Estimation of Mangrove Net Primary Production and Carbon Sequestration service using Light Use Efficiency model in the Sunderban Biosphere region, India

Srikanta Sannigrahi, Somnath Sen, and Saikat Paul

Department of Architecture and Regional Planning, Indian Institute of Technology, Kharagpur, India
(srikanta.arp.iitkgp@gmail.com)

Net Primary Production (NPP) of mangrove ecosystem and its capacity to sequester carbon from the atmosphere may be used to quantify the regulatory ecosystem services. Three major group of parameters has been set up as BioClimatic Parameters (BCP): (Photosynthetically Active Radiation (PAR), Absorbed PAR (APAR), Fraction of PAR (FPAR), Photochemical Reflectance Index (PRI), Light Use Efficiency (LUE)), BioPhysical Parameters (BPP) :(Normalize Difference Vegetation Index (NDVI), scaled NDVI, Enhanced Vegetation Index (EVI), scaled EVI, Optimised and Modified Soil Adjusted Vegetation Index (OSAVI, MSAVI), Leaf Area Index (LAI)), and Environmental Limiting Parameters (ELP) (Temperature Stress (TS), Land Surface Water Index (LSWI), Normalize Soil Water Index (NSWI), Water Stress Scalar (WS), Inversed WS (iWS) Land Surface Temperature (LST), scaled LST, Vapor Pressure Deficit (VPD), scaled VPD, and Soil Water Deficit Index (SWDI)). Several LUE models namely Carnegie Ames Stanford Approach (CASA), Eddy Covariance – LUE (EC-LUE), Global Production Efficiency Model (GloPEM), Vegetation Photosynthesis Model (VPM), MOD NPP model, Temperature and Greenness Model (TG), Greenness and Radiation model (GR) and MOD17 was adopted in this study to assess the spatiotemporal nature of carbon fluxes. Above and Below Ground Biomass (AGB & BGB) was calculated using field based estimation of OSAVI and NDVI. Microclimatic zonation has been set up to assess the impact of coastal climate on environmental limiting factors. MODerate Resolution Imaging Spectroradiometer (MODIS) based yearly Gross Primary Production (GPP) and NPP product MOD17 was also tested with LUE based results with standard model validation statistics: Root Mean Square of Error (RMSE), Mean Absolute Error (MEA), Bias, Coefficient of Variation (CV) and Coefficient of Determination (R^2). The performance of CASA NPP was tested with the ground based NPP with $R^2 = 0.89$ RMSE = 3.28 P = 0.01. Among the all adopted models, EC-LUE and VPM models has explained the maximum variances (>80%) in comparison to the other model. Study result has also showed that the BPP has explained the maximum model variances (>93%) followed by BCP (>65%) and ELP (>50%). Scaled WS, iWS, LST, VPD, NDVI was performed better in a minimum ELP condition whereas surface moisture and wetness was highly correlated with the AGB and NPP ($R^2 = 0.86$ RMSE = 1.83). During this study period (2000-2013), it was found that there was a significantly declining trend ($R^2 = 0.32$ P = 0.05) of annual NPP and the maximum decrease was found in the eastern part where built-up area was mainly accounted for reduction of NPP. BCP are explained higher variances (>80%) in the optimum climatic condition exist along the coastal stretches in comparison to the landward extent (>45%).