.

Dr. Nandini Menon provided an overview of collaborative projects conducted at NERCI in partnership with various national and international organizations. The need to focus on primary production, the impact of water quality on health, and capacity

building programmes to build climate adaptability and resilience among the vulnerable communities were highlighted.

Dr. Grinson George discussed the changing marine ecosystem and its impact on fisheries resources and stakeholders. He highlighted the development of 100 model climate-resilient fishing villages across India. Dr. George raised concerns about India's position in the global carbon trading market and emphasized the importance of implementing a carbon credit system. He noted that while numerous carbon sequestration projects exist, their monetary implications need better realization. Dr. George also recommended establishing a citizen science network for long-term water quality monitoring and stressed the value of in situ data collection using technologies like passive georeferencing. Additionally, he described CMFRI's work on ecological niche changes and species spread.

In the active discussion that followed, Mr. Kesavadas, retired scientist from NIO emphasized the importance of raising climate change awareness among students starting at the school level, Dr. Balasubramanian pointed out the need for efficient garbage disposal systems to address environmental challenges, and Dr. Ravichandran called for the development of robust local forecasting models and their validation. He also advocated for outreach projects focused on climate change and related issues in local areas.

Dr. Shenoi concluded by highlighting the crucial role of society in fighting climate change and reiterated the importance of awareness programs for students addressing the demands on energy, food, health of ecosystems, and the well-being of society and economy. He also pointed out the importance of collaborative research to tackle climate change and adaptation and mitigation strategies as key solutions to these challenges.

2. Way forward for NERCI- Opportunities and Challenges

Moderator – Prof. T Balasubramanian, Former VC (Chettinad University) & NERCI Scientific Council member

Panelists

1. Mr. Mathew Abraham, Kanan Devan Hill Plantations Pvt. Ltd
2. Dr. K. Ajith Joseph, Principal Scientist & Executive Director, NERCI
3. Dr. K.N.Babu, Head, Earth Ocean Planetary Science, ISRO-SAC, Ahemedabad
4. Prof. Madhusoodana Kurup, Former VC, KUFOS
5. Mr. Sharon Philip, VP- Tridel Technologies & CEO – M/s. Shankar Surveys
6. Dr.Alexander Baklanov, Niels Bohr Institute, Copenhagen, Denmark

The panel discussion began with an overview presented by the Moderator, Prof. T. Balasubramanian, who emphasized the importance of defining a clear strategic direction for NERCI in addressing emerging challenges in marine and coastal research. He highlighted the need to strengthen institutional collaborations with leading national organizations such as CUSAT and CMFRI, particularly in advanced areas including marine biotechnology and genetic engineering of marine resources. He further underscored the importance of integrating research on food, health, and environment with effective waste management technologies to support sustainable coastal development.

Prof. Madhusoodana Kurup highlighted key research priorities at the interface of climate change and marine ecosystems. He listed out the thrust areas related to climate change impact that need scientific attention. He also outlined the availability of funding opportunities from international climate and marine ecosystem agencies, private organizations, and national funding mechanisms. However, he noted that NERCI faces challenges related to funding constraints, ecosystem complexity, policy and governance barriers, limited community engagement, data gaps, competition for resources, and shortages in skilled manpower and infrastructure. He emphasized that these challenges

can be addressed through strong funding proposals, enhanced institutional capacity, strategic partnerships, effective networking, adaptability, and systematic impact assessment.

Mr. Sharon Philip emphasized the importance of developing commercially viable and scalable models alongside research activities. He highlighted the relevance of industry collaboration, ISO standardization, and aligning institutional efforts with carbon neutrality goals to enhance NERCI's relevance and sustainability.

Dr. Alexander Baklanov stressed the value of international collaboration through global research and funding programs, including Horizon Europe initiatives. He highlighted the importance of integrating research with education and training programs such as Erasmus Mundus and adopting co-design approaches involving stakeholders.

Dr. K. N. Babu highlighted the critical role of satellite data in marine and coastal research and emphasized the need for capacity-building initiatives through specialized training programs. He also noted the potential for renewable energy and industrial projects that rely on satellite-based data products.

Responding to the deliberations, Dr. K. Ajith Joseph outlined NERCI's ongoing initiatives and institutional status. He highlighted that the institution is registered with several national, private, and international funding agencies, while also acknowledging limitations in implementing international training programs such as Erasmus Mundus due to institutional capacity constraints. He further outlined key institutional challenges, including issues related to organizational identity, human resource sustainability, data and infrastructure sharing, industry-supported academic chairs, and ranking mechanisms for non-profit research organizations.

In his concluding remarks, the Moderator, Prof. T. Balasubramanian, emphasized that Corporate Social Responsibility (CSR) funding represents a significant opportunity for NERCI's future growth and encouraged greater engagement with industry partners. He reiterated the importance of collaboration, capacity building, and strategic alignment in strengthening NERCI's role in marine and coastal research.

Figure 5: Glimpses from the 25th anniversary celebrations of NERCI

NEWS

Training and capacity building

As part of the NERCI contributions to capacity building, regular training programmes were conducted in 2024. This included training for the School of Naval Oceanology and Meteorology members, students from the Institute of Climate Change, Amity University, Cochin University of Science and Technology, Kerala Agricultural University, Annamalai University and URSAMAJOR project stakeholders. The training at NERCI included basics of remote sensing and GIS, and water quality monitoring, air quality monitoring and modeling and social aspects of smart city developments.

Visit of Ambassador of Norway

HE May- Elin Stener, the Norwegian ambassador to India along with delegates from the Norwegian Embassy visited NERCI on 22 May, 2024. During HE visit, the Ambassador congratulated NERCI for its 25 years of contributions to science and society. The Ambassador was very much keen on strengthening the ongoing institutional collaborations between Norway and India and appreciated NERCI's sincere efforts in contributing to ocean science through student and scientist exchange between these two countries via fellowship programmes and joint projects funded by the Research council of Norway.

Visit of EU delegation

Mr Pierrick Fillon-Ashida, First Counsellor and Head, Research and Innvoation, EU Delegation to India of European Union led the delegation to NERCI on 2nd December 2024 with Dr. Vivek Dham, Advisor, Research and Innovation, European Union and

accompanied by delegates Mr. Apoorva Mahendru, Deputy Director and Head, DAAD German Academic exchange service; Dr. Nutan, Senior Innovation Advisor & Ms. Aleena Joseph, Innovation assistant, Consulate General of Kingdom of the Netherland; Dr. Indraneel Ghose; Senior Advisor-Research, education and innovation, Embassy of Switzerland; Ms. Leena Pishe Thomas, Director-Global Business Inroads. Their visit to NERCI was to see and understand NERCI's research expertise and to identify mutual areas of research and innovation for knowledge exchange as a first step to build a new network of cooperation. Mr. Pieric Fillion expressed his appreciation for NERCI for the successful implementation of projects under EU-FP7 programme (INDO-MARECLIM) and EU-Horizon 2020 programme with co-funding by Ministry of Earth Sciences, Govt of India- (COMFORT project and ObsSea4Clim project).

OUR RESEARCH STORIES

The first EU-H2020 project implemented by any Indian institution, COMFORT, came to an end in 2024. As part of the project work, aA research paper published from the project entitled 'Impact of marine debris on coral reef ecosystem of Palk Bay, Indian Ocean' was published in the journal Aquatic Conservation: Marine and Freshwater Ecosystems (DOI: 10.1002/aqc.4160). Excerpts from the paper are given below:

The principal objective of this study was to give a baseline status on the marine debris scenario in the Palk Bay coral reef system, its interaction with coral reefs and the efficacy of debris removal in coral reef management. The study provided an estimate

of the diversity and abundance of anthropogenic marine debris accumulated in the Palk Bay coral reef ecosystem. Marine debris actively interacted with coral colonies, resulting in reduced coral cover and low coral recruitment in the Palk Bay region. It is important to note that the debris interaction with the coral reefs and associated reef ecosystem degradation has significant socioeconomic implications, mainly by way of the direct impact on fisheries. Majority of the local coastal population in Palk Bay depends on fisheries for their sustenance and livelihoods (Menon et al., 2016). Reef degradation can significantly reduce fish stocks, and catch, in turn leading to instability in the economic status of fishing communities. Additionally, the coral reef degradation affects the aesthetic quality of the ecosystem, resulting in a loss of revenue from tourism activities. Reef locations from where debris materials were regularly removed showed improved live coral cover and high recruit density (fig. 6). It is also evident from the present study that manual removal of debris materials from the reef system, without disturbing the coral communities, could be adopted as a mitigation plan to allow the disturbed coral reef habitat to recover and recruit successfully. Addressing the continuous accumulation of debris in coral reef ecosystems with high tourist density like the Palk Bay requires well developed guidelines including continuous field surveys and monitoring programmes to estimate debris distribution and its variability along the region and assess debris interaction with vulnerable benthic ecosystems.

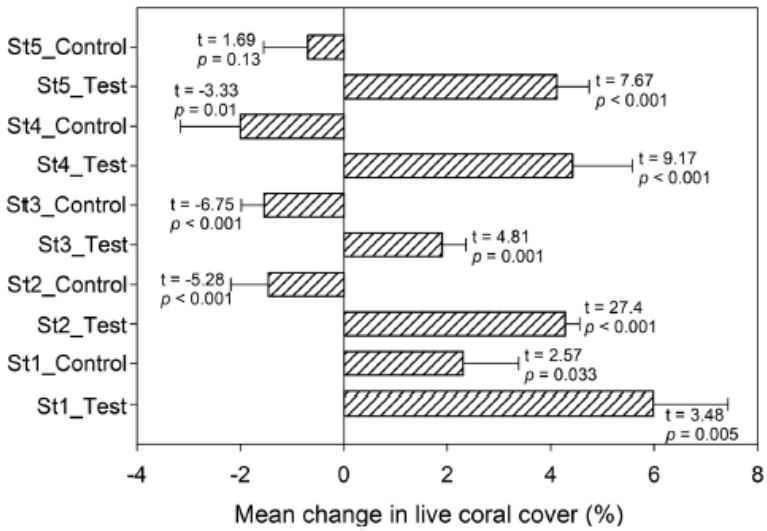

Figure 6: Mean change in live coral cover at the test and control reef locations of Palk Bay during the primary and follow-up survey.

The second EU -H2020 programme co funded by India in which NERCI is a partner started in February 2024. The project entitled " is coordinated by Dr. Steffen Olsen, Danish Meteorological Institute, Denmark and has 17 European and 2 Indian partners. Indian co-ordinators are Dr. Sourav Chatterjee, National Center for Polar and Ocean Research and Dr. K. Ajith Joseph, NERCI.

ObsSea4Clim is analyzing six ocean climate application areas (sea-ice loss, ocean transports, ocean stratification, sea level, ocean warming and marine heat waves, ocean mesoscale) in light of nations regional (European Sea, Atlantic, Arctic, Antarctic) implementation of multipurpose EOV/ECV based ocean observing suitable for climate products and indicators.

The key objectives of ObsSea4Clim are a) Develop ocean indicators, provide improved EOV/ECVs, b)Advance the use of EOV and ECV's for improved Earth System Models (ESM)and reduced uncertainty in projections, c)Create an interoperable data ecosystem serving multidisciplinary needs, d)Develop best practices and standards for interoperable in-situ and satellite observing, e)Set up an example for global coordination in ocean climate observation.

NERCI's role is to contribute to the use of Essential ocean variables and Essential climate variables for the Earth System models with reduced uncertainty in climate projections especially to study the characteristics of marine heatwaves in the North Sea and Barents sea of the Arctic region.

Oceansat-3 Cal-Val project is coordinated by ISRO-Space Application Centre, Ahmedabad and NERCI is a collaborating agency along with Regional Remote Sensing Center-East, Kolkata to calibrate and validate the bio geo physical products for two distinct and optically complex aquatic environments in India: the coastal waters off Kochi (south-eastern Arabian Sea) and the Hooghly estuary (northern Bay of Bengal).This project is lead by Dr. K. Ajith Joseph from NERCI and one Junior Research fellow is registered for Ph.D at KUFOS.

Inter comparison of Chl-a estimates derived from the Ocean and Land Colour

Instruments (OLCI) onboard Sentinel-3A satellite and OCM3 was done in an optically complex aquatic environment: the coastal waters off Kochi (south-eastern Arabian Sea). The data for this study were from OCM-3 L-3 Chl-a 8 day average and OLCI (Sentinel 3A & OC-CCI L-3) monthly chl-a data. Sentinel-3A and OCM-3 both showed moderate correlation (Fig.7 left panel) with in-situ Chl-a (R^2 = 0.50 with RMSE= 0.68), however they showed better correlation with lower Chl-a concentrations particularly in the offshore waters. Fig. 7 right panel shows the annual variation of Chl-a concentration in the Southeast Arabian Sea and northern Bay of Bengal where the Hooghly estuary enters into the bay region. From the figure it is observed that the chl-a concentration along the southeast Arabian sea is comparatively higher from August to September for the study period and it gradually decreases from October onwards until May, 2024.

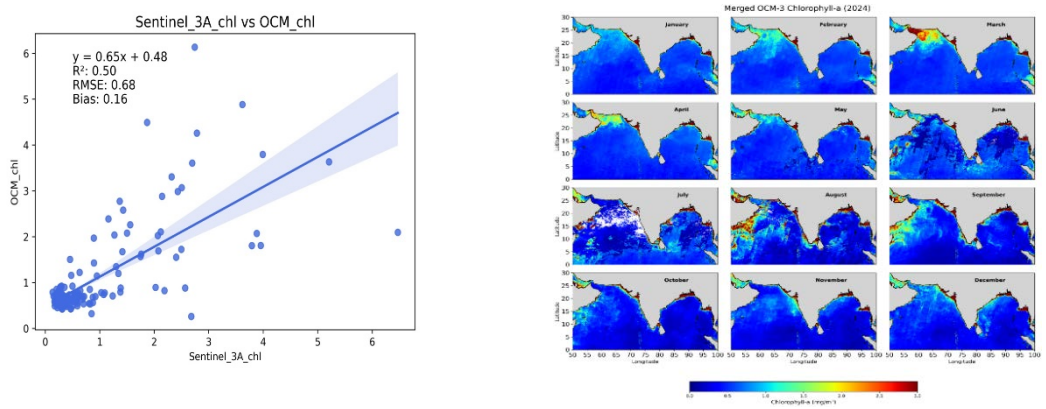

Figure 7(left) Regression between OCM-3 and OLCI data (Sentinel 3A) for the year 2024; (right) OCM3 Chl-a distribution in 2024 covering both the study regions

The project on 'A comparative assessment on the role of spatio-temporal variability of blue carbon dynamics in a seagrass driven and seagrass-coral reef connected ecosystem in mitigating climate change, funded by the Science and Engineering Research Board, India looked into the blue carbon dynamics of the fragile seagrass ecosystem using satellite data. The project also reported an unnoticed relationship between two tropical benthic communities; seagrasses and coral reefs in co-managing regional blue carbon, which was published in the Marine Pollution Bulletin "Assessment of coral reef connectivity in improved organic carbon storage of seagrass ecosystems in Palk Bay, India." (doi.org/10.1016/j.marpolbul.2024.116908).

This study investigated the influence of coral reef connectivity on seagrass ecosystem in the Palk Bay, and found significant advantage for seagrass meadows coexisting with coral reefs (SC), compared to the standalone seagrass meadows (SG) in sequestering and storing carbon. The advantages of seagrass-coral reef connectivity were assessed by studying the variability in seagrass biomass and sediment organic carbon concentration between SC and SG areas. SC areas displayed considerably higher above ground biomass (AGB), below ground biomass (BGB) and sediment organic carbon (SOC), compared to the SG areas.

While nutrient concentration did not differ significantly between the SC and SG areas, suspended sediment matter was significantly higher in the SG area. Wave action and wind associated resuspension of sediments largely influence suspended sediment load in an ecosystem. The combined action of seagrass-coral reef ecosystem can significantly trap suspended sediments, leading to reduced water column turbidity, improved light availability and high organic content for improved seagrass extent and root-shoot density of seagrass (Nobi and Dinesh Kumar, 2014). Within seagrass-coral reefs connected ecosystems, the benthic setup can significantly alter higher hydrodynamic energy, making the environment optimal for establishment and expansion of seagrass meadows (Gillis et al., 2014). Such improved environmental conditions from the coral reef -seagrass connectivity at SC area could have promoted increased AGB and BGB in seagrass at SC area. The findings highlight the importance of coral reefs in enhancing the blue carbon potential of seagrass ecosystems and underscore the need for integrated conservation and restoration strategies for coral reefs and seagrasses.

The PhD research work of Mr. Ullas M Pillai, guided by Dr. Ajith Joseph K from NERCI and Dr. Roshin Raj from NERSC and funded by the Nansen Scientific Society, on Sea level changes in the North Indian Ocean yielded remarkable results that got published in the Deep-Sea Research Part-II. Excerpts from the paper 'Enhanced eddy kinetic energy in the south-eastern Arabian Sea in winter: the influence of surface currents and wind force" (doi.org/10.1016/j. dsr2.2025.105537).

The study investigated the spatial and temporal characteristics of the eddy kinetic energy (EKE) in the SEAS (fig. 8), explained its generation mechanism using barotropic energy conversion, and examined the influence of the winter EKE on Chl-a distribution. While baroclinic instability dominates across all seasons, barotropic instability attains appreciable strength during winter, localized predominantly within the Laccadive Sea, where it substantially contributes to eddy generation. The barotropic instability was found to be driven by a pronounced negative wind stress curl over the southern tip of India, extending south-westward. This forcing was found to induce anticyclonic circulation and establish a recirculation pattern that facilitates the transfer of mean kinetic energy to EKE through barotropic energy conversion. The spatial correlation between EKE and BR substantiates this mechanism. Additionally, a moderate positive correlation was detected between wintertime EKE and surface chlorophyll-a concentration. Elevated Chl-a during winters with anomalously high EKE suggests that mesoscale eddies in the SEAS exert a significant influence on phytoplankton distribution, thereby enhancing biological productivity and potentially supporting regional fisheries.

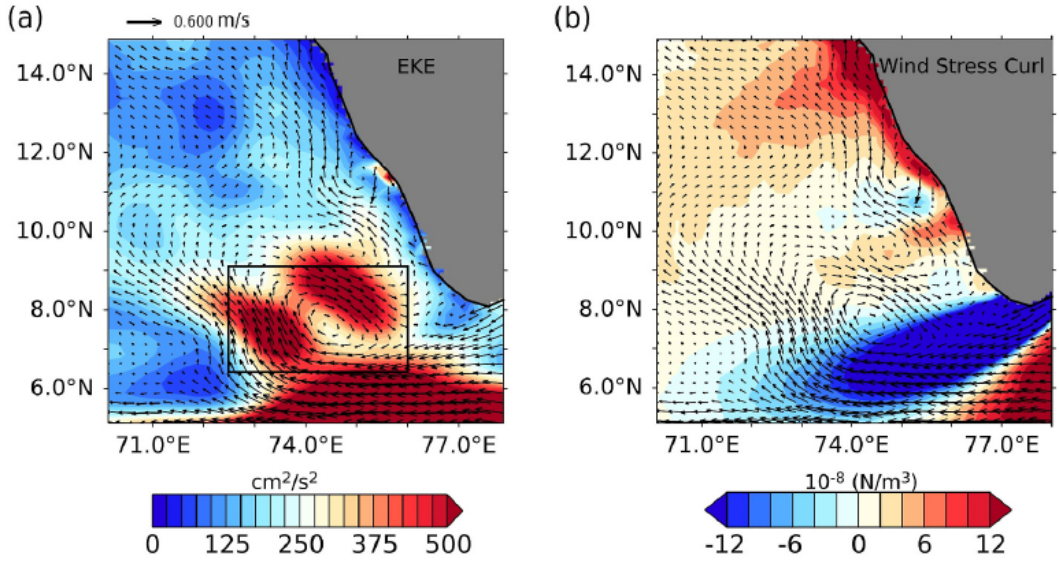

Figure 8: Winter climatological map of (a) EKE (region within the box represents the region of high EKE and circular motion of current), and (b) wind stress curl overlaid by the total current vectors.

MEMORANDA OF UNDERSTANDING

NERCI has functional MoUs with the following institutions:

- ICAR-Central Marine Fisheries Research Institute, Kochi, India
- Trevor Platt Science Foundation, India
- Kerala University of Fisheries and Ocean Studies, Kochi, India
- Plymouth Marine Laboratory (PML), UK
- Nansen Scientific Society, Bergen, Norway

LIST OF PUBLICATIONS

1. Kaliyath, Devika Raj, Anas Abdulaziz, Jasmin Chekidhenkuzhiyil, Abdul Jaleel Koovapurath Useph, and **Nandini Menon** N. 2024. "Unveiling the Faunal Diversity in the Water Column Adjacent to Two Seamounts in the Deep Arabian Sea Using Environmental DNA Metabarcoding." Journal of Marine Science and Engineering 12, no. 6 (2024): 971.
2. **Ranith RP**., Senthilnathan Lakshmanan, Machendiranathan Mayakrishnan, Grinson George, and **Nandini Menon** N. 2024. "Impact of marine debris on coral reef ecosystem of Palk Bay, Indian Ocean." Aquatic Conservation: Marine and Freshwater Ecosystems 34, no. 5 (2024): e4160.
3. **Ranith, R P, Nandini Menon**, N., Elavumkudi Paulose Nobi, Alexkirubakaran Augustin Raj, and Sigamani Sivaraj. 2024. "Assessment of coral reef connectivity in improved organic carbon storage of seagrass ecosystems in Palk Bay, India." Marine Pollution Bulletin 207 (2024): 116908.
4. **Ullas M Pillai, Ajith Joseph K**, Roshin P Raj, and Johannessen O M. 2024. Influence of Climatic Events on Sea Level Variability over the Bay of Bengal: Insights from EOF Representation. *Defense Science Journal.* (accepted).

CONFERENCE PROCEEDINGS

1. Ullas M Pillai, Ajith Joseph K, Roshin P Raj & Ola M Johannessen. (2024). Book of Abstracts. Influence of Climatic Events on Sea Level Variability over the Bay of Bengal. *National Symposium on Coastal Oceanographic Studies: Modeling & Observations An Underwater Domain Awareness Perspective (COSMOS 2024)*. held at IMA House, Kochi during 17-19 April 2024. 259p [Oral presentation]
2. Anand M Vijayan, Ajith Joseph, Ranith R. 2024. Book of Abstracts. A Comparison of In situ Chlorophyll data with OCM-3 Data MODIS data. *National Symposium on Coastal Oceanographic Studies: Modeling & Observations An Underwater Domain Awareness Perspective (COSMOS-2024)*, held at IMA House, Kochi during 17-19 April 2024. 161p [Oral presentation]
3. Anand M Vijayan, Ajith Joseph, Ranith R. and Lasse H. Pettersson, 2024. Book of Abstracts. A Comparison of in-situ CHLOROPHYLL DATA with GHRSST and MODIS data. GHRSST User' symposium and GHRSST Science team meeting, Ahmedabad.
4. Akash S, Ranith R, Ajith Joseph K, Annette Samuelsen, Grinson George and Nandini Menon N. 2024. Book of Abstracts. A Comparison of Dissolved Oxygen Simulations Using Regional Physical-Biogeochemical Models and Copernicus Marine Service Data Products. International Conference on Marine Sciences (MARICON-2024), held at School of Marine Sciences, Cochin University of Science and Technology, Kochi during 08-10 April 2024. 181p. ISBN: 978-81-922264-8-4.
5. Rakhi K Raj and Bindu G. 2024. Book of Abstracts. Identification of Air Pollution Hotspots in Kerala: A Decadal Analysis of Spatio-Temporal Variations in Ambient Air Pollution Levels. International Conference on Marine Sciences (MARICON-2024), held at School of Marine Sciences, Cochin University of Science and Technology, Kochi during 08-10 April 2024.
6. Rithin Raj M, Ranith R, Nancey Terrance, Mohammed Siyad P V, Anas Abdulaziz, Grinson George, Shubha Sathyendranath and Nandini Menon N. 2024. Book of

Abstracts. Water Quality Estimation of Beaches in Kochi, South West Coast of India Using Changes in Phytoplankton Community Structure. International Conference on Marine Sciences (MARICON-2024), held at School of Marine Sciences, Cochin University of Science and Technology, Kochi during 08-10 April 2024.

TECHNICAL REPORTS

1. Farzana Haris, Hemand A., Ibrahim Bathis K., Kiruthika N., LayanaVijayan, Ranith R, Sarath Kumar D., Swathy Krishna M. C. Lasse H. Pettersson, Victoria Miles and Ajith Joseph K., 2024. Assessing Urban Air Quality: A Comparative Study of Pollutant Trends in Delhi and Kochi (2019-2023). URSA MAJOR HACKATHON, Cherai, Kochi. NERCI Technical report no.1/2024. 56pp
2. Ajaya Indrani, Anagha Satheesan K., Anjaly P. S., Bindu G., Igor Esau, Jayanarayanan Kuttippurath, Madhuraj P. K., Peediyakkathodi Sajna, Pravin Punde, Prince Vijay, Rakhi K. Raj, Sneha K. S., Sruthy Robert, Vishnu N. G. and Lasse H. Pettersson, 2024. Assessing Urban Growth and Its Impacts on Surface Urban Heat Island in Kochi City, Kerala. URSA MAJOR HACKATHON, Cherai, Kochi., NERCI Technical report no.2/2024. 52pp
3. Abhinand S., Anusha Roy, Alenka Temeljotov-Salaj, Bintang Noor, Sobah Petersen, Hafin P. K., Lalitha Shanmugasundaram. Lasse H. Pettersson, 2024. Barriers to SMART City Development: Cochin Scenario. URSA MAJOR HACKATHON, Cherai, Kochi., NERCI Technical report no.3/2024.48pp
4. Bindu. G, Chandu P J, Jaishnu J Nair. , Ajith Joseph, K. and 2025. PAS 2060:2024: Demonstration of carbon neutrality submitted to The Peria Karamalai Tea and Produce Company Limited (PKT) Valparai, Tamil Nadu, India. NERCI Technical report no.4/2024. 38pp.

THESIS CONTRIBUTIONS IN 2024

1. Sandra Bhasi.2024. Influence of extreme climate events in modulating Ekman transport along North Kerala coast during upwelling months. College of Climate change and Environmental Science, Kerala Agriculture University, Trichur. Supervisor-Dr.K.Ajith Joseph
2. Abhishek Mohan. 2024. Assessment of the influence of environmental vulnerability in the incidence of waterborne diseases along the banks of Vembanad lake. College of Climate change and Environmental Science, Kerala Agriculture University, Trichur. Supervisor-Dr. Nandini Menon N
3. Vishwa V Komath. 2024. Harmful Algal Bloom in the Kerala Coast: A spatiotemporal study. AMITY institute of Geoinformatics and Remote Sensing, Amity University, Noida, Uttar Pradesh. Supervisor – Dr. Ranith R
4. Arya U Wilson. 2024. Urban Sprawl and its impact on Vembanad lake. College of Climate change and Environmental Science, Kerala Agriculture University, Trichur. Supervisor-Dr. Ranith R
5. Vishnu Sharan K R .2024.Temporal Analysis of Land Surface Temperature and Urban Heat Island Effect in Kochi and Fairbanks: A Comparative Study (2000-2023) :, College of Climate Change and Environmental Science, Kerala Agricultural University, mannuthy. Supervisor-Dr. Bindu G.
6. Devika M R, Sona S Kumar, Parvathi VM, Anjaly P S, Sneha K S, Devika P Dayanand, 2024. Living with Urban Heat: A Study of Local Climate Zones, Thermal Comfort, and Social Responses in Koch MSc Environmental Sciences, Christ College, Irinjalakuda. Supervisor-Dr. Bindu G.

ONGOING RESEARCH PROJECTS - NERCI

1. COMFORT project - EU HORIZON 2020 project funded by Ministry of Earth Sciences. Indian co-ordinator: Dr. Nandini Menon N (2020-2024).
2. Ocean Observations and Indicators for Climate And Assessments

(ObsSea4Clim) project funded by Ministry of Earth Sciences. Indian co-ordinator: Dr. Ajith Joseph K (2024-2028).

3. NANO-DOAP (Global project on deoxygenation, acidification and primary production) project funded by NF-POGO. Indian co-ordinator: Dr. Nandini Menon N (2018 – till date).

4. Oceansat-3 Calibration-Validation Project. Funded by ISRO Space Application Centre. Principal Investigator: Dr. Ajith Joseph K (2022-2025)

5. URban Sustainability in Action Multi-disciplinary Approach through Jointly Organized Research Schools (URSA MAJOR) (https://www. ursamajor-nerci.in). Funded by Research Council of Norway. Indian co-ordinators: Dr. Ajith Joseph K and Dr. Bindu G (2021-2024).

6. Validation of 3D-printed Mini Secchi Disc (3DMSD) for environmental pollution monitoring using in-situ measurements and remote sensing. Funded

7. by DST-Women Scientist Scheme, Principal Investigator: Dr. Jasmin C under the mentorship of Dr. Nandini Menon N (2021-2024).

8. Waterborne Infectious Diseases and Global Earth Observation in the Near shore (WIDGEON). Funded by European Space Agency. Indian co-ordinator: Dr. Nandini Menon N (2021-2024).

9. Water-Associated infectious Diseases in India: digital Management tools (WADIM). Funded by Welcome Trust. Indian co-ordinator: Dr. Nandini Menon N (2023-2028).

10. Climate change impact on the marine coastal ecosystem of Kerala.(C3e Kerala). Funded by Research council of Norway. Indian co-ordinator: Dr.Nandini Menon N (2023-2028).

11. Engaging researchers and coastal population in communicating Ocean's role on Human Health (ENRICH) project funded by Research council of Norway. Indian co-ordinator: Dr. Ranith Raj (2024-2026).

Projects supported by the Industry

12. Validation of Achieving Carbon Neutrality for Rossell Tea Estates, Assam. Funded by Rossell Tea Estates (Division of Rossell India Limited). Investigator: Dr. Bindu.G (2024).

13. Validation of Achieving Carbon Neutrality for Peria Karamalai Tea Plantations, Valparai,Tamil Nadu. Funded by The Peria Karamalai Tea & amp; Produce Co. Ltd. Investigator: Dr. Bindu. G (2024).