자연 삼림의 탄소 분리 추정에 관한 연구

Estimation of carbon sequestration in natural forests - A Geospatial Approach -

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요 약

Estimation of carbon in the natural forest regions is a pre-requisite for carbon management. In the light of increasing carbon dioxide concentration in the atmosphere, the amount of carbon present in the plants and soils are very much needed to estimate the sequestered carbons stock of any region. Carbon stock estimation studies are limited in India, especially in the natural forest regions of Eastern ghats of Tamil Nadu. Remote sensing, Geographical Information System (GIS) and global positioning system (GPS) were used along with extensive field and laboratory works to estimate the carbon stock in the living biomass and soil. About five forest types were identified and mapped using satellite data. The total biomass carbon including above and below ground were 2.74 Tg and the total soil organic carbon was 3.48 Tg. This study has yielded significant information about the carbon stock in a natural forest region and it could be used for future comparative studies.

1. Introduction

The world has now realized the effect the CO2 in global climatic change. Houghton et al., (1997) predicted that carbon dioxide emission to the atmosphere would increase from 7.4 Gigatons (Gt) carbon (C) per year in 1997 to approximately 26 Gt C per yr by 2100. The documentation of carbon stored in forest biomass and soil was started during 1980. Several studies have established the fact that carbon sequestration by trees could provide relatively low-cost net emission reductions. In India, the studies related to carbon sequestration by natural forests are very limited. Few attempts were made to assess carbon sequestration studies at macro level (Chaturevedi and Khanna, 1982), mostly with the available data. No attempt has been made so far to assess the biomass and soil carbon sequestration at micro-level. Therefore, a pilot study is taken up to estimate the carbon stock available in a natural forest in the Eastern Ghats of Tamil Nadu (TN), India using geospatial technology.

2. Study Area

The Eastern Ghats of TN is a broken chain of hills spread in the eastern side of the TN state. The present study

was carried out in one of the hills, situated in the Namakkal district of TN. Geographically it is situated between 11°10'–11°30 N and 78°15'–78°30' E, covering an area of about 503 sq. km. The altitude ranges from 200 to 1415 m msl. The study area has both forest and non-forest area. Geomorphologically it is a structural hill made up of composite valleys on all side, which are occupied by forest of various types and density. As far as climate of this region is concerned the temperature ranges from 18 - 31℃ and the rainfall is 1318 mm annually.

3. Materials and Methods

3.1 Forest cover mapping and biomass carbon estimation

The forest type and cover density map was prepared by expert classification technique (Ramachandran et al., 2007). Growing stock volume of different forest types was estimated bivariate regression formulae developed by Ramachandran et al., (2007). Biomass of stem (timber volume) of each tree species was calculated by multiplying the volume with the wood density of each species published by Forest Research Institute, India. For certain non-timber species, wood density was calculated (Moore et al., 1981) based on the universal mean wood density of 0.2 t/m. From the timber biomass, the biomass of crown as well as the stump and root was calculated using biomass expansion factors. Finally, the total biomass of each species present in the 1 ha area in different forest types was summed up and the total biomass of each forest type was estimated. Carbon estimation from the biomass was calculated based on the methodology described by Koch (1989) and the minimum value of 49.1 was adopted as the conversion factor.

3.2 Estimation of SOC

Systematic sampling technique was adopted to estimate SOC. Samples were collected in different forest region once in two kilometers from 145 locations. Removing the top organic litter, soil samples were collected at the surface (0 to 30 cm), middle (30 to 60 cm) and bottom (60 to 90 cm) layers. Bulk density was determined using the Clad method and the determined bulk density was corrected for per cent coarse fractions. The corrected bulk density (mg m-3) was used for the estimation of SOC density (mg ha-1) and SOC stock. The SOC content in the 0.5 mm sieved soil samples was estimated by following Walkley and Black's wet oxidation method as described by Page (1988). The data were analysed using Microsoft ® Excel® worksheet. The least significant difference (LSD) was worked out using MstatC software to compare the SOC mean values of different forest types at different depths. SOC density was calculated for each layer in each profile as follows (Akala and Lal 2001).

4. Result and Discussion

The forests area occupied about 271.1 km2 and there were five forest types, namely semi-evergreen, deciduous, secondary deciduous, southern thorn and southern thorn scrub. The semi-evergreen forest occupied 39.62 km2, comprising 15% of the total forest region. The deciduous forest occupied 126.85 km2, comprising 46% of the forest area. The secondary deciduous, southern thorn and southern thorn scrub forests

Table1. Different forest types, biomass carbon and soil organic carbon status of the study area

Forest types	Timber biomass (tons/km²)	Branch and root (tons/km²)	Stumps and root (tons/km²)	Biomass (tons/km²)	Area of each forest (tons/km²)	Total biomass (M tons)	TOC A/G (Tg)	SOC stock (Tg)
Evergreen	19698.8	4727.7	6303.6	30730.2	39.62	1.22	0.60	1.01
Deciduous	16131.6	3871.6	5162.1	25165.3	126.85	3.19	1.57	1.63
Sec. Deciduous	4228.2	3719.6	4959.5	24177.3	29.60	0.72	0.35	0.35
Southern thorn	4228.2	1014.8	1353.0	6596.0	66.76	0.44	0.22	0.47
Southern thorn scrub	3685.9	884.6	1179.5	5750.0	3.04	0.02	0.01	0.03
Total	59242.8	14218.3	18957.7	92418.8	265.87	5.58	2.74	3.48

occupied 29.6, 66.76 and 3.4 km2 res pectively (Table 1). The spatial distribut ion of SOC on top layer is given in Fig ure 1.

4.1 Above and below ground biomass carbon

The total above and below ground bi omass carbon stock in Kolli hills in dif ferent forest types was estimated to be 2.74 Tg of which the semi-evergreen f orest contributed 22%, the deciduous f orest contributed to the maximum of 5 7% and the other forest types contribut ed 21%.

4.2 Estimation of SOC

The SOC content of the soils ranged from 0.1 to 9.7%, 0.1 to 5.38% and 0. 1 to 4.92% in surface, middle and bott om soil layers respectively. The mean SOC contents of surface, middle and b ottom layers were 1.40 (CI: 1.18, 1.6 3), 0.86 (CI: 0.73, 0.99) 0.66 (CI: 0.5 5, 0.78) per cent respectively. In gener al, the distribution of SOC followed the order of surface > middle > bottom lay er.

4.3 Soil organic carbon density

The maximum mean SOC density wa s found in semi-evergreen forest, 184 mg ha-1 (CI: 139.19, 228.82). The me an SOC density in the study area was 96.05 mg ha-1 (CI: 83.37, 108.73).

4.4 Total SOC stock

The total SOC stock of the study are

a was 3.48 Tg (Table 1). The SOC sto ck distribution in semi-evergreen was 1.005 Tg. In the deciduous forest it wa s 1.62 Tg. and in secondary deciduou s, southern thorn forest, and southern thorn forests, it was 0.35, 0.46 and 0. 03 Tg respectively.

4.5 Net carbon stock

The total biomass carbon was 2.74 T g and total SOC was 3.48 Tg. The tot al carbon stock in the study area was 6.22 tg. The ratio between SOC and bi omass carbon was 1.18.

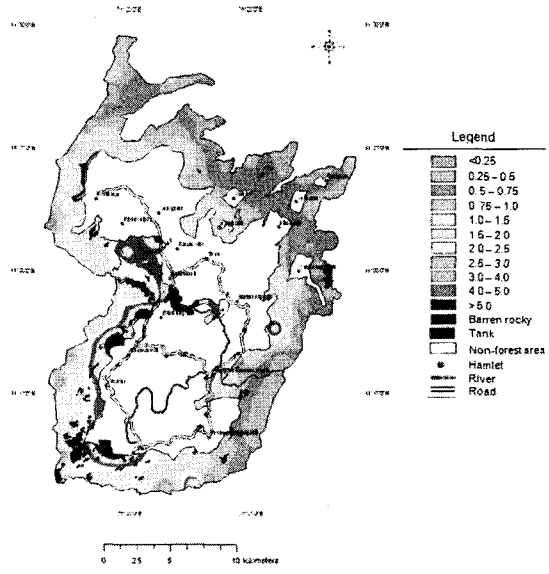

Fig1. Soil organic carbon distribution in the surface layer(0-30 cm) in Kolli hill

5. Conclusion

In the present study the carbon sto ck in terms of biomass and soil in a n atural forest was estimated in the East ern ghats of TN, India using geospatial technology. IRS 1D LISS III satellite dat a was found to be good source of inf ormation for forest classification. GIS w as very much useful in extrapolating ca rbon stock in different forest region. T he result of this study could be extrap olated to other forest area in the Easte rn ghats, where similar forest types are present with minimum field studies with GPS.

6. References

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