

Synopsis of Thesis

**Modelling of NPP over Tropical Deciduous Forest using
Meteorological and Satellite Data**

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Terrestrial net primary production (NPP), the time integral of the positive increments to plant biomass, is the central carbon-related variable summarizing the interface between plant and other processes. It describes both the removal of carbon from the atmosphere and the potential delivery of carbon to herbivores, decomposers, or humans interested in food or fiber. As a principal indicator of ecosystem health, resource utilization, and biospheric carbon fluxes, NPP is of great importance to ecological studies, natural resource management, and estimates of the terrestrial carbon sink. Terrestrial ecosystems drive most of the seasonal and inter-annual variations in atmospheric carbon dioxide (CO₂) concentration and have taken up about one-fifth of the total anthropogenic emission of CO₂ since the Industrial Revolution (Prentice and others 2001). Atmospheric measurements and inverse modeling reported that the net terrestrial carbon uptake increased substantially from the 1980s to the 1990s, but the causes of the increase are not well understood. Quantifying variations in terrestrial NPP should provide insight into the processes and factors that regulate the terrestrial carbon sink. Net primary production is highly variable in space and time. Spatial variations of NPP are related to factors such as climate, vegetation distribution, and land use across the planet from local to global scales. Temporal changes in NPP are linked to both “fast” processes (such as diurnal and seasonal variability in weather and the consequent physiological responses) and “slow” processes (such as changes in atmospheric composition, climatic changes, and ecosystem redistribution).

Field based, satellite based and Process-based ecosystem models have been widely applied as a means of quantifying spatio-temporal variations in NPP at large scales. Field based NPP measurements have been conventionally carried out using long term ecological monitoring of biomass in selected ecological site. Most frequently, peak-standing biomass is assumed to measure NPP in grassland ecosystem. Methods to measure forest productivity are more diverse than those of grasslands. Biomass increment based on stand specific allometry plus litter fall is used to

estimate NPP. Field NPP measurements are more accurate but time and labor-intensive nature, tedious, and are limited by its spatial distribution, which are difficult to upscale for understanding the global carbon balance. It is, therefore, necessary to calibrate and use computer-based models in combination with remote sensing and other datasets to quantify the spatio-temporal variability of NPP. The most commonly used remote sensing data include vegetation indices as the key-driving variables, land surface properties in the form of land/vegetation cover types, and soil properties.

Global ecosystem models ranging from simple one based on light use efficiency (LUE) to more mechanistic one based on Soil-Vegetation-Atmospheric-Transfer scheme are designed to overcome difficulties involved in capturing variability in biospheric processes and NPP over space and time. LUE based models are less complex and easily amenable to remotely sensed data, which has made them widely acceptable to map primary production of the terrestrial biosphere over large areas. Satellite data-driven LUE models such as C-Fix, CASA, GLO-PEM, SDBM etc, and Moderate Resolution Imaging Spectroradiometer (MODIS) NPP algorithm have been developed and tested to analyze spatio-temporal pattern of NPP over continents or global land surface. Estimates of daily gross primary production (GPP) and annual net primary production (NPP) at the 1-km spatial resolution are now produced operationally for the global terrestrial surface using imagery from the MODIS sensor. Similar NPP product (with spatial resolution of 1 km and temporal resolution of 10 days) based on C-fix model also operationally available at Geo-success. Many studies are being carried out to estimate the terrestrial NPP and analyze its spatio-temporal variability over India. However, most of these studies could not explain the broad spectrum of NPP seasonal variability over the country; they led to different estimates of seasonal and annual NPP budgets over the country owing to the following limitations: (1) studies are carried out for different years; (2) different methodology and datasets are being used, (3) no attempts are made to describe inter-annual variability of NPP over India.

.India rank 10th amongst the most forested countries of the world with 20.6 percent (77.82 Mha) of its geographical area under forest and tree cover. Of which,

maximum area (15%) comprised by deciduous forest. However, net carbon exchange between the forest and the regional atmosphere has been little studied. Thus an accurate assessment of carbon fixation in the ecosystem is fundamental for realistic global and regional carbon budgets and for projecting how these will be affected by changing climate and atmospheric composition. To overcome this circumstance reliable biogeochemical model is indispensable. Field measured NPP and remote sensing derived NPP data are further needed for validating and calibrating global biogeochemical models. Field data on the relation of tropical forest NPP to these factors are needed to resolve these uncertainties. Such data will also be important for assessing the carbon-sequestering potential of these forests and as benchmarks for carbon offset agreements involving tropical countries. Keeping the aforesaid perspectives in the mind, the study has been carried out by **modelling NPP in tropical deciduous forest using satellite and meteorological data**. Study has been also carried out to understand the **influence of regional weather parameters on NPP of the forests**.

The study was conducted in **three wildlife protected national parks** in Madhya Pradesh (India). The regions have predominantly covered by dry deciduous and moist deciduous forest species. Sub-humid climatic conditions prevail over these regions. Usually, May is the hottest month with a mean daily maximum temperature of about 40°C and January is the coldest month with average daily maximum and minimum temperatures of about 24°C and 7°C, respectively. Total annual rainfall in the regions varies from 895 mm to 1445 mm. About 90 percent of the annual rainfall in the regions is received during the monsoon months (June-September). The regions are found climatologically distinct. Diversity and uniqueness was observed in the NPP estimated from the quadrates laid out across different forest types and density in the regions. Many of the representative trees were marked for long-term monitoring of biophysical parameters (Phenology, biomass etc). Satellite based NPP was estimated using Global Production Efficiency Model (GloPEM) and Modified Carnegie-Ames-Stanford Approach (CASA) Model. Inputs are necessitated to train the models were provided by satellite based measurements, field measurements or literature survey. Assessment of the model estimates was carried out by comparing estimates with the field based NPP estimates. Influence of regional weather

parameters on the seasonal and inter-annual variation in NPP was studied by comparing the model based estimates with long-term satellite measured weather parameters in the study regions.

Analysis of field, satellite and process based model showed high NPP in moist deciduous forests compared to the dry deciduous forest. Assessment of satellite based NPP indicted a good agreement with field NPP. Comparison between seasonal and inter-annual variability of NPP with satellite based regional weather parameters showed a good correlation. The field measurements based NPP estimates are very much required in assessing landcover specific net carbon fixation as well as for validating the satellite derived NPP products. The satellite derived NPP would be helpful in quantifying the actual quantitative contribution of deciduous forest ecosystem in the global carbon cycle. Understanding the relationship between NPP and regional weather parameters would help in projecting climate and ecosystem models. **Detailed results and interpretation will be included in the thesis with appropriate statistical analysis and relevant citations.**