An assessment of the impact of human-induced changes on ecosystem services in the Sundarban Biosphere Reserve region, India

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Ecosystem services are the bundle of natural processes and functions which are crucial for human well-being, subsistence, and livelihood. Human appropriation, especially unusual changes in land-use and land cover, significantly affects ecosystem services and functions. The Sundarbans is the world's largest mangrove forest ecosystem situated in the coastal region of the Bay of Bengal, India, and Bangladesh. In 1987, Sundarban was acknowledged as a UNESCO World Heritage Site, and on 21 May 1992, it was acknowledged as a Ramsar Site of ecological importance. The area studied was divided into six major categories; cropland, mangrove forest, sparse vegetation, built-up urban area, water bodies and sandy coast, and the land coverage was calculated for the years 1973, 1988, 2002, and 2013. Two major provision services (Food production, Raw material production), four regulation services (Gas regulation, Climate regulation, Freshwater regulation and supply, and Waste regulation), two supporting services (Soil conservation and control and Biodiversity and habitat conservation) and one cultural and recreational service (aesthetic provision service) were incorporated to quantify the spatiotemporal changes of ESV. The spatial explicit value of the primary regulatory and supporting ecosystem services (climate regulation, raw material production, water regulation) was quantified through the indirect market valuation approach. Several light use efficiency (LUE) based ecosystem model, i.e. Carnegie- Ames-Stanford-Approach (CASA), Vegetation Photosynthesis Model (VPM), Eddy-Covariance Light Use Efficiency (EC-LUE) including the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model was employed to estimate various regulatory, supporting, and provisioning ecosystem services for Sundarban biosphere region (SBR). During 1973 – 2013, ESV (million US$ year) of mixed forest has been decreased by 20.73% (26.19 in 1973 to 20.76 in 2013) with -0.52% yearly decreasing rate, followed by water bodies (-7.87% (2882.52 in 1973 to 2655.63 in 2013) with -0.20% yearly decreasing rate), and cropland (-2.73% (65.08 in 1973 to 63.31 in 2013) with -0.07% yearly decreasing rate, respectively. In this period, the ESV of mangrove has been increased by 2.62% (2291.71 in 1973 to 2351.65 in 2013) with 0.07% yearly increasing rate. Waterbodies were found most sensitive (with higher coefficient of sensitivity (CS) value, 0.55, 0.56, 0.52 and 0.52 in 1973, 1988, 2002 and 2013), followed by mangrove (0.44, 0.49, 0.46 0.46), and cropland (0.01, 0.01, 0.01, 0.01), respectively.