

Synopsis

An assessment and predictive modelling of land use and mangrove cover change dynamics in the Sundarbans Biosphere Reserve from the perspective of climate change

Sundarbans Biosphere Reserve (SBR), a world heritage and a Ramsar site, with 4.37 million strong human population (2011) and 100 odd Royal Bengal Tigers in the mangrove forest of unique species diversity has undergone rapid changes over the last two decades due to various natural and anthropogenic forcing. Rapid land conversion of agricultural land and marginal forest to human settlement as well as aquaculture has been reported (Chopra et al. 2009, DasGupta et al. 2018). On the other hand, loss of mangrove area (Giri et al. 2007), as well as its health deterioration (Ishtiaque et al. 2016), is raising serious concern over the sustainability of this global heritage. The present research envisages developing probabilistic models of various land use/land cover change and mangrove forest cover under different climatic scenarios in the SBR up to 2050.

Statement of the problem: Increasing erosion, sea-level rise, cyclone frequency, and intensity, population growth, salinity change, water unavailability, unplanned land conversion, embankment breaching, pollution (soil, water, air), deforestation, subsidence are causing mangrove loss, deterioration of its health and overall changes in land use/land cover (LULC) in the SBR region (Bera and Maity 2019, Ghosh et al. 2015, Hazra et al. 2002, Mandal and Hosaka 2020, Hazra and Samanta 2016, DasGupta et al. 2018, Sardar and Samadder 2021, Samanta et al. 2021). The Sundarbans is also vulnerable under changing climate scenarios (Das et al. 2020). Mangroves are degrading in terms of health as well as the areal extent and with accelerating sea-level rise they will continue to submerge in this century (Ishtiaque et al. 2016, Awty-Carroll et al. 2019, Payo et al. 2016, Samanta et al. 2023).

Study Area: Sundarban Biosphere Reserve (SBR) of India.

The gap in the previous researches: Dutta and Deb (2012) produced a LULC change map of the SBR using Landsat satellite images concentrating on mangrove change. The findings showed a decline in open mangroves over time, which is just the opposite of the dense mangrove area. Sahana and Sajjad 2019 revealed that the LULC of the SBR has been diversely changed during 1975-2015. Their findings also revealed that there has been a dramatic increase in settlement, swamp, and water-logged areas. Their study also showed that the vegetation/plantation in the study area is also decreasing. DasGupta et al. 2018 in their study aimed to explore the decadal land-use changes in the Indian Sundarbans delta, particularly the changes in mangrove cover and to identify the likely trade-off between loss of agriculture and expansion of aquaculture. Sardar and Samadder 2021 have tried to understand the past trends of land-cover change (1998-2018) and project the future distribution of land covers. They also tried to understand the greater Sundarban landscape dynamics under landscape ecological parameters. However, none of this research concentrated on the classification of cropland into cropping areas of three intensities, distinction between fringe mangroves and reserve forest or classification based on species composition and health of the mangrove forest, and their changes

In this present research work, LULC has been classified into fifteen (15) classes. This is a first attempt of this kind where LULC is classified considering three crop systems (mono-crop, double-crop, and triple crop). In the study, the prediction of LULC will be done up to 2030 and 2050 under the business as usual scenario.

Mangrove change due to sea-level rise is already studied by Payo et al. (2016) using the SLAMM model in Bangladesh with certain limitations (GDTR=0). This research produced the mangrove change in SBR in a more sophisticated way using the SLAMM model and three RCP scenarios. Future projection of shorelines with sea-level rise has been done for calculating future mangrove loss in the SBR. Ishtiaque et al. 2016 have generated MODIS-based ecosystem health on Sundarbans. Awty-Carroll et al. (2019) have made Landsat based health conditions from 1988 to 2018 using classification and NDVI. High resolution and accurate mangrove species mapping and species-specific health deterioration assessment has been carried out in this research for future planning and policymaking.

Thus, the Objectives of the present research to achieve the above goal:

1. Study the LULC change of two decades (2000-2020 period) and land use projection for the years 2030 and 2050.

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2. To model future scenarios of LULC in the SBR under different socio-economic and climatic conditions under the BAU scenario
3. To analyze the changes in the mangrove health and decline in forest area over the past twenty years (2000-2020 period with emphasis on the climatic drivers for the change
4. To model habitat transitions in the Sundarbans, encompassing mangrove loss and migration, across various climate change and sea level rise scenarios throughout the 21st century.

To achieve the first two objectives the LULC change for the years 2000, 2010, and 2020 has been analysed using Landsat TM, ETM+, and OLI Satellite data and supervised classification technique. A hybrid CA-Markov Chain modelling has been used for projection of future LULC scenario under the business-as-usual scenario for the years 2030 and has been generated and discussed with various stakeholder for future planning.

To address the third objective on the examine the health of the mangrove forest, the present research analyses the variations in both the extent and health parameters of the mangroves within the Indian Sundarbans Forest from 2000 to 2020 using remotely sensed data and ground truthing both the changes in mangrove forest area, species composition, and health indicators across the Indian Sundarbans using Landsat and MODIS satellite imagery have been accomplished. The assessment is conducted at spatial, temporal, and seasonal levels by directly measuring forest area changes and developing health-related indicators, such as different vegetation indices. For evaluating the potential factors influencing observed changes in mangrove ecosystems, this study examines historical drivers such as land reclamation, ongoing progressive factors like temperature rise and declining rainfall, sea level rise and sudden disturbances, including frequent cyclone and surges

To address the fourth objective is how the Sundarban mangrove forest will behave with progressive climate change and sea level rise scenarios, a hybrid model is employed, combining the Sea Level Affecting Marshes Model (SLAMM) for simulating habitat changes driven by subsidence and inundation constrained by presence and absence of protective embankments with an empirical model capturing shoreline erosion induced by sea-level rise (SLR). The study conducts a series of exploratory simulations considering the regional climatic pathways or RCP 2.6, RCP4.5, and RCP8.5 with future climate trends for global SLR. Additionally, geological subsidence in the delta region is factored in, along with a constraint on the mangroves' ability to vertically accrete.

The present research finds that between 2000 and 2020, mangrove cover declined by 4%, wetlands by 50%, and single-cropped agricultural land shrank by 38.4%, while urban settlements increased by 64.7% and aquaculture expanded at the cost of agricultural land. By 2050, urban settlements are projected to expand by 155.9%, mangrove cover may shrink by an additional 9.7%, and aquaculture could rise by 25.4%, exacerbating biodiversity loss and ecosystem degradation. However, exploratory simulations of the Indian Sundarbans' response up to 2100 under various RCPs and SLR scenarios indicate that 42% to 80% of mangrove cover could be lost if current management practices continue in the future. The scenario of managed realignment, though can mitigate some of the losses allowing the mangroves to migrate towards the human habitat, but may require significant trade-offs, including the relocation of human settlements and repurposing of productive land.

It is envisaged that the study would help in developing an integrated adaptation strategy for the mangrove forest and human habitat of the Sundarban Biosphere Reserve under climate change adhering to the sustainable development goals for 2030.

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Sourav Samanta.
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