A.O. Kovalevsky Institute of Biology of the Southern Seas of RAS (IBSS)

VULNERABILITY OF COASTAL ECOSYSTEMS TO CLIMATE CHANGE – EXPERIENCE OF INTERNATIONAL COOPERATION

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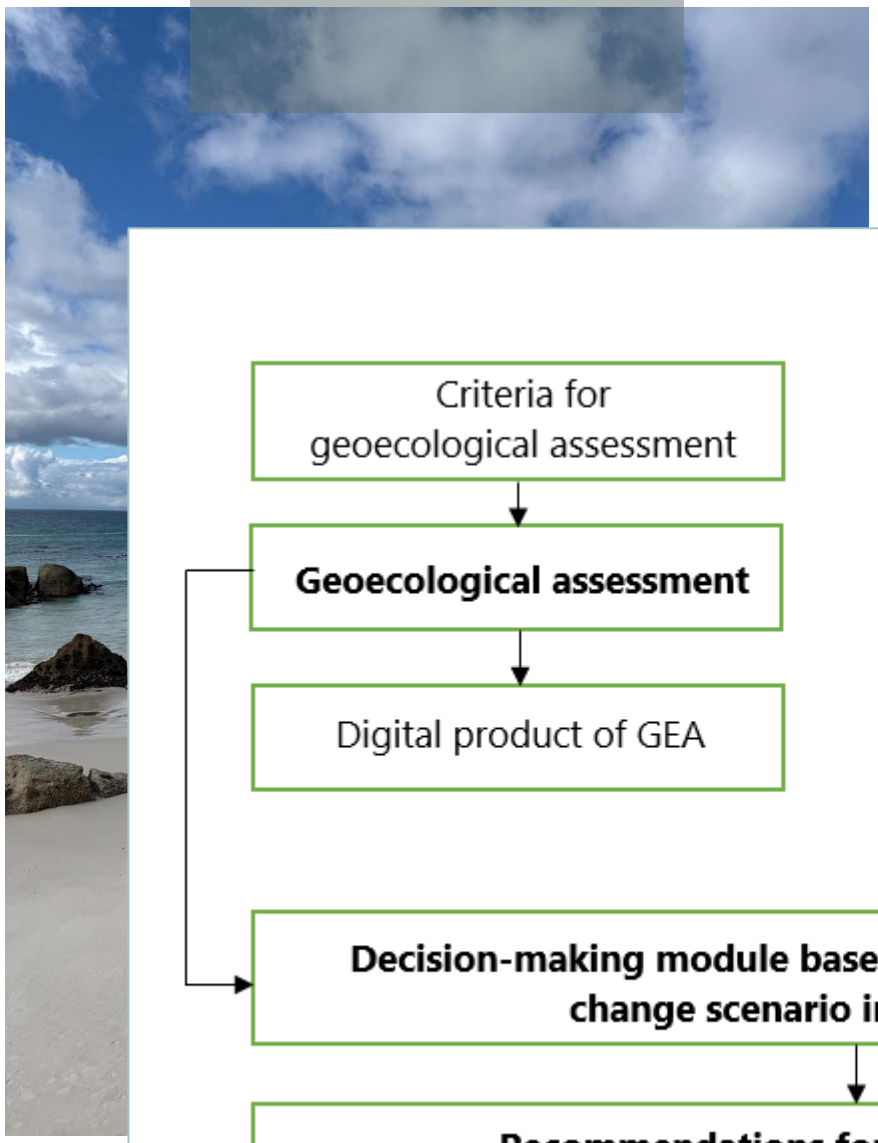
Moscow - 2025



RESEARCH METHODOLOGY :

Criteria for geoecological assessment

Geoecological assessment

Digital product of GEA

Reactions of natural and natural-anthropogenic ecosystems

Vulnerability of ecosystems

Algorithm capable to describe the effects of climate change

Climate change

Decision-making module based on the developed climate change scenario in coastal zones

Recommendations for nature management

MAIN RESULTS

Grant from the MSHE of RF № 075-15-2024-657
"Assessment of vulnerability of coastal ecosystems in the tropical zone to climate change for the purpose of adapting of governance nature management"

Project acronym VULNECOAST

The project is supported by the Ministry of Science and Higher Education of the Russian Federation as part of its grant program in the field of science, provided in the form of subsidies from the federal budget. These subsidies enable scientific research by Russian scientific organizations and/or higher education institutions in collaboration with foreign organizations, facilitating the implementation of bilateral and multilateral scientific and technological cooperation programs.

The project is implemented under the **BRICS STI Framework Program "Climate Change Adaptation and Mitigation,"** which supports outstanding research in key areas where a multinational approach can yield the most substantive results. The initiative aims to foster collaboration among scientists and research institutions within consortia that include partners from at least three BRICS countries.

VULNECOAST

"Study of the features of functioning and dynamics of landscapes of Central and Southern Vietnam under conditions of anthropogenic load and climate change in order to create a scientific basis for their rational use"

ECOLAN 1.3

The project is being carried out under the scientific research and technological work program of the Joint Russian-Vietnamese Tropical Research and Technological Center (2025-2029)

This study aims to perform a geoecological assessment of diverse landscape types in Central and Southern Vietnam. This assessment will be based on understanding how their functional processes and dynamics are transforming due to regional climate change and anthropogenic pressures, with the ultimate goal of establishing scientific principles for rational nature management.

YOUNG SCIENTISTS' INVOLVEMENT IN EXECUTING INTERNATIONAL PROJECTS



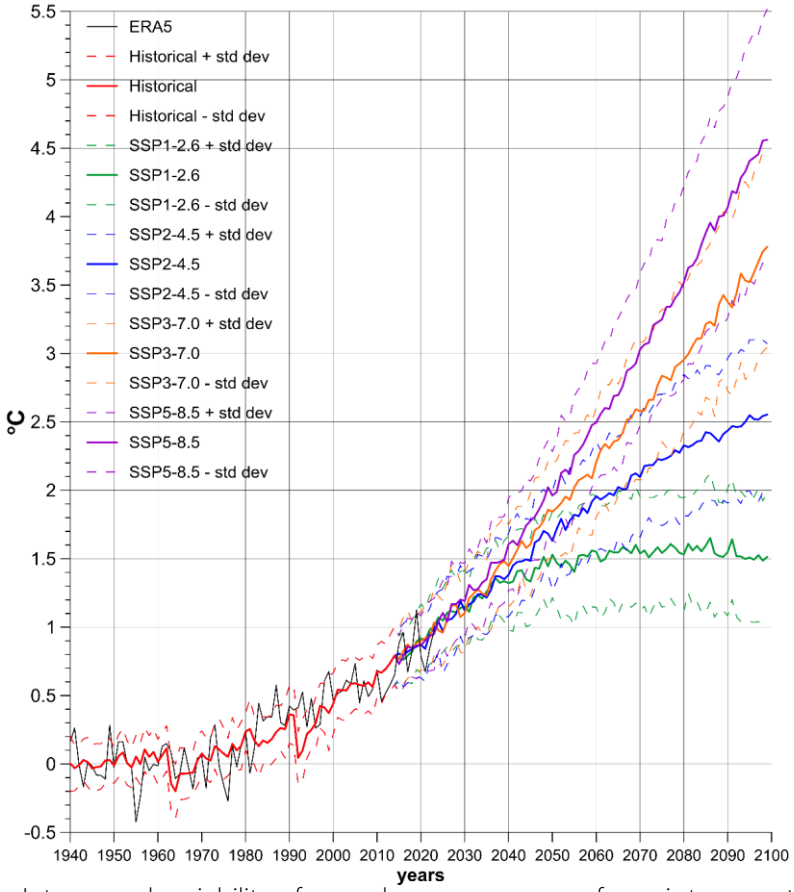




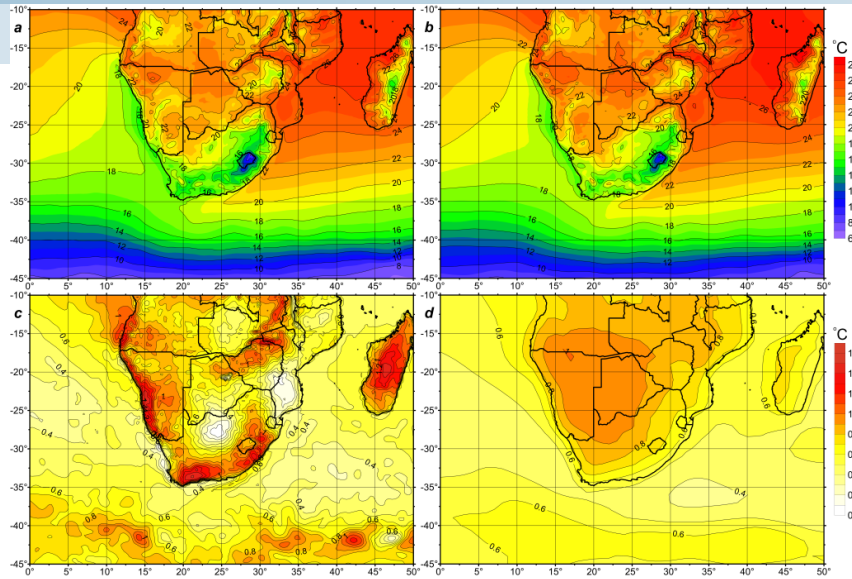


Identification of the role of global climate processes in climate change in the key areas under consideration

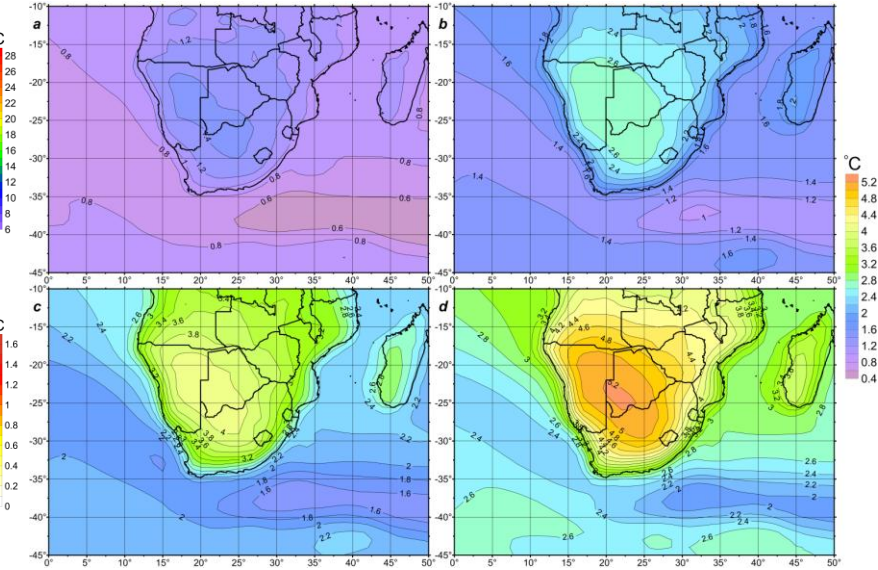
South Africa



Interannual variability of annual average near-surface air temperature anomalies (Ta, °C) over the South African region based on ERA5 data (black) for 1940–2023, and based on CMIP6 model ex-periment results for the following scenarios: Historical (red) for 1940–2014, SSP1-2.6 (green), SSP2-4.5 (blue), SSP3-7.0 (orange), and SSP5-8.5 (purple) for 2015–2099. The boundaries of the variability ranges of the 33 CMIP6 models (standard deviation) are represented by dashed lines.



Average near-surface air temperature (NSAT) (Ta, °C) from ERA5 reanalysis for 1940–1969 (a) and 1994–2023 (b). Difference between the average NSAT (ΔTa, °C) for 1994–2023 and 1940–1969 from ERA5 reanalysis (c) and from 33 CMIP6 models (Historical and SSP2-4.5 experiments) (d).



Fields of changes in average near-surface air temperature (ΔTa, °C) from 33 CMIP6 models be-tween 1994–2023 and 2070–2099 based on the results of the SSP1-2.6 (a), SSP2-4.5 (b), SSP3-7.0 (c), and SSP5-8.5 (d) scenarios.

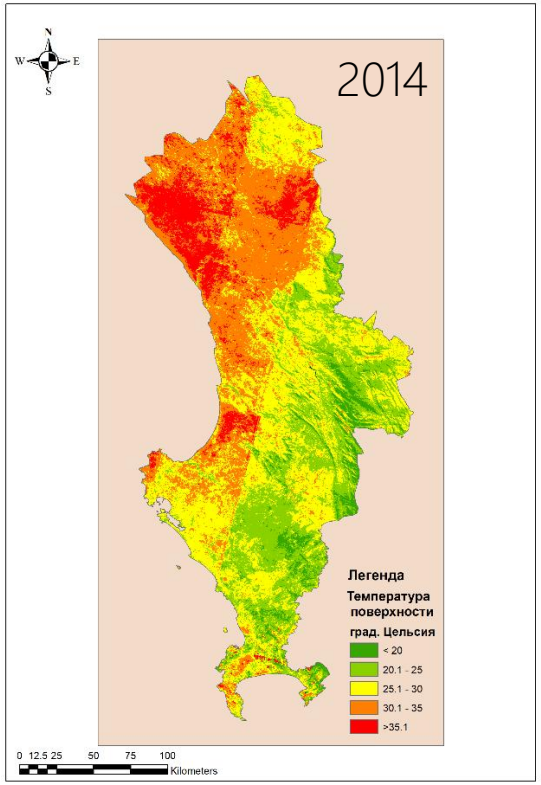
According to ERA5 reanalysis, the increase in average NSAT in the region (45–10° S, 0–50° E) for 1940–2023 was 0.11±0.04 °C. Furthermore, from 1940 to the mid-1970s, weak interdecadal NSAT changes were observed, and after the mid-1970s, rapid warming began in the region.

It was found that the NSAT increase in South Africa will occur according to the results of all 33 studied CMIP6 models under any of the considered SSP scenarios, both in the next 30 years and by the end of the 21st century. The CMIP6 model ensemble showed that the average NSAT of the South Africa will increase between 1994–2023 and 2070–2099 by 0.92±0.36 °C under the SSP1-2.6 scenario, by 1.73±0.44 °C under SSP2-4.5, by 2.52±0.50 °C under SSP3-7.0, and by 3.17±0.68 °C under SSP5-8.5. Between 1994–2023 and 2025–2054, the increase in the average NSAT of the studied region, taking into account the inter-model spread, will be 0.49–1.15 °C, depending on the SSP experiment.

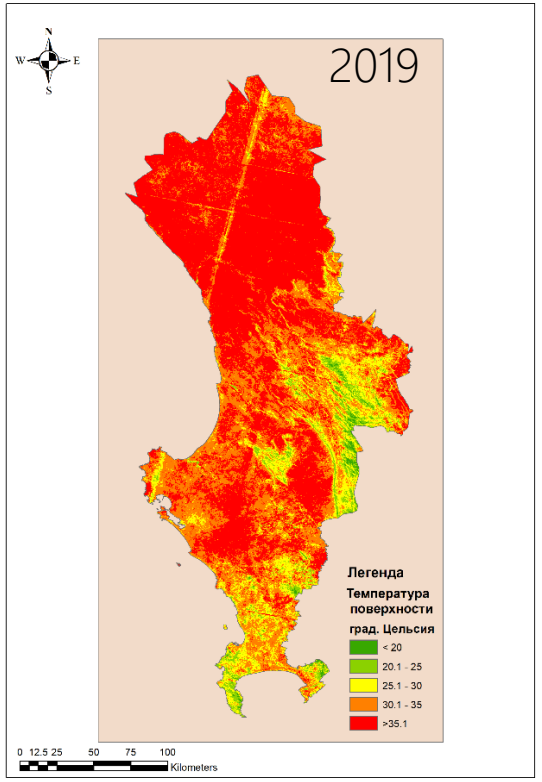
Identifying ecosystem responses to climate change

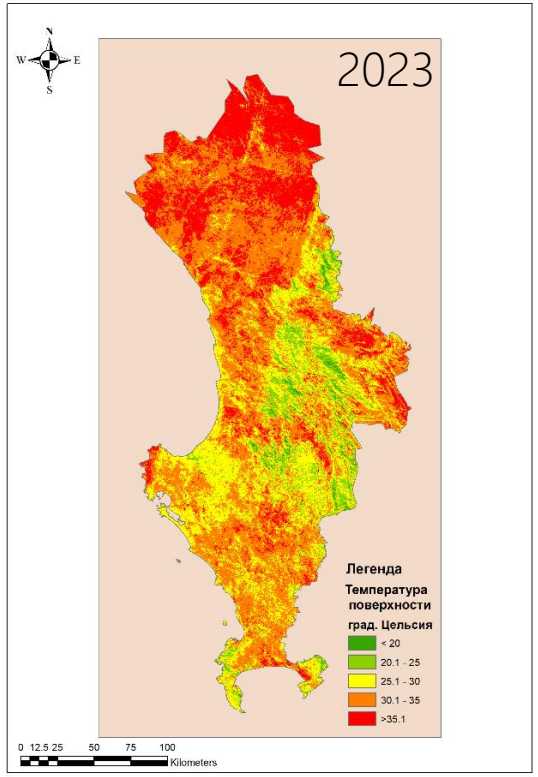
Western Coast and Cape Town, South Africa

With Earth's average annual temperature projected to increase by over +2°C by the end of this century compared to pre-industrial levels, the international scientific community has devised a strategy to avert the negative environmental consequences of global warming. However, distinct from this global trend, major urban agglomerations experience phenomena known as "urban heat islands," characterized by elevated air and surface temperatures within the urban environment.



Heat islands are localized zones of abnormally elevated temperatures, stemming from either natural or anthropogenic causes. By analyzing the developed surface temperature databases, heat islands – representing the peak surface temperature values within the examined key sites – were identified. Their temporal evolution and variability between 2013 and 2023 were then depicted.

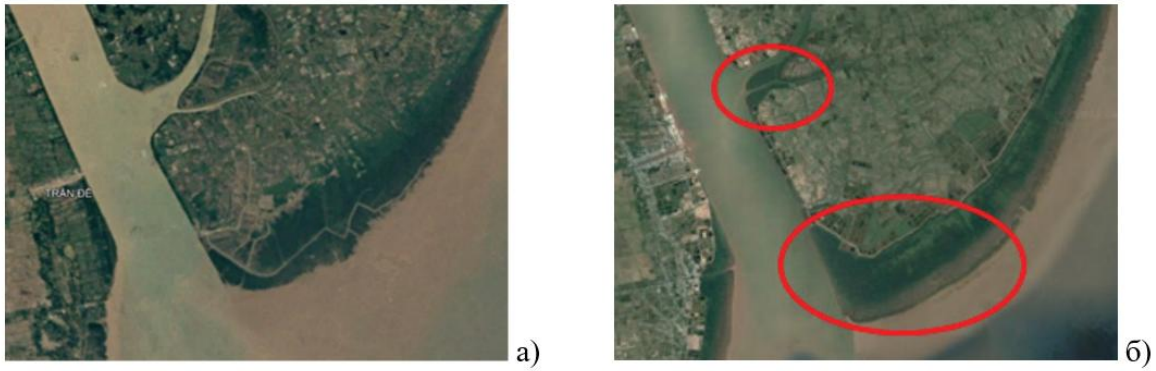




Land Surface Temperature (LST) arises from the interaction between Earth's surfaces and the atmosphere, generating heat that impacts humans. Urban heat islands and high LST are primarily instigated by human activities and the built environment, revealing an evident connection. In many urbanized cities, temperature shifts stemming from elevated LST, influenced by the prevalence of impervious surfaces, can amount to 5°C, posing increasing threats to the environment and human well-being.

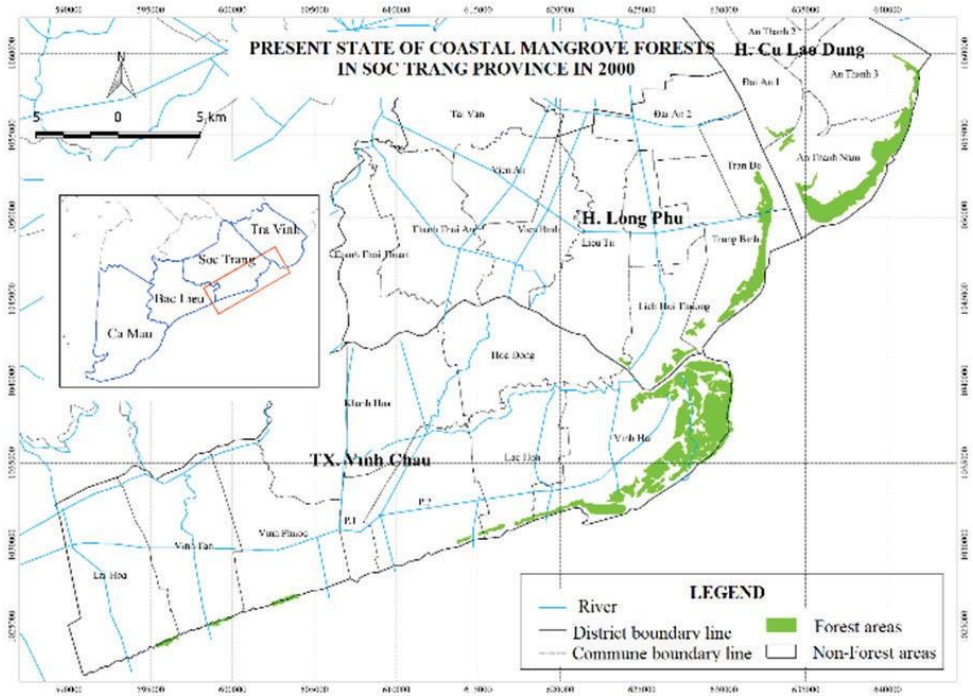
Identifying mangrove forest dynamics in Soc Trang Province, Vietnam, using satellite data from 2000 to 2020

Soc Trang province, Vietnam



Changes in forest status over time as seen from satellite images: a) the state of forest in 2000.; b) the state of forest in 2020 r.

Mangroves, unique in their adaptation to intertidal zones of tropical and subtropical regions, are crucial due to their considerable ecological and economic benefits. They play a critical role in soil stabilisation and coastal protection against natural disasters, proving more efficient at soil preservation than artificial structures. Furthermore, mangroves act as powerful carbon sinks, particularly efficient in tropical climates, sequestering carbon in both aboveground and below-ground biomass, as well as sediments. Multi-temporal satellite imagery allows for timely and accurate assessment of spatially distributed variables, including changes in mangrove vegetation cover.



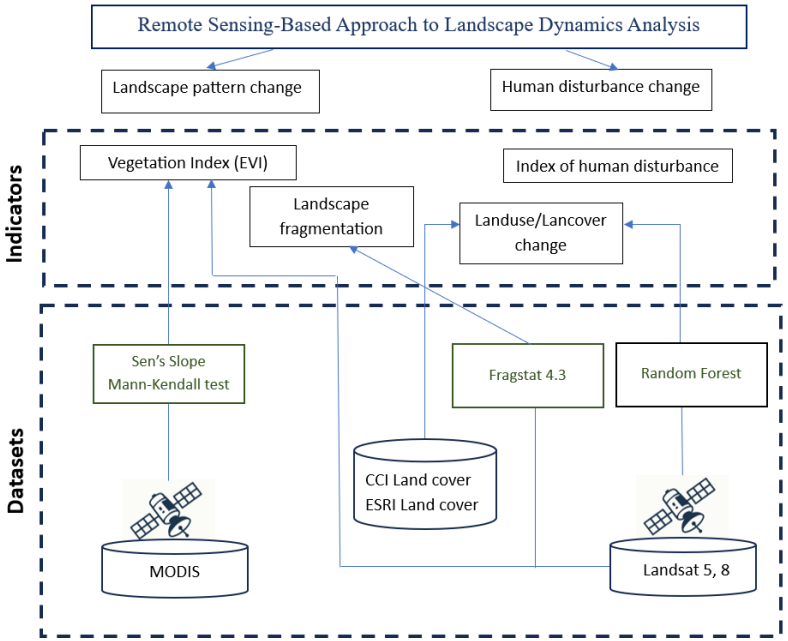
Map shows changes in the state of coastal forest in Soc Trang province between the period 2000–2020

Analytical results revealed that from 2000 to 2020, the mangrove area in Soc Trang province has increased. Generally, the forest in the coastal region of Soc Trang province has been rehabilitated and expanded over time. Based on these research results, the authors have established a map demonstrating the current state of the coastal mangrove forest in Soc Trang province. The findings presented a somewhat optimistic picture of the changing dynamics of South Vietnam's mangroves in general, and specifically in Soc Trang province, reflecting a transition from a negative trend to a positive one. Measures taken for the protection and restoration of mangrove forests have started to yield initial results. The analysis indicated that protection efforts have made the most significant contribution, primarily by reducing deforestation. Restoration efforts, on the other hand, have produced less noticeable impacts thus far. A more nuanced analysis of changes in areas with short intervals between surveys, especially within the past decade, would assist in evaluating whether this trend is representative of Southeast Asia as a whole.

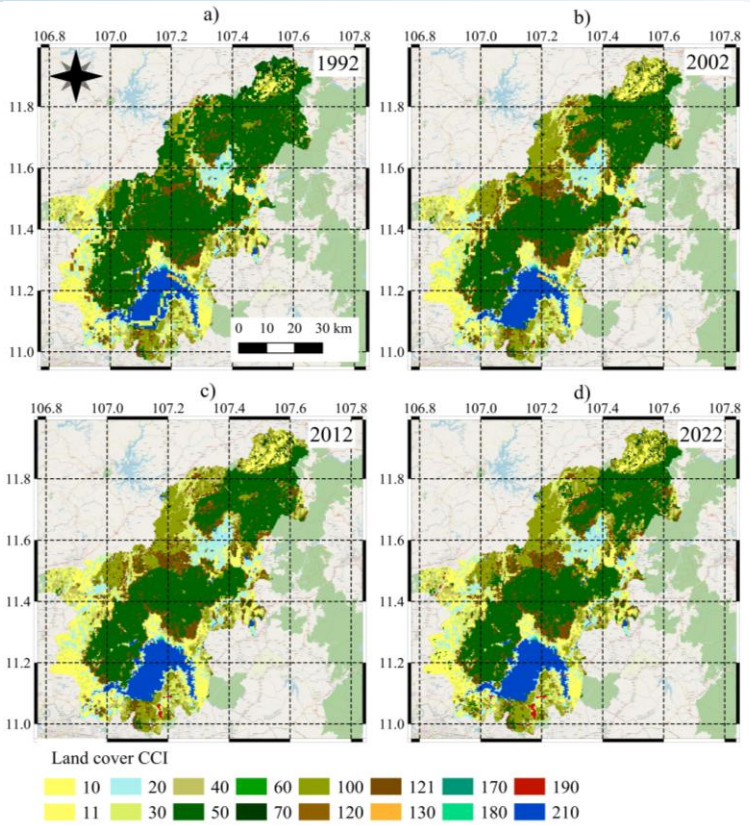
Identifying ecosystem responses to climate change

Dong Nai Biosphere Reserve

Recent research highlights the significant vulnerability of tropical forests, particularly coastal ones, to anthropogenic pressures and climate change. The monitoring of tropical forest status is crucial. Remote sensing techniques enable the extraction of landscape structure information through classified imagery (Land Use / Land Cover) and spectral indices. Tropical forest ecosystems face threats from forest fragmentation, which modifies habitat structure, compromises species range integrity, and may result in biodiversity decline. The spatial configuration of the landscape also impacts energy and material fluxes, including water cycles, biogeochemical cycles, and pollutant dispersal. Highly fragmented areas may promote accelerated surface runoff and soil erosion. This subsequently influences ecosystem resilience to floods, droughts, and other extreme phenomena, particularly against the backdrop of climate change. Furthermore, fragmentation metrics themselves (e.g., patch size, isolation index, contour shape, degree of clustering) act as quantitative indicators of these processes, enabling landscape state diagnostics and the modeling of transformation consequences.



Methodological framework for analyzing landscape dynamics using remote sensing data



(10—Rainfed cropland, 11—Herbaceous cover, 20—Irrigated cropland, 30—Mosaic cropland >50%/natural vegetation <50%, 40—Mosaic natural vegetation >50%/cropland <50%, 50—Tree cover, broadleaved, evergreen, closed to open (>15%), 60—Tree cover, broadleaved, deciduous, closed to open (>15%), 70—Tree cover, needleleaved, evergreen, closed to open (>15%), 100—Mosaic tree and shrub (>50%)/herbaceous cover (<50%), 120—Shrubland, 121—Evergreen shrubland, 130 —Grassland, 170 —Closed (>40%) broadleaved forest or shrubland permanently flooded water,180 —Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil,190—Build up (Urban), 210—Water).

PROBLEMS AND RISKS

- Different financial opportunities
- Finding mutual intersection points
- Different legal framework
- Language barrier
- Different levels of involvement of young scientists

11

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FOR YOUR ATTENTION!

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