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Book of Abstracts

Two-day Seminar on

Mitigating Climate Change Impact on Marine Ecosystems: An Integrated Approach of Science, Community and Nature

5-6 August 2025
At ICAR-CMFRI, Kochi

Institute of Social Sciences, New Delhi

and

ICAR-Central Marine Fisheries Research Institute, Kochi

Collaborative Research sponsored by ICSSR

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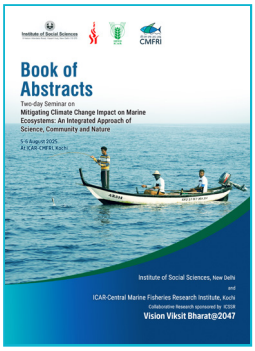

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FOREWORD

It is with great pride and anticipation that I present this volume of abstracts for the National Seminar on "Mitigating Climate Change Impact on Marine Ecosystems: An Integrated Approach of Science, Community, and Nature", jointly organized by the Institute for Social Sciences, New Delhi, and the ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi, under the national vision framework of *Viksit Bharat@2047*.

This seminar brings together a diverse group of scientists, young researchers and policymakers, to deliberate on collaborative and sustainable approaches to address the pressing challenges posed by climate change on marine ecosystems. The impact of climate change on marine ecosystems is no longer a distant threat but a present reality, especially for coastal and island communities whose livelihoods are intimately tied to the health of the oceans. Besides, for the sustenance and development of social and economic activities and the national revenue opportunities, the climate change becomes a serious challenge.

The collaboration between the Institute for Social Sciences and ICAR-CMFRI reflects a growing recognition of the fact that complex environmental problems require interdisciplinary thinking and inter-institutional cooperation, followed by policy recommendations. This seminar exemplifies that spirit, providing a platform for sharing research insights, traditional wisdom, policy perspectives, and practical solutions rooted in both science and social outreach.

The Union Territory of Lakshadweep (UTL) islands and other ecologically sensitive coastal zones in the country stand as stark reminders of the urgent need for integrated, locally adapted responses to the challenges posed by rising sea levels, warming oceans, shifting marine dynamics and social inertia. The abstracts in this compilation explore these issues through multiple lenses of scientific innovation, community resilience, and nature-based solutions underscoring the need for inclusive and adaptive strategies.

I am confident that this volume will not only serve as a repository of current thought and inquiry but also inspire new collaborations that bridge the gap between research and real-world impact. My sincere thanks to all the contributors, organizers, and institutions whose collective efforts have made this seminar a landmark event in our ongoing journey towards studying a climate-resilient marine future of the UTL.

Grinson George
Director, ICAR-CMFRI

CONTENTS

Climate-driven migration of Oil Sardine (*Sardinella longiceps*) in the Indian Ocean

Rose P. Bright, Sreenath K. R, Eldho Varghese*, Ratheesh Kumar R, J. Jayasankar and Grinson George

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The Indian oil sardine (*Sardinella longiceps*) is a key small pelagic species in the Indian Ocean, playing a vital role in coastal livelihoods and regional food security. However, climate change is altering the oceanographic conditions critical to its survival. This study applied machine learning-based Species Distribution Models (SDMs), with the MaxEnt algorithm identified as the most effective tool for mapping current habitats and forecasting future distribution shifts. Presence data were gathered from field surveys, scientific literature, and open-access repositories. Environmental predictors included variables such as sea surface temperature, primary productivity, salinity, dissolved oxygen, pH, bathymetry, mixed layer depth, and ocean currents. The models performed robustly (AUC > 0.9) with primary productivity emerging as the dominant driver of sardine distribution. Projections under three CMIP6 climate scenarios (SSP1-2.6, SSP2-4.5, and SSP5-8.5) consistently indicated a potential northward shift in habitat suitability. Notably, habitat loss is projected along the Indian coastline, while potential habitat gains are predicted near the Somali coast. This study also made an initial attempt to estimate the latitudinal rate of habitat shift for oil sardine under future climate conditions. These findings highlight the species vulnerability to climate change, with potential shifts in fishing grounds likely to cause socioeconomic disruptions.

Keywords

Climate change, Future projections, MaxEnt, Marine fisheries, Species distribution models

TS-1-002

The impact of temperature variations on the survival and naupliar production in calanoid copepods in the possible climate change scenario

Muhammed Anzeer F*, Aneesh K.S, Dispindas Y, Akhil A.R, Ajimi J.S, Muhammed Arshaduddin, Athira S, Santhosh B, Ambarish P. Gop, Anuraj A, Surya S, Krishna Sukumaran, Rathi Bhuvaneswari G, Boby Ignatius, Suresh V.V.R, Dineshbabu A. P and Grinson George

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Anthropogenic activities have resulted in increased atmospheric greenhouse gases, leading to global warming. As a consequence, sea surface temperatures are predicted to rise by 2-4°C by 2100. This will have a significant impact on the marine ecosystem. Copepods form a key component of the marine food web and are highly sensitive to temperature variations, making them a valuable bioindicator of climate change impacts. Calanoid copepods and their larval forms are pelagic and are more vulnerable to changes in the sea surface temperature. The present study evaluates the abrupt temperature tolerance and naupliar production in three species of marine calanoid copepods: *Acartia southwelli, Parvocalanus crassirostris,* and *Temora turbinata.* The copepods used for the study were collected and isolated from the Vizhinjam offshore area, and stock cultures were maintained as monocultures at the Vizhinjam Regional Centre of ICAR-CMFRI at a temperature of 28±0.5 °C. A total of 10 newly moulted adult copepods from each species were stocked in 125 ml sample containers with 100 ml filtered (one-micron) seawater. The containers were maintained in incubators with designated temperatures of 24, 27, 30, and 33 ^{o}C. During the trials, copepods were fed with an equal mixture of microalgae, *Chlorella marina, Isochrysis galbana, Pavlova lutheri, Nannochloropsis oculata, N. salina,* and *Dicrateria* sp. at a density of ~30000 cells/mL.

In the experimental containers, the salinity was maintained at 34-35 ppt, the pH was 7.9-8.1, the dissolved oxygen (DO) level was 4.04-5.25 mg/L, and ammonia was always kept below 0.02 ppm. After 48 h, the adult survival and naupliar production were assessed. The data were subjected to ANOVA after being transformed using the square root transformation to stabilize the error variance and ensure the normality of the data. Multiple range comparison was performed using Tukey's Honest Significant Difference test (Tukey's HSD) to assess the pair-wise significance among the treatments using PROC GLM of SAS 9.4.

Results indicated that the copepods, *A. southwelli, P. crassirostris,* and *T. turbinata* were able to tolerate all the temperatures tested in the present experimental conditions. However, at 24, 27, and 33°C, the naupliar production in *A. southwelli* was significantly lower compared to that of naupliar production at 30°C. Meanwhile, in *P. crassirostris,* the naupliar production was significantly low at 33°C, among other temperatures. In *T. turbinata,* the highest naupliar production was observed at 27°C, and other temperatures, naupliar production was significantly lower. Results indicated that all three species were able to tolerate the tested temperatures; however, their naupliar production was significantly reduced at higher temperatures, suggesting a potential threat to calanoid copepod production due to global warming. The results indicated the possible vulnerability in the productivity of the species to variations in their ambient temperatures. The results also emphasize the potential of calanoid copepods in predicting the impacts of climate change on the marine food web.

Keywords

Copepod productivity, Marine ecosystem, Ocean warming, Temperature tolerance

TS-1-003

Decadal thermal variability and coral bleaching risk in Lakshadweep: Insights from SST and DHW indicators

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The Lakshadweep Islands in the southeastern Arabian Sea host ecologically significant coral reef ecosystems that are increasingly vulnerable to thermal stress induced by ocean warming. The present study examined decadal trends in Sea Surface Temperature maxima (SST_{max}) and Degree Heating Weeks (DHW) from 2000 to 2020 to understand the coral bleaching risk and thermal stress dynamics in the region. DHW, a cumulative metric of temperature anomalies above the climatological threshold, is widely used to assess coral stress, with values exceeding 4 °C-weeks signifying a high risk of bleaching. Hence we categorised the DHW into DHW 0-1 °C, 1-4 °C and >4 °C to understand the frequency of occurrence of these thresholds in the region. Analysis revealed that SST_{max} exceeded the bleaching threshold in 15 of the 21 years examined, particularly during 2001–2007, 2010, and 2014–2020. Though the two decadal periods was characterised with DHW 0-1 °C and 1-4 °C with significant variation in the frequency of occurrence ($p<0.001$), DHW >4 °C was observed exclusively during 2010-2020. Furthermore, only the years 2010 and 2016 recorded DHW values above the bleaching threshold 6.72 °C-weeks and 5.2 °C-weeks, respectively coinciding with major bleaching episodes in the region. These extreme years were associated with SST maxima ≥31.5 °C, indicating a critical thermal tipping point beyond which DHW values begin to rise. The decade 2000–2010 experienced more frequent but generally lower-intensity thermal stress events, whereas 2010–2020 was marked by fewer but more extreme episodes.

Keyword

Coral bleaching, Degree heating weeks (DHW), Sea surface temperature (SST), Thermal stress

TS-1-004

Projections of temperature and precipitation under different SSP scenarios over the coastal districts of India

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India's coastal districts, which support dense populations and climate-sensitive sectors such as fisheries, are increasingly vulnerable to the impacts of climate change. This study evaluates long-term temporal trends in temperature and precipitation across these districts using projections from the MIROC6 global climate model under four Shared Socioeconomic Pathways (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). Historical climate data (1979–2000) was compared with future periods (2021–2100) divided into four time slices: 2021–2040, 2041–2060, 2061–2080, and 2081–2100. The results revealed a clear and consistent increase in annual average temperature (Tavg) across all future scenarios, with the most rapid warming under SSP5-8.5. By the end of the century (2081–2100), Tavg projections increased by over 3°C compared to the baseline in high-emission scenarios. This rise was gradual from 2021 onwards, showing a near-linear trend with seasonal structure preserved coolest in January and warmest in May, though each subsequent period reflected higher temperatures. Precipitation (Prec) projections also showed significant upward trends, especially from 2061 onward. Under SSP3-7.0 and SSP5-8.5, coastal districts exhibited sharp increase in rainfall, particularly during the post-monsoon months of September and October. These increases may intensify flood risks, disrupt fishing and aquaculture activities, and challenge coastal infrastructure resilience. Climate risk assessments at national and state levels were derived from these temporal trends, highlighting the regions and periods of highest vulnerability. The study concluded with tailored Resilience Planning Recommendations focusing on early warning systems, climate-resilient infrastructure, and adaptive livelihood strategies. This work underscored the urgency for data-driven, region-specific adaptation planning to safeguard India's coastal communities. By mapping the plausible climate scenarios, the study provided a scientific foundation for enhancing climate resilience and sustainability along India's coastlines.

Keyword

Climate risk assessments, Coastal resilience, Shared socioeconomic pathways (SSPs), Vulnerability

TS-1-005

Climate Oscillations and Cyanobacterial proliferation: The case of *Trichodesmium erythraeum* in the coastal waters of Kochi, south west coast of India

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Trichodesmium erythraeum (*TE*), an autotrophic filamentous cyanobacteria prevalent in tropical and subtropical waters has a vital role in ocean biogeochemistry, as a major contributor to the biological nitrogen fixation. Their competitive advantage in thriving in the warmer, nutrient-depleted waters makes them an efficient bio indicator of the ocean-atmospheric anomalies, such as El Niño Southern Oscillation (ENSO). The present study elucidated the proliferation of *TE* in the coastal waters of Kochi across two distinct phases of the ENSO, the Moderate La Niña phase and the subsequent transition phase of La Niña to El Niño. As *TE* are known to proliferate during pre-monsoon periods (February- May), the water quality and phytoplankton abundance of the coastal waters of Kochi during the year 2021(Moderate La Niña) and 2023 (Transition phase from La Niña to Strong El Niño) was assessed. The study revealed a marked shift in phytoplankton community structure corresponding to changes in the water quality concurrent to the ENSO phases. Surface water was relatively warmer (av. 31.7 °C) and nitrate-limited (av. 0.03 mg/L) during the transition phase while it was cooler (av. 30.5°C) and nitrate (av. 0.93 mg/L) rich during the La Niña phase. These changes in the water quality favored the proliferation of *TE* from 39400 ±53374 to 177766± 184790 cells/liter from 2021 to 2023. The phytoplankton community structure also showed an evident change with a decline in the contribution of diatoms and dinoflagellates from 32% and 36 % respectively during 2021 to 12% and 11 %, respectively in 2023, while the *TE* contribution increased from 32% to 77% respectively. The output of the study indicates that warming associated with the climate patterns can elicit changes in the marine food web and productivity of the coastal waters through a shift in the phytoplankton community structure, which forms the base of the pelagic food web.

Keywords

Climate phenomena, ENSO, Phytoplankton, *Trichodesmium erythraeum*

TS-1-006

Study to assess the impact of higher temperature on seaweeds, *Ulva lactuca* and *Kappaphycus alvarezii*

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Ulva lactuca is an economically important native edible green seaweed which is distributed along the coastal areas of south Tamil Nadu. It has been gaining significant interest due to its potential for use in animal feed, human food, medicinal value, bioactive compounds, biofuel and also in wastewater bioremediation. *Kappaphycus alvarezii*, also known as elkhorn sea moss, is a red macroalgae native to the Indo-Pacific region, known for its commercial value in producing carrageenan and polysaccharide used in various industries. The present study was carried out assess the impacts of higher temperatures on these two seaweed species. Seaweeds were grown in two sets of FRP tanks of 300 L capacity with sea water of 35 ppt salinity. In the treatment group, water temperature was raised to 30 ^{0} C using thermostat controlled submersible heaters and in the control group ambient temperature (28 ^{0} C) was maintained. The seaweeds maintained at normal temperature (28^{0}C) showed better growth performance than the group maintained at higher temperature (30^{0}C). Spore formation of *Ulva lactuca* was observed only at 28^{0}C but not at 30^{0}C. The thallus structure of *Ulva lactuca* was shrunken in treatment (30^{0}C) whereas thallus structure was normal in control (28^{0}C). The present study indicates that, higher temperature has an adverse impact on growth and spore formation of the seaweed Ulva lactuca and *Kappaphycus alvarezii*. Further research is needed to assess the specific impacts of higher temperatures on different seaweed species found in Mandapam and to identify potential strategies for mitigating the negative effects of warming on these valuable marine resources.

Keywords

Assess the growth, Green seaweed, Red seaweed, Spore formation

TS-1-007

Effect of water temperature on spawning performance and larval rearing of commercially important marine finfishes

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The present study was aimed to assess the impact of water temperature on the gonadal development, spawning and larval rearing of three commercially important finfish species such as orange spotted grouper, *Epinephelus coioides*, Indian pompano, *Trachinotus mookalee* and John's snapper, *Lutjanus johnii*. The data collected during the previous five years showed that the Orange spotted grouper spawning performance was significantly higher at a temperature range of 26-30°C (10 spawning events/month) compared to 30-32°C (5 spawning events/month). Similarly the Indian pompano spawning performance was found to be significantly higher at a temperature range of 26-30 °C (7 spawning events/month) compared to 30-32° C (4 spawning events/month). These two species, Indian pompano and orange spotted grouper were found to spawn at 26-27 °C, which was found to be lowest water temperature at the experimental place. However, John's snapper did not matured at less than 27°C. Even the performing female's gonad regressed to stage I, when the water temperature became less than 27°C. However, the same female recouped gonadal development at above 27°C. John's snapper spawning performance was found to be significantly higher at temperature range of 27-30°C compared to 30-32°C. The result inferred that the spawning behaviour of the cultivable marine finfish is significantly impacted by the higher or lower temperature. The larval rearing of marine finfish can be divided into two phase as per the temperature requirement for their optimum development. The first phase is during the initial larval rearing period i.e. day post hatch (DPH) 0-10°C and second phase i.e. after 10 DPH. The larval survival as well as growth during the initial phase was found to be significantly higher at a temperature range of 27-30°C compared to 30-32°C and 24-27°C. However, the larval survival as well growth during the second phase was found to be significantly higher at a temperature range of 27-32°C compared to 24-27° C. A mass mortality was observed during the metamorphosis, if the water temperature remains lower than 27°C. The result of the present study indicates that the water temperature impact the finfish gonadal development, spawning performance and larval rearing the fish as well as their developmental stages.

Keywords

Finfish brood stock, Larval rearing, Temperature

Impact of higher temperature on egg and larvae of silver pompano, *Trachinotus blochii*

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The Silver pompano, *Trachinotus blochii* is a promising candidate species for mariculture owing to its wide salinity tolerance, acceptance of artificial feed, good growth rate, market demand and also availability of hatchery seed production technologies. Few studies have been conducted to assess the resilience of this species to climate change scenarios. Under this context a study was undertaken to assess the impact of higher temperature on the fertilized eggs and larvae of this species. Fertilized eggs of sliver pompano obtained from spawning were maintained at two temperatures, viz; 28^{0}C (same as that of spawning tank, which served as the control) and at a higher temperature (30^{0}C which served as the treatment). Embryonic development was recorded by taking photo of the eggs at every 30 min intervals from both the groups. The hatching percentage in both the groups was assessed by counting the number of unhatched eggs. After hatching was completed, the larvae were further reared in separate tanks at the same temperatures (control and treatment) where hatching happened. In the treatment tanks (at higher temperature) number of unhatched eggs were 18% higher than the control tank, which indicates that hatchability might have been affected due to high temperature. On further rearing of the larvae in the two sets of tanks, it was observed that after one week of rearing, complete larval mortality was observed in the treatment group, perhaps due to the impact of higher temperature on yolk absorption/utilization by the larvae. The present study indicates that, higher temperature has an adverse impact on the embryonic development, hatching and larval survival of silver pompano.

Keywords

Climate change, Larval survival, Silver pompano

TS-1-009

Spatio-temporal pattern of Ovalbone cuttlefish (*Sepia elliptica*) abundance and oceanographic determinants- a case study using trawl fishery and satellite data along Maharashtra coast, India

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The Ovalbone cuttlefish (*Sepia elliptica*) is one of the important species supporting the cephalopod fishery along Maharashtra coast. The distribution and abundance of the Ovalbone cuttlefish are influenced by dynamic oceanographic conditions, making it imperative to understand their spatio-temporal patterns for sustainable fishery management. This study integrates fishery-dependent data from trawl fishery with satellite-derived oceanographic parameters to investigate the environmental drivers that determine S. elliptica distribution along the Maharashtra coast, India. Oceanographic environment parameters such as Sea Surface Temperature (SST), Chlorophyll-a concentration (CHL), Sea Surface Height (SSH), Sea Surface Salinity (SSS), Mixed Layer Depth (MLD), and Ocean Currents (OC) were derived from MODIS and Copernicus Marine Environment Monitoring Service (CMEMS). The GAM model results reveal ovalbone cuttlefish abundance was significantly related to latitude, longitude and Sea Surface Temperature (SST). The high abundances of Ovalbone Cuttlefish along Maharashtra coast were located between 15^0 and 19.42^0 N latitude and 71.18^0 to 73.20^0 E longitudes, SSTs of between 28^0C and 29.5^0C. Monthly maps of ovalbone cuttlefish abundance with background of SST were created to visualize changes in abundance in relation to the changes in SST. The temporal patterns of ovalbone cuttlefish abundance depicted through monthly abundance in trawl landing along Maharashtra coast.

Keywords

Ovalbone cuttlefish, SST, Trawl fishery

TS-1-010

Study to assess the impact of higher temperature on seaweed *Gracilaria corticata*

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Gracilaria corticata, red seaweed, is important for its diverse applications. It's a source of agar, a valuable ingredient in food and biotechnology. Additionally, it exhibits antioxidant and cytotoxic properties, potentially making it useful in natural antitumor studies. It also serves as a source of essential nutrients and minerals for human consumption. *G. corticata* is cultivated in different coastal regions and can be grown using various methods, including raft and long-line cultivation. It's known to be relatively tolerant to environmental fluctuations, which makes it suitable for commercial production in many areas. The present study was carried out assess the impacts of higher temperatures on seaweed *Gracilaria corticata*. Seaweeds were grown in two sets of acrylic tanks of 120 L capacity with sea water of 35 ppt salinity. In the treatment group, water temperature was raised to 32 ^{0}C using thermostat controlled submersible heaters and in the control group ambient temperature (30 ^{0} C) was maintained. growth and spore formation were studied. After 60 days, seaweeds maintained at normal temperature (30^{0}C) showed better growth than the group maintained at higher temperature (32^{0}C) where 50% of seaweeds were bleached. Spore formation was observed only at 30^{0}C but not at 32^{0}C. The present study indicates that, higher temperature has an adverse impact on growth and spore formation of the seaweed *Gracilaria corticata*.

Keywords

Growth assessment, Higher temperature, Red seaweed, Spore formation

TS-1-011

Signs and signals from coastal marine sentinels due to climate change: Observations from Tamil Nadu and Andhra Pradesh coasts

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Marine fisheries in Tamil Nadu and Andhra Pradesh have been the backbone of seafood production from the Bay of Bengal for the past few decades, significantly contributing to the country's economy. Artisanal and traditional fishermen immediate the majority of the fishing communities on this coastline, which encompasses numerous small ecosystems and habitats: river, discharges and estuaries. Studies and observations conducted over the past two decades in these areas have revealed the state of sentinels of the near-shore and immediate coastal ecosystems under stress. These ecosystems are impacted differently, affecting the livelihoods of thousands of people. Key resources that indicate stress include bivalves such as clams, green mussels, and oysters, decapods such as portunids and shore crabs, littoral sea weeds, mullets, whiting's, lesser sardines, snads, flatheads, hairfin catfish, sciaenids, groupers, perches, milkfish, Indian salmon, tiger and Indian white shrimp, eels and mud crabs. The increasing occurrences of flash floods, unusual rains and tsunamis, unusual exposure hours with higher light intensities, and variable monsoon patterns have unsettled the recruitment and establishment rates of most of these aforementioned resources, particularly the delicate larval settlements in molluscs and crustaceans. These settlementsare again dependent on highly volatile and dynamic phytoplankton and zooplankton diversity and abundance, which are essential for efficient conversions to post-larvae or seeds. The presence of marine fauna in interior estuarine and coastal water bodies indicated the feasible transplanting of seeds, probably post-tsunami. However, flash floods, untimely river runoff, and the opening of bar mouths have resulted in excessive green mussel and mud crab fisheries, as well as mullet fisheries. Overall, the sentinels of sediment and bottom living resources are highly disturbed. They find less space in increasingly shallow creeks and coastal water bodies, and the increasing temperatures there lead to hypoxia and mass mortalities. Variable plankton distribution has impacted the synchronous larval recruitment in larger groups in the area. The reducing depth in near-shore areas and water bodies has increased sediment loading, with carbon and other earth materials, stressing the bottom sediment engineering and forming more oxygen-depleted zones. Juveniles of pelagic shads, mullets, and lesser sardines get trapped in these zones and wash ashore or die en masse due to suffocation. The habitats of mussels and clams are invaded by black mussels and barnacles. Sea weeds and littoral colonial organisms are repeatedly bleached and killed annually at their highest exposure times coinciding with extreme solar radiations. The increasing intensity of coastal fishing and massive changes affecting the dynamics and abundance of these ecosystems threaten the survival of many of these true sentinels of each habitat, impacting the livelihoods of the fisher community.

Keywords

Artisanal fishermen, Biodiversity conservation, Environmental stress, Population recovery, Sustainable fisheries

Effects of salinity on the growth, physiological and biochemical components of microalga *Tetraselmis* sp.

Rathi Bhuvaneswari G[1]*, Ambarish Gop [1], Krishna Sukumaran [1], Anuraj A[1], Amal Vasu[1], Sharanya M.P[1], Muhammed Anzeer F[1], Aneesh K[1], Dispin Das[1], Dinesh Babu[2], Santhosh B[1] and Grinson George[2]

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Global ocean salinity patterns are changing due to climate change, which impacts microalgae, a crucial compartment of marine ecosystems. Changes in salinity can impact the physiology and growth of microalgae. The possible effects of these changes on marine microalgae, however, have not received much attention and are still little understood. Therefore, it is imperative to investigate and comprehend the impacts that various climatic shifts have on the growth of marine microalgae. In this study, changes in growth, physiological and biochemical indices such as cell density, photosynthetic pigments Chl a, carotenoid content, protein of *Tetraselmis* sp under different salinity treatments (20, 25, 30, 35 and 40 ‰) were analysed. The experiment was carried out in batch culture mode for a period of 10 days. The results showed that the highest cell density was observed at a salinity of 30‰ with the highest specific growth rate. Significantly lower specific growth rate was observed at 20‰ with the corresponding higher doubling time. The lowest photosynthetic pigment Chl a and carotenoid content was observed at a salinity of 35‰ where the highest content was observed at 30 and 20‰. These results indicated that 30‰ salinity was more conducive to *Tetraselmis* sp reproduction and growth. Increased pigment content with low cell density reveals the increased photosynthetic activity of microalgae by significantly increasing Chl a and carotenoid content in response to salt stress. This study provides new information for understanding the salinity adaptation strategies of *Tetraselmis* sp and has practical significance for its development and utilization.

Keywords

Climate change, Growth, Microalga, Pigment, Salinity

TS-1-013

Climate impact on small pelagic fish stocks in southeastern Arabian Sea: biomass dynamics modelling with environmental variables in multispecies multigear fisheries

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Climate change is likely to alter the natural environmental conditions of marine ecosystems, resulting in significant impact on the abundance of fish in coastal waters. The southwest coast of India, encompassing southeastern Arabian Sea, is one of the most significant regions for marine fish production along the coast of India, due to its high productivity. A large number of upwelling zones, associated with the southwest monsoon increase productivity which supports significant pelagic fisheries in this region. The impact of changes in various environmental variables on the stock biomass and fishery of small pelagics in southeastern Arabian Sea are not well studied except for some studies on the Indian oil sardine. There are many other small pelagic resources which significantly contribute to the pelagic fishery of the region. Hence, in the present study, an attempt was made to find out the relationship between lagged terms of environmental variables and the biomass of selected small pelagic fishery resources namely, Indian mackerel, scads and *Stolephorus* sp. in southeastern Arabian Sea. The study used a modified version of Biomass Dynamic Models to investigate relationships between environmental variables and the biomass to predict future changes in their stock biomass and landings under various SSP scenarios. For modelling, the time-series data on species/resource wise, gear-wise annual landings and fishing effort for the harvest of these resources for the period 1995-2019 were used, along with the environmental variables time series data. The environmental variables incorporated in the model were sea surface temperature (SST) and precipitation (PPT). The SST for the period 1993-2019 at a resolution of 0.25^0 X 0.25^0 were downloaded from 1/4 degree daily Optimum Interpolation Sea Surface Temperature (OISST) dataset, from NOAA-NCEI and data on PPT for the period 2000-2019 from Global Precipitation Measurement (GPM) products (GPM IMERG Final Precipitation L3 Half Hourly 0.1^0 X 0.1^0- V06). The impact of variations in these climatic parameters resulted in increase in the biomass of these fishery resources along the southwest coast of India. The results indicate that about 13.44% of

the annual additions to Indian mackerel stock biomass in the southeastern Arabian Sea is contributed by variations in sea surface temperature and only 1.32% increment in biomass due to the effect of precipitation. The impact of SST on the biomass increments of scads and *Stolephorus* sp. were very low with 0.014 and 0.30% respectively. The predicted changes in biomass as well as annual landings of these small pelagic resources under various SSP scenarios were also estimated using the fitted model, in order to develop suitable harvest control rules for sustaining the marine fisheries of the region.

Keywords

Biomass dynamic model, Climate impact, Precipitation, Small pelagics, SST

TS-1-014

Turning the Tide with Seaweed: Unlocking Blue Carbon for a Sustainable Coastal Future

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Seaweeds are marine macrophytes that play a crucial role in ecosystems by providing habitat, oxygen, and facilitating carbon sequestration. As a part of the blue carbon ecosystem, seaweeds capture and store organic carbon in oceans and coastal areas. Recognizing their potential for promoting sustainable coastal livelihoods and the blue economy, the ICARCentral Marine Fisheries Research Institute (ICAR-CMFRI) initiated seaweed farming along the coastal zones of Kutch, Gujarat. As part of the implementation plan, more than hundred custom-designed HDPE seaweed rafts measuring nine square meters was successfully deployed in 2025. The Seaweed Kappaphycus alvarezii showed significant growth and a total of 19.8 tonnes of wet seaweed was harvested from the suitable sites within 45–55 days cultivation cycle. Carbon storage assessment using calculation showed a total of 540 kg stored across all sites, with an average of 4.47 kg per raft. Recent ICAR-CMFRI estimates indicate that approximately 2,796 hectares of coastal area in the Kutch region are suitable for seaweed farming. With a deployment capacity of 500 rafts per hectare, the region has the potential to deploy 1,398,000 rafts. At this scale, seaweed cultivation has carbon storage potential of approximately 6,245 Megagrams of carbon per cultivation cycle. In contrast, mangrove forests typically store an average of 355.25 Megagrams of carbon per hectare. Accordingly, a single cultivation cycle of seaweed across the entire suitable farming area in the Kutch region can store carbon equivalent to that stored in approximately 17.5 hectares of mangrove forest. Along with that seaweed offers a faster and more scalable carbon storage solution with multiple cultivation cycles per year. With its high productivity, shorter growth cycles, and vast suitable farming areas, seaweed cultivation presents a more efficient and practical alternative for enhancing blue carbon storage and supporting coastal afforestation strategies

Keywords

Blue carbon, Climate change mitigation, Coastal afforestation, Marine macrophytes, Seaweed farming

Evidence of Acidification in the Coastal Waters of India: A Satellite Remote Sensing Approach

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This study investigates inter-annual and seasonal pH variations along the northwest (NW), southwest (SW), southeast (SE), and northeast (NE) coasts of India over three decades (1993–2022) using satellite-derived data. The results reveal a gradual decline in coastal pH values (R2=0.727), with minor fluctuations. Despite regional variability, the NE coast exhibited the highest pH stability and minimal decline (R^2=0.798), while the SW coast experienced the lowest variability (R^2=0.490). Seasonal variations were significant across all regions, with winter consistently recording higher pH levels and monsoons reflecting the lowest. Regional differences in pH variability suggest differential resilience to ocean acidification. The NE and SW coasts, with higher variability, may be more susceptible to environmental changes, necessitating focused monitoring and mitigation strategies. Stable trends observed along the SE and NW coasts provide an opportunity to explore long-term resilience mechanisms. Spatially, a north-to-south gradient was observed, with higher pH values in northern regions across seasons. Principal Component Analysis (PCA) indicated that the first two components accounted for 85.7% of the variance, highlighting key drivers such as seasonal riverine input, biological activity, and monsoonal freshwater discharge. The comprehensive analysis highlights the necessity for region-specific coastal management strategies to mitigate the impacts of climate change and anthropogenic pressures on coastal ecosystems. The study serves as a baseline for monitoring future ocean acidification trends and their implications for marine biodiversity and ecosystem services.

Keywords

Acidification, coastal waters, Indian EEZ, Satellite-derived data, Spatial variability

TS-2-001

Mapping waste generation system in Minicoy: Its challenges, issues and way forward

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The coastal regions across the globe experience unprecedented vulnerabilities related to climate change and disaster. With more and more urbanization and modernization, waste disposal has eventually become the greatest challenge of coastal regions across the globe. Excessive rise in tourism and modernization consequently affects the waste management system. In this context, the study navigates the waste disposalsystem of Minicoy, mapping the waste segregation methods involving different stakeholders, the waste disposal service providers, the people employed, the state and non-state agencies, etc. The study examines the current state of waste generation in Minicoy and identifies key issues related to waste disposal challenges. The study deploys GIS to map waste collection sites, enabling efficient visualization and spatial analysis of solid waste management infrastructure. It identifies optimal collection points and uncovers service gaps, thereby enhancing route planning and overall waste collection efficiency. The study adopts purposive sampling by deploying a structured questionnaire comprising specific questions related to the challenges and concerns of the waste disposal system in Minicoy. The stakeholders are interviewed, reflecting a sample of around 35 to 40 respondents to comprehend the process of segregation of waste, and strategizing its disposal system.

Keywords

Coastal region, Climate change, Waste management system, Waste disposal services, Modernization Minicoy, Tourism

TS-2-002

Giant Trevally (*Caranx ignobilis*) a potential climate-resilient species for farming in coastal waters

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One of the most significant weather events related to climate change is the global shift in rainfall patterns. This can cause sudden fluctuations in precipitation, ultimately leading to sudden variations in the salinity of coastal waters. Coastal waters are ideal for small-scale and artisanal farming of marine species. Hatchery seed production of three species of carangid fishes, silver pompano (*Trachinotus blochii*), Indian pompano (*Trachinotus mookalee*) and giant trevally (*Caranx ignobilis*) has been standardized, and these are popularly recommended for farming in coastal waters of India. Pond culture, cage culture, and pen culture are standard practices in coastal aquaculture here. Fish mortalities due to sudden salinity fluctuations are often reported from coastal aquaculture farms, especially during monsoon and cyclons. Fluctuations,especially the drop in salinity, can severely affect species like the silver pompano (*T. blochii*) and the Indian pompano (*T. mookalee*). Recently, seed production and farming technologies have been developed for another promising species of carangid fish – the giant trevally at Vizhinjam Regional Centre of ICAR CMFRI. The giant trevally is a fast-growing, high-value carangid species suitable for cage culture, pen culture and farming in coastal saline ponds. This species is widely distributed across tropical and subtropical regions and is reported to be adaptable, even in freshwater environments. All the three species have been farmed in the Ashtamudi region of Kollam, Kerala, for the past three years. There were mortalities in both silver pompano and Indian pompano when the salinities dropped beyond 10ppt. This study confirms the 100% survival of giant trevally in overcoming the challenges posed by sudden declines in salinity, often induced by heavy rainfall and freshwater runoff, in the farming conditions of cage farms in this region. A study was conducted to assess the salinity tolerance of captive-bred juveniles (2.5 cm TL) of the species in tanks (2000 L capacity). The results confirmed that the species is adaptable to a wide salinity range, from 35 ppt to 2 ppt. This study highlights the importance of selecting this climate-resilient species to mitigate the impacts of erratic weather patterns and ensure the long-term sustainability of coastal aquaculture systems.

Keywords

Climate change, Climate-resilient species, Coastal aquaculture, Kollam

TS-2-003

The impact of "pelagification" on the small-scale fishermen of Andhra Pradesh

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Pelagification is the phenomenon wherein ecosystems move towards more pelagic fish (Muktha et al., 2014) and pelagic-based food webs (Petrik et al., 2020). Among pelagic fish, the small pelagics are especially significant as they form food for humans as well as major prey items for predatory fish (Hilborn et al., 2021). As a result of fishing down the food web (Pauly et al., 1998), it is estimated that the biomass of small pelagic fish has doubled since before industrial fishing (Christensen et al., 2014). The abundance of small pelagic fish being highly responsive to environmental signals, their biomass usually shows high periodic fluctuations. Hence, we have a situation wherein a highly "volatile" resource is increasing in abundance and consequently its landings, which in turn will impact fishermen livelihoods. So, we conducted this study to know the status of small pelagic fish landings in the small-scale fisheries of Andhra Pradesh and its possible implications for fishermen livelihoods. The study analyzed the landings of lesser sardines *Sardinella* spp. (Family Dorosomatidae) in motorized gillnets during 1992-2024. The overall landings, fishing effort and catch rates of motorized gillnetters in Andhra Pradesh showed an increasing trend, with fluctuations across the years. The dominant species landed showed a change over the years, with groups like sharks, shads and seerfish giving way to sardines, mackerel, etc. The overall contribution of lesser sardines increased during 1992-2024 with high periodic fluctuations from 2012 onwards; in 1990s the average contribution was 5.5%, which rose to 15.3% during 2020-2024. Lesser sardines are a low value resource which are increasingly dominating gillnet landings in Andhra Pradesh. As a result, gillnet fishermen of the state are increasingly getting dependent on a low value resource with high periodic fluctuations for their fishery livelihood, thereby impacting their livelihood security in a future of climate uncertainties.

Keywords

Pelagic fishes, Lesser sardines, Small-scale fisheries

TS-3-001

Impact of Climate change and Socio-Economic factors on Agriculture in Assam: A district-level Analysis

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The macroeconomic impacts of climate change has been studied extensively, yet the predictions remain uncertain. However, research on the diverse socio-economic factors affecting the impact of climate change at sectoral and regional levels is limited. Understanding how the agriculture productivity and livelihoods of people is affected to climatic fluctuations can help in identifying support needed to mitigate for agricultural growth.The main objective of this study is to examine district-level climatic changes and socio-economic factors that influence farm yield and overall economic growth in Assam. The analysis follows a two-fold approach: first, estimating the direct effects of climate change on Gross Domestic Product (GDP), and second, examining its indirect role in migration patterns. The study assesses firstly, the impact of climatic change and disasters on agricultural yield and secondly to assess how these climate change and disasters affect the migration of rural workforce, key socio-economic determinants including the Human Development Index (HDI), Gini coefficient, employment levels, and infrastructure are incorporated to evaluate their influence on agricultural performance. By identifying critical factors shaping agricultural resilience in Assam, this paper aims to contribute to informed policy-making for sustainable development and climate adaptation.

Keywords

Agricultural performance , Climate change, Gini coefficient, Employment levels, Human Development Index (HDI), Infrastructure

TS-3-002

Empowering women in fisheries: case studies from north Tamil Nadu

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The fisheries sector in Tamil Nadu has grown substantially over the past few decades, contributing significantly to the economic growth of the state. Women in fishing communities play multidimensional roles in capture fisheries. Empowerment of fisher women will lead to socio-economic development of the fishing communities. In Tamil Nadu fisherwomen engage in collection of prawns and molluscs from local water bodies, fish segregation, fish auction, fish loading, fish retail sales, fish wholesale businesses, fish export, seaweed collection in addition to the traditional jobs of fish curing, net making and prawn peeling. Under the Scheduled Caste Sub-Plan (SCSP) component of the project National Innovations in Climate Resilient Agriculture (NICRA), 211 SC women beneficiaries from three fishing villages of north Tamil Nadu - Kottaikadu in Chingleput District, Thonirevu in Thiruvallur District and Kolathur in Chingleput District - were given support through awareness generation on good practices for allied fishing activities and distribution of essential field accessories for their livelihood. This study focuses on the impact of these programmes and the role of science-based community awareness actions in improving socio-economic status of fisherfolk, with particular impetus on women empowerment. The results of this study will be of use in drafting model action plans for popularizing additional livelihood activities among womenfolk in coastal fishing communities.

Keywords

Fisherwomen, NICRA, SCSP, Socio-economic status, Women empowerment

TS-3-003

Interlinkages between climatic and socio-economic vulnerabilities: A case study of Kerala

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In this era of climate change and catastrophic disasters, all the coastal areas demonstrate extreme vulnerability and experience a considerable amount of the detrimental impact of climate change. Kerala, a coastal state in southern India, experiences acute vulnerability due to climate change in the form of extreme rainfall, sea-level rise, shifting weather patterns, coastal erosion, etc. The degree of vulnerability varies significantly across various districts in the state of Kerala. This study adopts a two-fold objective: firstly, to classify Kerala under varied climatic zones reflecting different degrees of vulnerability; and secondly, to investigate how climate change vulnerability intersects with socioeconomic vulnerability—determined by factors such as income inequality, human development index (HDI), and urbanization. Coastal urban centers with unplanned growth face elevated risks due to stressed infrastructure and socio-economic marginalization. The study analyzes land use and land cover (LULC) dynamics across Kerala from 2000 to 2025 using Landsat satellite data at five-year intervals. Climatic variables—temperature and precipitation—are drawn from the CHELSA database, while socioeconomic drivers include population density and land-use patterns. Findings reveal distinct regional trajectories of urban expansion, agricultural decline, and forest variability, shaped by both ecological pressures and human activities. The research highlights the need for region-specific, integrated climate and development strategies to enhance resilience and adaptive capacity.

Keywords

Climate change, Income inequality, LULC, Socio-economic vulnerability

TS-3-004

Mapping the impact of climate change and disaster on Tourism in Rajasthan: A district-level analysis

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The present era is marked by the catastrophic impact of climate change and disasters. The impact is not limited to one sector but trickles down to every sector, affecting its growth trajectory. Rajasthan is known for its tourist destinations, its vibrant culture, historical sites, tradition, and landscape. A variety of tourism, such as cultural tourism, wildlife, desert tourism, heritage tourism, as well as eco-tourism, have been the highlights of Rajasthan tourism since the 1990s. Moreover, the effect of climate change is conditioned upon the landscape and terrain-specific factors; therefore, the study disintegrates regions in Rajasthan based on climatic conditions. Based on the hypothesis that climate change has a mixed effect on tourism in Rajasthan and the tourism policy significantly positively contributes to improving the status of tourism in Rajasthan, the study examines the factors that influence the status of tourism in various clusters of districts of Rajasthan. To achieve this objective, the paper constructs clusters of the areas impacted due to climate vulnerability and evaluates the impact of climate change, disaster, agglomeration or urbanization, migration, employment, human development index, Gini coefficient, tourism policies etc., by performing a panel data regression from 1990 to 2024 for the selected districts in clusters considered for the analysis. The findings of the study suggest a significant contribution of tourism policies to the status of tourism, coupled with the impact of disaster. In this context, the study suggests nature-based solutions and eco-tourism as policy recommendations.

Keywords

Climate change, Disaster, Eco-tourism, Gini coefficient, Human development index, Nature-based solutions, Rajasthan, Tourism

TS-3-005

Seaweed Farming: advancing environmental sustainability and socio-economic prosperity for Scheduled Caste fishers — A NICRA Initiative

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Seaweed farming is an emerging sector in sustainable aquaculture. With rising global demand driven by its applications in food, pharmaceuticals, biofuels, and bioplastics there is a growing need for innovations to enhance both productivity and sustainability. Large-scale seaweed mariculture is recognized as a climate-resilient aquaculture practice and plays a crucial role in mitigating ocean acidification. This green technology requires no energy, fertilizers, or chemical inputs and is relatively low in labour demand. It offers a sustainable and diverse source of income, especially for coastal fishing communities in India. Additionally, it contributes to carbon sequestration, enabling India to earn carbon credits. Acknowledging its social and environmental importance, the Government of India has identified seaweed farming as a national priority. Since 2019, the Mandapam Regional Centre of ICAR–CMFRI has been promoting seaweed farming under the NICRA–Scheduled Caste Sub-Plan (SCSP) programme in the districts of Ramanathapuram, Pudukkottai, and Thanjavur in Tamil Nadu. This initiative specifically supports fisherwomen, empowering them through sustainable livelihoods. A total of 31 fisher families across six villages have benefited from the programme, with the distribution of 615 raft/monoline units. Initially, each family received 20 monoline units along with hands-on training, inputs (including seed), and technical guidance. Encouraged by their initial success, each family later expanded their operations by adding 10-20 more units. Currently, they earn a net monthly income of Rs. 15,000 to Rs. 18,000. During 2024–2025, beneficiaries of the NICRA–SCSP programme collectively produced 355 tonnes of fresh *Kappaphycus alvarezii,* equivalent to 35.5 tonnes of dry seaweed (10% of the fresh weight). This production contributes to carbon dioxide sequestration of approximately 674.5 kg CO_2 per day, calculated at 19 kg of CO_2 per tonne of dry seaweed. The income generated through seaweed farming has enabled fisherwomen to spend on their children's education,

repay loans, cover medical expenses, and invest in household assets. They also recommended expanding the programme to include more women, particularly housewives, in similar communities. This initiative clearly demonstrates how seaweed farming can improve financial management, enhance decision-making skills, and promote entrepreneurship among fisherwomen. It has successfully paved the way for the emergence of empowered and self-reliant fisher woman preneurs.

Keywords

Fisherwomen, NICRA, SCSP, Seaweed farming, Sustainable livelihoods

Relationship between socio-economic factors, awareness of environmental challenges, and nature-based solutions: A case study of Minicoy

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The present era faces an unprecedented challenge of climate change and environmental degradation. Minicoy, located in the Lakshadweep archipelago, encounters several challenges such as coastal erosion, consistent sea rise, biodiversity loss, etc. The study examines the relationship between socio-economic factors such as education, age, income levels, and occupation patterns and the extent or degree of awareness of environmental challenges among the local communities. The extent of environmental awareness will be measured by creating an index by deploying the Principal Component Analysis (PCA) method. In addition, the paper attempts to explore the perception and willingness to adopt nature-based solutions such as mangrove conservation, sustainable practices, and coral reef protection.

The study deploys a mixed methods approach, which involves household surveys, random sampling, as well as focus group discussions for collecting the data on socio-economic factors and their awareness of environmental challenges. The two hypotheses are that firstly, the socio-economic status plays a critical role in the extent of awareness of environmental challenges, and secondly, the traditional knowledge system and cultural practices play a pivotal role in willingness to adopt nature-based solutions. The paper finds that a participatory approach under the social contract theory is a plausible solution for all environmental challenges of Minicoy. The paper holds great relevance for policy implications as the localized approach in integrating local socio-economic contexts can enhance community resilience and sustainability in the fragile island of Minicoy.

Keywords

socioeconomic factors; environmental awareness, nature-based solutions; community resilience, Principal Component Analysis, Minicoy

TS-4-001

Climate resilience and economic sustainability: The role of salt marshes in mitigating climate change in Lakshadweep

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Salt marshes play a vital role in mitigating climate change by acting as effective carbon sinks, storing organic carbon in their sediments over millennia. In Lakshadweep, a low-lying coral atoll ecosystem in the Indian Ocean, has an overall mean density of salt marsh vegetation of 19 ± 1 plants per m^2 with the highest density recorded in Lakshadweep (28 m^{-2}). These salt marshes are increasingly impacted by climate change-induced sea-level rise, altered precipitation patterns, and warming temperatures. This abstract explores the response of salt-marsh carbon accumulation to these climatic factors and highlights its economic implications. In that moderate sea-level rise can promote vertical sediment accretion and enhance carbon storage capacity. However, accelerated sea-level rise may lead to submergence, vegetation loss, and eventual conversion of salt marshes into open water, thereby reducing their carbon sequestration potential. Similarly, rising temperatures and changes in precipitation can influence primary productivity, decomposition rates, and microbial processes, further affecting carbon dynamics. The blue economy of Lakshadweep, driven by fisheries, aquaculture, and eco-tourism, depends directly on the health of these ecosystems. Coral reefs alone contribute significantly to tourism revenue, attracting visitors for recreational diving and snorkeling. Meanwhile, seagrass beds and lagoons underpin the fisheries sector, which provides employment and sustenance for the majority of the island population. Investing in climate mitigation not only safeguards these ecosystems but also ensures long-term economic growth by stabilizing industries reliant on natural resources. From an economic perspective, the preservation and enhancement of salt-marsh carbon sequestration hold significant potential for Lakshadweep. These ecosystems could be integrated into global carbon credit mechanisms, providing financial incentives for conservation efforts. Furthermore, salt marshes act as natural buffers against coastal erosion and storm surges, reducing the economic costs associated with climate-related damages. Marine ecosystems support fisheries and biodiversity, benefiting local communities. However, degradation could lead to economic losses. A holistic approach combining ecological conservation and economic sustainability is crucial for climate resilience in small island territories.

Keywords

Climate change, Lakshadweep, Salt marshes

From Silos to synergy: Navigating changing tides in interdisciplinary mangrove carbon research

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Mangroves are among the most optimised natural systems for long-term carbon storage, playing an indispensable role in global climate mitigation. More nuanced methods to understand its potential are being tried, tested and implemented every year. Yet, the scientific inquiry into mangrove organic carbon remains deeply fragmented. Research across disciplines, ranging from basic ecology and geospatial science to biogeochemistry, data modeling, and policy- often operates in isolation, resulting in incoherent data streams, scale mismatches, and a reduced capacity to reflect effective climate strategies. This review navigates the "*changing tides*", a metaphor used in this present review paper for the emerging shift in mangrove carbon research, from isolated, discipline-specific investigations toward more unified, transdisciplinary approaches. This paper discusses the trends of advancements in mangrove organic carbon research, highlighting where disciplinary silos have limited data integration, hindered restoration effectiveness, and slowed policy translation. Through an analysis of current literature and select case studies, key conceptual, methodological, and scale-based gaps between fields were identified. Emerging efforts, such as hybrid Artificial Intelligence–ecology models, community-integrated monitoring, and cross-sectoral carbon finance platform, that exemplify the move toward research synergy were highlighted. We also explore how recent advancements, such as AI-driven carbon mapping, UAV-integrated monitoring, and community-partnered data networks, exemplify this transition and how projects like WWF's ManglarIA and novel AI-integrated emissions frameworks highlight the potential of merging ecological knowledge with technological innovation and governance insight. Finally, by delineating key discontinuities and highlighting exemplary models of integration, this review attempts to chalk a strategic framework for the progression of mangrove carbon science that is anchored in interoperability, inclusivity, and systems-based thinking. Effectively navigating through these shifting paradigms and building a bridge amidst research approaches from different silos is imperative for harnessing the full potential of mangrove ecosystems as equitable, resilient, and empirically grounded nature-based solutions to climate change.

Keywords

Artificial intelligence, Carbon mapping, Changing tides, Mangrove Carbon research

TS-4-003

Restoration of seagrass meadows - A primary sustainable development goal in Lakshadweep atolls

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Seagrasses are ecosystem engineers as they decide the trophic level and productivity of coastal ecosystem and they are the third most valuable ecosystems on our planet. Seagrass meadows are ocean's greatest carbon sink which are highly productive and dynamic. These underwater prairies form the feeding and breeding grounds for dugongs, green turtles, many finfish and shellfish resources besides, large number and quantities of invertebrates of commercial and ecological importance. Seagrass meadows though occupy only below 0.2% area of the world's oceans, are considered one of the major blue carbon sinks that contribute indirectly to climate change mitigation as they are known to capture and bury enormous quantities of carbon annually. The value of one ha area of seagrass meadows is about 19000 USD per year which is excluding the values of commercial fisheries they offer.

National Centre for Sustainable Coastal Management has estimated a total area of 516.59 km^2 as seagrass cover in India using geospatial tools without including seagrass beds in many atolls of Lakshadweep and Pulicat and Ashatamudi Lakes. Throughout the world, seagrass habitats face severe decline due to herbivory, habitat destruction and climate change that has become faster in the current decade. The standing crop and density of seagrass vegetation in the reef and lagoons of Agatti, Chetlat, Kavaratti and Kiltan Islands of U.T. Lakshadweep, indicated gradual but steady shrinking of seagrass meadows. The percentage reduction in density of seagrass meadows since December 2011 to November 2015 was estimated at 88.5% in Agatti, 88.7% in Chetlat, 78.4% in Kavaratti and 81.3% in Kiltan. Hence it has become so essential to understand the factors responsible for the rapid shrinking of seagrass meadows and to undertake seagrass restoration measures immediately while checking the herbivory, pollution and other anthropogenic interferences.

Keywords

Climate change, Coastal ecosystem, Lakshadweep

TS-4-004

Blue Forest Frontiers: Unlocking the Climate and Coastal Potential of Seaweed Cultivation and Ocean Afforestation

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Seaweed cultivation and open-ocean macro algal afforestation are gaining attention as scalable, nature-based strategies that can contribute to climate change mitigation, marine ecosystem recovery, and sustainable economic development. Coastal seaweed farming offers multiple ecosystem services, including carbon uptake, nutrient removal, habitat provisioning, and the sustainable production of food, feedstock, and bio-based materials. Expanding these efforts offshore commonly referred to as ocean afforestation may increase global carbon dioxide removal (CDR) potential by facilitating the deep-sea export of algal biomass. However, this approach introduces ecological uncertainties, including possible disruptions to ocean chemistry, oxygen depletion, and biodiversity impacts. This review integrates current scientific knowledge on the carbon sequestration capacity of seaweed systems, their co-benefits for ecosystem health, innovations in cultivation technology, and the evolving governance landscape. Special emphasis is placed on the importance of transparent carbon accounting, full life-cycle assessments, risk evaluations, and adaptive regulatory frameworks to ensure environmental integrity. While significant challenges remain particularly around permanence of sequestration, infrastructure scalability, and policy enforcement if carefully managed, seaweed-based interventions could become a vital component of the global climate response and sustainable ocean economy.

Keywords

Bio-based materials, Carbon accounting, Carbon sequestration, Carbon uptake, Seaweed

TS-4-005

Carbon sequestration potential of selected mangrove ecosystems in Western India

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Mangrove ecosystems are globally recognized for their exceptional capacity to sequester and store carbon, playing a pivotal role in mitigating climate change through blue carbon mechanisms. This study focuses on estimating and mapping mangrove carbon sequestration across the coastal states of Maharashtra, Goa, Karnataka and Kerala using field sampling and GIS-based analytical framework. We utilized multi-temporal Landsat and Sentinel-2 imagery, NDVI indices, and mangrove extent data from Global Mangrove Watch to assess trends in mangrove cover dynamics and carbon stock variations. Sampling was conducted across 23 mangrove ecosystems in the region and sediment samples were collected and organic carbon was estimated using the Walkley-Black method. The results reveal that Maharashtra sites such as Purnagad and Dabholi recorded the highest organic carbon values, while in Goa, the Pernem region showed the most significant carbon content. Karnataka's highest values were observed in the Kali mangrove region. Spatial analysis identified hotspots of carbon sequestration and areas vulnerable to degradation. This integrative approach highlights critical zones for conservation and restoration, providing essential insights for sustainable coastal management and climate resilience planning. The findings reinforce the ecological and climatic value of mangroves and emphasize the need for targeted conservation policies in the western coastal region of India.

Keywords

Climate resilience, Carbon sequestration, Mangrove ecosystems, West Coast

TS-4-006

Evaluating Carbon sequestration and climate mitigation potential in natural and planted mangroves of the Panchagangavali estuary

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Mangroves are the keystone species of tropical and temperate coasts, now in spotlight globally for its high susceptibility to the adversities of climate and anthropogenic impacts. Quantifiable restoration and mitigation efforts are put through understanding the concept of "*blue carbon*"; where these intricate ecosystems help in sequestering atmospheric greenhouse gases (GHG's) by entrapping them in deep layers throughout ages of the past and the coming. The present study attempts to understand the true carbon sequestration potential of selected sites from Panchagangavali estuarine complex which represents both natural undisturbed mangrove ecosystem and restored sites of true mangrove plantations. A non-destructive stratified random sampling method is used to take the tree measurements for the analysis of Above Ground Biomass (AGB) and Below Ground Biomass (BGB) by allometric equations. The age of the trees in the selected are determined by DBH (Diameter at breast height) and classified into natural patch and restored plantation sites through non-destructive parameters like size variation, tree arrangement, species diversity, root adaptation and soil distribution patterns. A total of six different species were found in both of the later distinguished sites. Although only Rhizophora apiculata and Kandelia kandel were uniformly found across the planted sites, which indicated the restored sites followed a meticulous monoculture planting. The estimated mean Above Ground Biomass (T_{AGB}) across the Natural sites with diverse species was found to be 348.90 t ha^{-1} and mean Below Ground Biomass or Root Biomass (T_{BGB}) was estimated to be 152.28 t ha^{-1}. Whereas, the mean estimated T_{AGB} and T_{BGB} across the homogenous patch of planted sites are 225.54 and 95.56t ha^{-1} respectively. Their SOC is estimated to be 24.38 and 14.48 t ha^{-1} respectively. The following estimation implies a need for more refined strategic restoration plans that are scientifically and ecologically sound. This paper reflects on effective climate mitigation that provides carbon storing permanence through apt rehabilitation methods and discusses assisted natural regeneration (ANR) that might prove as the most resilient technique for the following generations.

Keywords

Assisted Natural Regeneration, Climate Change, Carbon permanence, Mangrove Restoration,

TS-4-007

Influence of anthropogenic activity on organic carbon in mangrove ecosystems: A natural solution to climate change

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Organic carbon is a powerful "*biomonitor*" in mangrove ecosystems, linking primary productivity, ecological integrity, and soil fertility to the global climate system. Mangrove sediments lock away "blue carbon" for centuries, buffering atmospheric CO_2 increases and helping communities adapt to climate-change impacts such as sea-level rise and extreme weather. To understand how human pressures affect this climate-regulating service, we assessed two structurally distinct mangrove forests using an Anthropogenic Interference Determination Index (AIDI) that scores (0–4) tourism pressure (T), aquaculture/fishing intensity(A), settlement density (S), solid-waste and pollution load (P), and habitat alteration (H). The Netravati estuary scored 3.6, indicating severe disturbance, while the Panchagangavali estuary scored 1.8 (moderate). Soil organic carbon (SOC) stocks were quantified from sediment cores by measuring soil bulk density (SBD), percentage organic carbon (POC) and sediment texture. In Netravathi, SBD ranged from 0.7 to 1.3 g cm^{-3}, POC from 0.20 to 4.23 %, and SOC from 5.16 to 25.02 t ha^{-1}. In Panchagangavali, SBD ranged from 0.3 to 1.2 g cm^{-3}, POC from 0.10 to 2.89 %, and SOC from 2.43 to 33.15 t ha^{-1}. Sites with lower bulk density tended to store more carbon per hectare, underscoring how intact root systems and fine sediments enhance long-term sequestration as observed in the present study.

Statistical analyses revealed strong correlations between SBD, POC, and SOC, where SBD is inversely proportional to POC and SOC, indicating that anthropogenic disturbances can degrade ecosystem health and thereby carbon sequestration capacity. Protecting and restoring mangrove patches—through curbing habitat alteration, enforcing waste management, and promoting sustainable tourism and aquaculture—will not only preserve biodiversity and fisheries but also safeguard these coastal carbon sinks, strengthening regional resilience to a rapidly changing climate.

Keywords

Anthropogenic index, Biomonitoring, Climate change, Mangroves, Restoration, Soil organic Carbo

TS-4-008

Resilience in the face of climate change: Coastal strategies in developed and developing regions

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Coastal areas in every region of the globe are becoming more vulnerable to the effects of climate change, such as sea-level rise, weather events, and coastal erosion. Such hazards render disaster resilience a matter of utmost urgency for developed as well as developing countries. This research applies a set of chosen case studies of developed Western coastal regions and South Asian coastal economies to benchmark and contrast their disaster preparedness and resilience strategies. It is organized into four principal criteria: adaptation to climate change, sustainable ways of living, reduction of disaster impacts, and other social benefits such as jobs and improving the quality of life. Western coastal areas tend to have more financial means and technological resources. Their approaches, therefore, tend to revolve around engineered solutions like flood defense works, storm surge barriers, and advanced early warning systems. These are effective in minimizing upfront disaster threats and safeguarding valuable assets. Yet, they might not have complete attention to long-term sustainability or social justice. In other instances, these solutions can even undermine natural systems and engender dependency on centralized infrastructure.

In contrast, coastal communities in South Asia are more likely to depend on community-based and ecosystem-oriented methods. Mangrove rehabilitation, traditional fishing, and community-based conservation programs are some of the initiatives that promote natural resilience against climate risks while maintaining local livelihoods and biodiversity. These strategies play a pivotal role in sustainable living and community resilience but are usually troubled by insufficient funding, institutional capabilities, and competing development agendas. By comparing these case studies, the research identifies the strengths and weaknesses of each method. It advocates for increased integration of technological innovations with socially inclusive and nature-based approaches. Knowledge sharing across regions can be used to construct holistic disaster resilience policies that not only minimize dangers but also ensure long-term sustainability and enhance the well-being of coastal communities.

Keywords

Coastal resilience, Climate change, Disaster preparedness, Engineered solutions Nature-based solutions

TS-4-009

Sandy nature of substrata limits the carbon sequestration and storage potential of mangrove ecosystem – A case study from Kunthukal in the Gulf of Mannar, India

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Mangrove ecosystem is one of the blue carbon ecosystems that render many environmental services, which are crucial for the existence of human life. Besides, serving as a physical barrier protecting the coast, as breeding and nursery grounds for fishes and invertebrates, foraging ground for avian fauna, fishing, aquaculture and many other ecosystem services, they also assume significance as important sequesters of atmospheric carbon and are, therefore, important in the light of climate change mitigation.

In the present study, we attempted to assess the biomass and carbon stock of mangroves in Kunthukal, near Pamban in the Gulf of Mannar, India. The study assumes significance due to the low levels of carbon stock, could be primarily due to the sandy nature of substrata and the consequent stunted nature of mangrove trees. The mangrove species composition encompassed of *Avicennia marina, Pemphis acidula, Ceriops tagal* and *Lumnitzera racemosa*. The estimated mean total biomass was 61.86 t ha^{-1}; the mean above-ground biomass and below-ground biomass were 37.70 and 24.20 t ha^{-1} respectively. The C-stocks of above ground and root biomass were 18.85 t C ha^{-1} and 12.10 t C ha^{-1} respectively, while the C-stock in sediment was estimated to be 22.91 t C ha^{-1}. The estimated total Carbon stock of Kunthukal mangrove ecosystem was 53.86 t C/ha, equivalent to 197.67 t CO_2, which is very low. Our previous studies in mangrove ecosystems of North Kerala have indicated C-stocks ranging from 180 to 210 t C ha^{-1}, which indicates that the stunted nature of mangrove trees surviving in unfavourable conditions in Kunthukal might be the reason for low levels of C-stock.

Keywords

Biomass, Carbon stock, Mangrove ecosystem

TS-4-010

Unveiling the Hidden Riches: Ichthyofaunal Diversity from the Mangroves of Champa Estuary, West Bengal

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Mangrove ecosystems play a crucial role in fisheries and act as major blue carbon sinks, aiding climate change mitigation and coastal community livelihoods. They provide essential breeding, nursery, and feeding grounds for diverse aquatic species, including fish, crustaceans, mollusks, and crabs, with fish being the most diverse and abundant faunal groups. The present study provides a preliminary assessment of fish species diversity within the mangrove-associated zone of the Champa estuary, West Bengal. Fish specimens were collected fortnightly between 2023 and 2024 from local fishermen using traditional bag nets (Behendi jal). Fresh samples were photographed immediately to preserve natural coloration and pigmentation. Taxonomic identification was carried out using external morphological characteristics, following standard ichthyological references to classify specimens down to the lowest possible taxonomic level. Key community metrics including species richness, diversity, and evenness were computed to summarize species distribution and relative abundance. A total of 63 species, comprising both finfish and shellfish, were documented. These species represented 54 genera, 41 families, and 22 taxonomic orders, many of which hold significant commercial value. Among the identified groups, Decapoda emerged as the most species-rich, followed by Gobiiformes and Clupeiformes, though some groups were represented by only a few species. To enhance the accuracy of species identification, particularly for morphologically similar taxa, molecular techniques such as DNA barcoding are recommended for future studies.

Keywords

Champa estuary, Ichthyofaunal diversity, Mangrove ecosystem, Morphological identification

TS-5-001

TurbAqua: An Android-powered mobile application and mini secchi disks for monitoring water colour and clarity

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Smartphones have evolved into smart laboratories in your pockets, capable of scientific observations. Smartphone-based mobile applications are an indispensable part of environmental research, particularly in the field of water quality monitoring. Smartphones with integrated sensors and user-friendly applications enable data collection and exchange more rapidly and effortlessly. Point sampling methods, which depend on gathering samples from particular locations, frequently overlook the dynamic variations in water quality. TurbAqua, an Android-based mobile application by ICAR- Central Marine Fisheries Research Institute (CMFRI), was launched to support public participation in scientific research, for the conservation of Lake Vembanad, Kerala. This Android app makes it easier to collect data on water quality by logging variations in water colour and transparency across spatial and temporal scales. The present study offers an overview of the exciting and potentially transformative emergence of the TurbAqua application, its technical design and functionalities, including its Colour Vision Test, Digital Forel-Ule (FU) colour scale, Optimal Angle Assistant, Geotag Verification, and Secchi Depth calculation feature. We also highlight the mandatory photo upload feature, as well as the feedback and comment section, both of which are essential for validating and interpreting water body's health. These functionalities are critical in enhancing the quality and reliability of data collected through water-based citizen science activities, contributing to environmental monitoring efforts to an unprecedented degree.

Keywords

Forel-Ule colour, Smart phone, Secchi Disk, TurbAqua, Water quality

TS-5-002

Forecasting mangrove cover change in mumbai using a modeling approach for climate and coastal resilience

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Mangroves play a critical ecological and socio-economic role along the Mumbai coast, functioning as natural buffers against coastal erosion, storm surges, and tidal flooding. These intertidal ecosystems also support a wide array of marine life, acting as essential breeding and nursery grounds for numerous commercially important fish and crustacean species. Importantly, mangroves are now recognized as vital blue carbon sinks, with an exceptional capacity to sequester and store atmospheric carbon dioxide in both their biomass and sediments. Their protection and restoration are thus integral to global and local climate change mitigation efforts. However, Mumbai's fast-paced urbanization has placed immense pressure on its mangrove ecosystems. The expansion of infrastructure, land reclamation, and industrial pollution have resulted in the fragmentation and degradation of these coastal forests, threatening their ecological integrity and carbon storage potential. To address this, our study adopts a geospatial modeling approach to monitor and simulate mangrove cover dynamics across the Mumbai Metropolitan Region using the open-source MOLUSCE (Modules for Land Use Change Simulations) plugin in QGIS. Using multi-temporal satellite imagery and spatial layers such as proximity to coastline, geomorphological features, and urban infrastructure, the study employed Artificial Neural Network (ANN) and Cellular Automata (CA) modeling to project future mangrove scenarios. The simulation identified critical zones at risk of degradation, especially near infrastructure corridors, as well as ecologically favorable areas suitable for mangrove regeneration. The findings underscore the importance of integrating spatial data analysis into coastal zone planning and climate adaptation strategies. By identifying blue carbon hotspots and forecasting ecosystem trajectories, this approach offers a replicable, data-driven framework for ecosystem-based management. Ultimately, safeguarding Mumbai's mangroves enhances coastal resilience, sustains fisheries-based livelihoods, and contributes meaningfully to India's climate action goals.

Keywords

Coastal Resilience, Geospatial Modeling, Land Use Change Simulation, Mangrove Ecosystems, Remote Sensing

TS-5-003

Interactive maps: an efficient tool for ensuring last mile connectivity in climate hazard awareness

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Awareness is the cornerstone of preparedness, and the visual media is one of the efficient ways to educate different stakeholders about the threat posed by different hazards. Climate change is extensively recognized as a significant and multifaceted threat to the environment, ecosystems, economies, and societies around the world. Climate change can affect a wide range of characteristics of the climate system. However, for developing successful climate-responsive measures, evaluation should be more concentrated on the smaller set of changes (climatic impact-drivers, CIDs) that may have an impact on the ecosystem components. The relevant CID types that could cause coastal hazards were chosen from the framework of CIDs proposed in IPCC AR6. These include coastal, heat and cold, and wind. The different CID categories included in the study were as follows: the coastal CID type consisted of three CID categories, i.e. relative sea level, coastal flood and coastal erosion. Similarly, extreme heat was included under the heat and cold CID type. Mean wind speed and tropical cyclone were the two CID categories included in the wind CID type. A total of 14 threshold-based CID indices were utilized to quantitatively measure the intensity of these climatic impact drivers. Under each CID type, different CID categories (sea level rise, flood proneness, shoreline change, heatwave and cyclone proneness) were assessed with different threshold-based CID indices. The hazard indices for sea level rise, flood proneness, shoreline change, heatwave and cyclone proneness were normalized and aggregated and subsequently scaled to a range of 0-1 to arrive at the Multi hazard Index (MHI). The Multi-Hazard Index serves as a composite metric indicating the comparative proneness of coastal districts/states to a range of physical hazards related to climate change. Interactive map of district-level and state-level MHI were developed using Leafltet Javascript library, QGIS and ArcGIS. The map is uploaded to the CMFRI website (https://www.cmfri.org.in/inf/lcmap/MHI_Map/MHI_Map.html#4/22.23/83.50), and upon clicking the map, a window will pop up displaying the name of the district/state, and MHI values available at the location. A traditional map legend is also provided for easy understanding of the map. Interested stakeholders can easily access this interactive map and make the last-mile connectivity an easy task.

Keywords

Climate change, Interactive map, Last mile connectivity, Multi hazard index

TS-5-004

Artificial reefs to support traditional and small-scale fishers in India

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Anthropogenic activities, fisheries, and climate change have significantly strained coastal resources, posing a constant challenge to the livelihoods of millions of traditional fishers. Consequently, alternative options and strategies are urgently sought to address this crisis. In response, the Ministry of Fisheries (DoF) in Tamil Nadu (TN) collaborated with ICAR-Central Marine Fisheries Research (ICAR-CMFRI) for nearly two decades. With scientific and technical guidance from ICAR-CMFRI, DoF, TN deployed over 131 artificial reefs in nearshore sites with minimal fishing conflicts. These reefs have proven instrumental in salvaging the impacted resources and fishers of the affected area. Following the example set by ICAR-CMFRI & DoF, TN in the successful implementation of this initiative, its scheme was subsequently expanded to encompass the entire Indian coastline, benefiting all coastal states and Union Territories (UTs) under the Pradhan Mantri Matsya Sampada Yojana (PMMSY) program. As of now, the PMMSY has successfully deployed nearly 1000 artificial reef sites. Preliminary studies conducted on the economic benefits and returns of artificial reefs have yielded encouraging results. These studies indicate a substantial increase in biomass at reef sites, with a 1015-fold increase compared to non-reef areas. Additionally, there has been a ten-fold increase in bottom resources and a 25-fold increase in pelagic and mid-water resources. A notable achievement is the observation of a gross standing stock of 150 tonnes of biomass over an area of one hectare, developed after a six-month incubation period. Traditional fishers have experienced a significant increase in catch rates on reef sites. Hook and line fishing has seen a nearly 70% rise, while gill net catch realization has witnessed a 30-35% increase. Additionally, small seines have witnessed a 100% increase, and pelagic drift or encircling nets have seen a 300-500% fold increase in catches.

The proximity of fishing destinations and the availability of resources have significantly reduced the anxieties of traditional fishers regarding gear dependency and the increasing manpower required to

operate large nets. This has ultimately led to a reduction in carbon footprint of fishing practices. Artificial reefs provide a safe haven for fish, preventing them from migrating to deeper waters. This has resulted in the revival of stock status for many declining fish groups and improved the chances of successful seed transplanting and ranching with resident populations. The paper comprehensively discusses the social, economic, and biological benefits of artificial reefs in enhancing the resilience of coastal resources and communities.

Keywords

Artificial Reefs, Artisanal fishers, Biodiversity Conservation, Sustainable Fisheries

TS-5-005

Influence of transgenerational acclimation on thermal tolerance in marine medaka *Oryzias dancena*

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The marine medaka *Oryzias dancena* was selected as a model fish to investigate effects of climate change on a marine teleost. To study the transgenerational thermal acclimation on thermal tolerance in marine medaka, the F1 generation of *O. dancena* was produced from parents that were reared from the embryonic stage under four constant temperatures, 24± 0.5 °C, 27± 0.5 °C, 30± 0.5 °C and 33± 0.5 °C. The thermostatic conditions were maintained within 400 litre recirculatory aquaculture systems (0.5 L min^{-1}) equipped with thermostats, chillers and heaters. The F1 progeny were subsequently reared up to the adult stage (approximately 90 days post-hatch) under the similar thermal conditions as their parents. To estimate the critical thermal maximum (CT_{Max}), six fish from each temperature group were individually transferred to 50 L glass tanks and left undisturbed for 3 hours to alleviate handling stress. Thereafter, each fish from the respective group was subjected to constant rate of increase or decrease (0.5°C / min) until loss of equilibrium (LOE). The CT_{Max} of O. dancena was 42.08 ± 0.11 °C, 42.54 ± 0.25 °C, 43.26 ± 0.12 °C and 44.38 ± 0.24 °C at 24± 0.5 °C, 27± 0.5 °C, 30± 0.5 °C and 33± 0.5 °C respectively. An increase in CT_{Max} by 1.12 °C was recorded with rise in the transgenerational acclimation temperature from 30 °C to 33 °C; by 1.84 °C with rise in the transgenerational acclimation temperature from 27 °C to 33 °C and 2.3 °C with increase in transgenerational acclimation temperature from 24 °C to 33 °C indicating a significant (P←.05) enhancement in thermal tolerance with increase in acclimation temperatures. The results demonstrate the phenotypic plasticity of marine medaka with respect to thermal tolerance suggesting its capacity for adaptive response under projected climate change scenarios.

Keywords

Acclimation, Climate change, $CT_{Max,}$ Thermal tolerance, *Oryzias dancena*

TS-6-001

Eco-Anxiety, Eco-Depression and Eco-Anger: They psychological impact of climate change on youth in Delhi and Himachal Pradesh

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India is a large country, with majority of its population being youthful, mostly under the age of 35. A healthy youth will utilise the infrastructure development, job opportunities, socioeconomic advancements, and environmental recovery that a just transition will bring. However, Young people are among the most vulnerable to the damaging consequences of climate change, as they will have to endure its effects for a longer time. The concept of "health" is not limited to physical fitness, but takes a holistic approach that includes emotional and mental well- being. A changing climate poses a direct threat to the health of the young population. Given the importance of youth in India's growth and development, it is crucial to address the mental health issues they face due to climate change. This study assessed the impact of climate change on the mental health of youth in two contrasting regions of India. Delhi, the capital of India, is among the fastest growing union territories, whereas Himachal Pradesh is a state which is located in the pristine Indian Himalayas. Delhi has experienced prominent climate related havocs such as extreme seasonal temperatures and erratic rainfalls. In contrast, Himachal Pradesh is highly affected by geologically induced hazards such as cloudbursts, flash floods, landslides etc. Both states differ in terms of their geographical conditions, demographics, and the types of climate calamities they experience. One thing common between these two states is that youth in both the regions are severely affected.

To capture the severe impact of climate change, Focused Group Discussions (FGDs) were conducted with diverse age groups, including students from the University of Delhi and schools of Himachal Pradesh. Our results highlighted that the suicidal thoughts and anxiety are the major psychological outcomes. However, most youngsters are unaware of these health impacts and are not taking any major actions to address them. The outcome of this study will be very helpful in shaping state policies that target youth and address the psychological impacts generated by climate change.

Keywords

Climate change, Health of youth, Hazards, Himachal Pradesh

TS-6-002

Mapping ecological vulnerability to resilience: A conundrum of political economy

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This paper examines how political economy affects the interlinkages between ecosystems, environmental sustainability, and disaster resilience in coastal regions around the world. The research has a primary focus on Asian, South American, North American, and European island and coastal ecosystems, utilizing comparativeanalysis with the aid of decadal time-series data from 2000 to 2025. The research makes use of global indexes such as the Environmental Performance Index (EPI), Nature Based Systems (NBS) Index, Global Innovation Index (GII), ND GAIN Vulnerability Index, Disaster Risk Index, and the Fragile States Index (FSI) to measure regional variation in governance, ecosystem health, and disaster risk. The relationship between EPI and key factors such as FSI, GII, NBS, ND GAIN, and the Disaster Index is examined to understand environmental performancedynamics. In parallel, the interconnection between the Disaster Index and variables including EPI, FSI, GII, ND GAIN, and NBS is explored to assess the factors influencing disaster vulnerability. A correlation analysis is then performed on four important variables: EPI, Vulnerability Index, Disaster Index, and NBS. Other pairwise correlations are investigated to determine correlations between NBS and exposure to disaster, NBS and vulnerability, security and disaster, and NBS and EPI. This research focuses on differences in global coastal areas characterized by varying levels of urbanization, pressure on the environment, and capacity for governance. The coasts of Asia and South America are particularly beset with resource management issues and institutional weakness. North American and European coasts tend to have more robust infrastructure but are still plagued by environmental threats such as loss of biodiversity and sea-level increase. The world's nations are grouped into four categories: high performing, upper middle, lower middle, and highly vulnerable. The research is in favor of collective, multi-regional actions that combine science, local knowledge, and effective governance. It aligns with India's Viksit Bharat 2047 vision and provides implementable lessons to develop resilient, sustainable coastal ecosystems globally.

Keywords

Coastal regions, Climate resilience, Environmental sustainability, Environmental Nature-Based Systems Index, Infrastructure Index, Economic Performance Index, Political economy, Performance Index (EPI), Security Index

TS-6-003

A multi-decadal review of frequency and human impact of extreme weather events in Kerala (1981–2023)

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Extreme weather events (EWEs), exacerbated by climate change have been increasingly reported across India over the past few decades. This study investigates long-term trends in occurrence of EWE and its related mortality in the state of Kerala using 42 years of data (1981–2023) from India Meteorological Department (IMD). The analysis focuses on three major EWEs: floods and heavy rains, heatwaves, and cyclones. Floods and heavy rains were the most frequent events, accounting for 95.34% of all occurrences, followed by heatwaves (3.82%) and cyclones (0.83%). The distribution of mortality indicates that floods and heavy rains account for the vast majority of deaths (97%), with cyclones (1.9%) resulting in more fatalities than heatwaves (0.67%), despite their lower frequency. A death-to-event ratio analysis highlights the disproportionately high lethality of cyclonic events (22.80) compared to floods and heavy rains (10.19) and heatwaves (1.74). Over the two twenty year time periods, despite a significant increase in total extreme weather events (110%) and overall mortality rates (56.97%), cyclonic events have shown a decline in mortality rate by 11.1% in the most recent 20-year period. Heatwaves, while exhibiting a relatively low death-to-event ratio, have shown an increasing trend over the past two decades, reflecting the escalating influence of climate change on their frequency and severity. These findings underscore the need for tailored adaptation strategies, including climate-resilient infrastructure, enhanced early warning systems, improved cyclone preparedness, and comprehensive disaster management action plans to mitigate the impact of extreme weather events in Kerala.

Keywords

Climate change, Cyclones, Death to event ratio, Extreme weather events, Flood and heavy rains, Heat waves

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Revisiting the environmental Kuznets Curve in extended BRICS: A panel data analysis of carbon emissions, trade, and energy transition

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Climate change, driven by rising atmospheric carbon concentrations, is the defining crisis of our era—manifested through extreme heatwaves, melting glaciers, collapsing ecosystems, and widespread socio-economic disruptions. These changes displace vulnerable communities, exacerbate food insecurity, increase the global disease burden, and destabilize economies. In response, nations worldwide are adopting environmentally sustainable and climate-resilient policies aimed at reducing carbon emissions in alignment with the commitments under the UNFCCC framework. This study investigates whether such measures are effective by revisiting the Environmental Kuznets Curve (EKC) hypothesis in the context of the extended BRICS bloc—comprising Brazil, Russia, India, China, South Africa, and recent additions such as Egypt, Ethiopia, Iran, and the United Arab Emirates.

Utilizing a comprehensive panel data analysis spanning 1970 to 2024, this research tests the validity of the EKC hypothesis, which postulates an inverted-U relationship between environmental degradation and income per capita. Moreover, the study assesses the influence of climate-resilient and sustainable policy interventions on carbon emissions. A wide array of macroeconomic and socio-political variables—including trade openness, tariff structures, global oil prices, the Human Development Index (HDI), energy consumption, and energy transition metrics—are incorporated to provide a holistic understanding of the multifactorial drivers of emissions.

Keywords

BRICS, Carbon Emissions, Environmental Kuznets Curve (EKC), Energy Transition, GDP Per Capita, Oil Prices, Trade Openness

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