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Carbon Stock Estimation using Geo-Spatial Approach in Sariska Tiger Reserve (Rajasthan)

Abstract

Forests are the potential source for managing carbon sequestration and regulating climate variation. Forests especially in many Reserves have become drivers of generating carbon dioxide. Hence, the assessment of carbon stock and its spatial distribution is prerequisite for maintaining the health of forest ecosystem. The study estimated carbon stock using field inventory and Sentinel-2 data. We calculated Above Ground Biomass (AGB) using diameter at breast height, and volume parameters using allometric equation. We utilized Akaike's information criterion (AIC) model for estimating above ground biomass (AGB) for each species. Relationship between field based AGB and diameter at breast height (DBH) for six forest species in STR was analyzed using linear, logarithmic, polynomial and exponential models. Regression analysis of four vegetation indices provided best suitable bands (Red and NIR) for vegetation index. The vegetation index with highest semi-logarithmic value was considered as best predictor for carbon stock. The carbon stock was estimated through transformation of obtained biomass into carbon using conversion factor. Various widely used spectral vegetation indices have been used to establish an equation for assessing AGB, but however one of the indices Moist Adjusted Vegetation Index (MAVI) shows the better relation with ground surveyed data as the both NIR and Red band is used to calculate MAVI, which provides effective biophysical information of vegetation. Machine learning algorithm was used to validate Sentinel 2A derived biomass with field derived biomass and calculating the carbon.

A total of thirty soil samples were collected and analyzed with Walkley-Black titration method for estimating soil organic carbon. The carbon derived from machine learning algorithm and laboratory based SOC were integrated to estimate total carbon in STR. The estimated AGB was modelled with MAVI derived through satellite data. Regression analysis was performed to establish the relation between AGB measured through field sampled data and MAVI (predicated variable), which is found to be 0.87. The study also developed the machine learning linear regression to predict the AGB using the independent variable MAVI, where a set a sample set were derived using random process from the whole data set to validate the result on the test data set. The outcomes showed that the developed machine learning models were able to forecast the AGB efficiently with $R^2 = 0.90$ for the test data set, with a Root Mean Square Error (RMSE) of 3.65 t/ha. Carbon stock map derived from the AGB data revealed that the carbon stock varied with vegetation density. The average carbon stock of forty sampled tree species was found to be 40 t/ha. The carbon stock in *Boswellia serrata* is (35-48 t/ha) followed by *Anogeissus pendula* (20-35 t/ha), *Butea monosperma* (12-20 t/ha), Mixed *Acacia-Zizyphus* (6-12 t/ha), Mixed riverine forest (6-7 t/ha) and Mixed forest (3-6 t/ha). The highest concentration of carbon was found in *Boswellia serrata* Planch., *Anogeissus pendula* Edgew. Spatial distribution of carbon stock in the reserve showed that the high concentration and largest area of carbon stock was found in Core I followed by Core II, Core III and Buffer zone. The finding of the study can be helpful in maintaining species wise carbon stock spatially in the Sariska Tiger Reserve (STR). The methodology utilized in this study can help forest managers, environmentalist and conservationist in decision-making process for forest ecosystem management at various scales.

Keywords: Species diversity, Ecological indices, Soil organic carbon, Above Ground Biomass, Total Carbon Stock, Akaike's Information Criterion (AIC) model, Machine learning model, Sariska Tiger Reserve.