FOREST AS CARBON SINK - TEMPORAL ANALYSIS FOR RANCHI DISTRICT

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Abstract: It is being increasingly realized that the forests play a critical role in global carbon cycle and after significant potential to capture carbon and thus could play important role in climate change mitigation. In this background, based on growing stock of forest available in Ranchi district of Jharkhand state of India, carbon budget was prepared and comparing the past figures of growing stock; temporal carbon dynamics was also analysed. The above analysis leads to the carbon stored in the forest (Sal stratum) has decreased from 1981 to 1996, but it has increased in the forest (Misc. stratum). This suggests for mixed forest, which are otherwise also desirable for ecologically reasons - are doing better, compared to some what monoculture "Sal" forest. This gives a lead to think about possible changes in current forest management approach, as the miscellaneous forest are doing better in given constraints. The study also hints for more efforts on plantation in poorly stocked forest areas i.e. "Open canopy" and "Scrub" forests - which can help in sequestering more carbon as well. Also by using wood preservation treatments, the service life of wood used in the district can be increased to 3.07 times.

INTRODUCTION

The forest play a critical role in global carbon cycle and offer significant potential to capture and hold carbon, thus forming an important climate change mitigation option. Although, deforestation contributes to about 1.6 Gt C per year, thus provides a large mitigation opportunity to stabilize GHG concentration (2 to 4 Gt C annually) in the atmosphere (Scholes and Noble, 2001) along with significant benefits.

Forestry is broadly included under "Land use, Landuse-change and Forestry" (LULUCF) sector in climate convention. Forestry sector in the developing countries provides large and relatively low cost mitigation opportunities (Brown *et al.*, 1996; Sathaye and Ravindranath, 1998) to address climate change.

The mitigation potential of the forestry sector, based on a biomass – demand –based scenario, using short and long term commercial forestry option is estimated to be 122 Mt carbon for the period 2000-2012 (Ravindranath *et al.*, 2002). Decrease in deforestation helps preserve current carbon reservoir and afforestation helps holding carbon for longer time (Saxena *et al.*, 2003). It is estimated that preventing deforestation alone has the potential to conserve 1.5 Gt of carbon per year. This will also preserve species, which may be needed under elevated CO_2 regimes. Proper management in forestry and agriculture is a prerequisite for a stable global climate (Rawat *et al.*, 2003).

Good silvicultural practices like maintenance of optimum stocking levels and selection of trees ensure that the forests remain vigorous. These practices which may help the forests to adapt to climate change, include periodic inventories and stands examinations to provide for silvicultural prescriptions and harvest scheduling (Ciesla, 1995).

Estimating the volume of forest biomass or carbon stock by traditional field inventory methods is a difficult task due to their variability, leading to the use of remote sensing data for this purpose (Saxena *et al.*, 2003). Forest Survey of India (FSI); has developed a methodology in 1995 for integrated remote sensing satellite data with field inventory data to estimate the growing stock of forests.

Growing stock for the entire country (major forest stratum-wise) was assessed using information available from the vegetation maps, thematic maps and the ground truthing done by the FSI.

Recently, this methodology has been used by FSI and Forest Research Institute (FRI), Dehradun for assessment of 10 year change (from 1984 to 1994) in the growing stock, biomass and carbon stock of forest, under LULUCF component of India's Initial National Communications (NATCOM) to United Nations Framework Convention on Climate Change. (UNFFCC) (Saxena *et al.*, 2003).

Several other researchers have also provided estimates of forest biomass. Haripriya (2000) used FSI data on growing stock (FSI, 1995 b) and inventory data of FSI. Chabra *et al.* (2002) also used FSI data of 1995 and estimated above-ground biomass of the country. The current productivity of India's forests is very poor and ranges between 0.7-1.5 m^3 ha^{-1} yr^{-1} (TERI, 2000). Thus the present goal of Indian Forestry is to formulate a sound strategy for increasing growth and assimilation of more carbon for long-term storage in the form of wood (Pandey, 2003).

In this background, the potential of Ranchi district has been assessed. Major part of the forests of Ranchi is surrounded by villages, with a high density of population having a very high dependency on the forest . This has resulted in poor tree crop and poor carbon storage capacity. Hence, a detailed carbon budget with potential mitigation strategy for carbon sequestration is required to rejuvenate these forests in the present carbon marketing regime.

OBJECTIVES

The objectives of the present study are:

1. To prepare a stratum and district – level carbon budget for the Ranchi district.
2. To describe the temporal carbon dynamics of these forests.
3. Assessing carbon pool management through wood products.

Besides, an attempt has also been made to explore the possible potential of open canopy forests as potential sites for future carbon sequestration projects.

METHODOLOGY

For estimating the biomass and carbon budget, *interpretation of satellite data and processing of field* inventory data, collected from grids spread over Ranchi district, was carried out by FSI. Also, the data collected by FSI (1979-1981 and 1994-1995) from different sources and stand level data combined have been used.

A. In this study of FSI, Forest density - land use category occupying more than 50% of the grid was taken into account e.g. if more than 50% average was forested, the grid was marked as forest. This information was collected from satellite data used in 1979-1981 and 1994-1995 assessments. For each grid, the following three density classes were obtained from the satellite data.

Table-1: Area under different Forest Density Class

Class	Country density (%)	Area (ha)
Dense Forest	40 and above	161269
Open Forest	10 to 40	140744
Scrub	Below 10	30299
Total		332312

B. In the case of forest composition, major forest type/study (major forest species composition) in each grid was marked using information from the Thematic maps prepared by the FSI.

C. For forest inventory data, survey done by FSI has been used for determination of growing stock. The volume per ha (termed as wood volume factors) for a particular combination of density and forest composition was generated by procuring the data of forest inventory survey.

D. Biomass and carbon estimation was carried out, based on the information on forest covers for the assessment years 1979-1981 and 1994-1995, estimation has been made for the above-ground biomass and carbon stock for the corresponding data period.

E. Then the estimated volume of growing stock was converted into biomass by the following formula based on specific gravity (Rajput *et al.*, 1996; Limaye and Sen, 1956) of dominant tree species in each grid.

Biomass (tonnes) = Volume (m^3) x specific gravity

The Carbon stock in the above ground biomass was computed

Carbon (tonnes) = Biomass (tonnes) x Carbon%.

Also, the dry biomass is multiplied by the factor 0.48 for estimating carbon (Chaturvedi, 1994).

RESULTS AND DISCUSSION

Carbon storage

The total carbon pool in standing crop is estimated as 2033167.2 Metric Tonnes, 1013760 t for Sal stratum and 757632 Metric Tonnes for Miscellaneous stratum, for the year 1994-1995.

As far as tree biomass is concerned, the Sal (*Shorea robusta*) as a species mainly contributed 2224358.4 Metric Tonnes and 189235.2 Metric Tonnes respectively, as the total carbon in Sal stratum and Miscellaneous stratum respectively (Table-2).

The biomass for a particular species class has been calculated as above using the specific gravity of the species (FRI, 1983) and then converting the biomass into carbon (Chaturvedi, 1994). For the preparation of detailed carbon budget, a detailed study is needed considering all the forest types of the Ranchi district. Temporal dynamics of carbon storage is given in Table-3, which shows that there is no significant change Ct/ha in both the structures. The Ct/ha slightly decreases in Sal stratum due to absence of stems in 100+ diameter class. The marginal increase in Ct/ha in miscellaneous structure compared to 1979-1981 is obvious due to presence of trees in 100+ diameter class which contributes a substantial augmentation in this stratum. However, the situation is very poor, particularly in 10-19 cm diameter class, where there is a sharp decline in C/ha.

Table-2: Stratum wise Carbon estimates

Forest stratum	Species	Total Volume (000m³)	C(t)
Sal stratum	*Shorea robusta*	5266	2224358.4
	Buchanania lanzan	667	256128
	Terminalia crenulata	615	264204
	Madhuca latifolia	596	261763.2
	Anogeissus latifolia	278	124099.2
	others	2640	1013760
Misc. stratum	*Shorea robusta*	448	189235.2
	Adina cordifolia	356	120470.4
	Buchanania lanzan	225	86400
	Terminalia crenulata	268	115132.8
	Diospyros melanoxylon	279	111823.2
	Madhuca latifolia	559	245512.8
	Schlichera trijuga	503	266791.2
	Anogeissus latifolia	314	140169.6
	Other	1973	757632
	Total	14987	2033167.2

Temporal dynamics of carbon storage is given in Table-3 shows that more carbon storage was during 1994-1996 in miscellaneous stratum. Storage was low during 1994-1996 in Sal stratum, compared to 1979-1981.

$\triangle$ C = Ct 96 – Ct81 for Sal stratum

Where;

$\triangle$ C in change in bole carbon

Ct 96 is Carbon during 1994-1996

Ct 81 is Carbon during 1979-1981

$\triangle$ C= -0.278t.

Similarly $\triangle$ C = Ct 96 – Ct 81 for Miscellaneous stratum works out as:

$\triangle$ C= 0.068t

However, in the present study only above ground woody biomass is estimated. It can be further improved by using BEF for the entire forest composition and by including underground biomass.

Carbon pool management through wood products

A better post harvest approach that avoids waste and thus puts most of the wood into long lived

Table-3: Comparison of different stratum, temporal change in biomass

Diameter class (cm)	Stratum-Sal Area surveyed in				Stratum-Miscellaneous Area surveyed in			
	1979-1980 & 1980-1981		1994-1995 & 1995-1996		1979-1980 & 1980-1981		1994-1995 & 1995-1996	
	Volume (m³)/ha	C(t)/ha	Volume (m³)/ha	C(t)/ha	Volume (m³)/ha	C(t)/ha	Volume (m³)/ha	C(t)/ha
10 - 19	13.890	1.883	15.170	2.057	14.344	1.945	9.722	1.318
20 - 29	13.235	1.795	12.353	1.675	12.872	1.745	11.330	1.536
30 - 39	6.984	0.947	8.123	1.101	6.809	0.923	8.792	1.192
40 - 49	4.418	0.599	4.644	0.630	4.006	0.543	6.588	0.893
50 - 59	2.549	0.346	2.233	0.303	2.243	0.304	2.760	0.374
60 - 69	1.379	0.187	1.399	0.190	1.072	0.145	1.501	0.204
70 - 79	2.344	0.318	0.976	0.132	1.988	0.269	2.825	0.383
80 - 89	1.428	0.195	0.732	0.099	2.196	0.298	1.729	0.234
90 - 99	0.441	0.060	0.327	0.044	2.415	0.327	1.196	0.162
100 +	1.338	0.181	-		-	-	2.005	0.272
Total	48.006	6.510	45.958	6.232	47.945	6.501	48.447	6.569

products by applying various preservatives is an effective strategy to reduce global atmospheric CO_2.

The forests of India produce nearly 12 million m³ of industrial wood against annual requirement of 40 million m³ and excess requirement of 28 million m³ is either for new use or for replacement of timber. One effective means to avoid such frequent replacement of wood is through wood preservation; on an average untreated timber lasts less than 5 years and preservative treatment increases the life by about 3.6 times (Kumar, 1998).

Even by this conservative estimate, the life increase due to wood preservation treatments would result in increase of the service life by about 166962.5 m³ of wood from an average of 1855123.8 m³ years to more than 5698005.7 m³ years (Table-4), thus resulting in an increase of 3.07 times more life as compared to untreated wood.

Table-4: Influence of preservative treatment on life cycle of wood under different uses

Product/Use	Quantity used	Expected Life				Increase
		Untreated Wood		Treated Wood		
		Yrs/Unit	Total m³ yrs	Yrs/Unit	Total m³ yrs.	
Housing timber	18171 x 5.23m³ = 95034.33	10	950343.3	40	3801373.2	4 times
Housing bamboo	3906765 No. (6511.3m³)	5	32556.0	15	97669	3 times
Agricultural Implements	10902.9 m³	5	54514.5	15	163543.5	3 times
Furniture	54514 m³	15	817710	30	1635420	2 times
	166962.5 m³		1855123.8		5698005.7	3.07

Source: FSI. 1979-1981

Thus conversion of tree products into durable products extends their carbon sequestration, and will contribute to the cause of controlling global warming.

CONCLUSION

The following conclusions are made from the study:

The total area of woody vegetation (closed and open forests and scrub) is 332312 ha and it contains 2033167.2 t c. The carbon store in 1996 in Sal stratum is 6.51t/ha. There has been a decrease in this stratum by 0.268t yr^{-1} since 1981. while Carbon stored on average in Miscellaneous stratum has increased since 1981, by 0.068t. ha^{-1}.

Consequently, forest of Ranchi has grown towards the source rather than sink, in Sal stratum due to heavy disturbance in these forests since 1981 with consequent decline in the stores of woody vegetation. However, the miscellaneous stratum of Ranchi forests have shifted to sinks from 1981 to 1995. This might be due to increase in stored carbon in the form of wood as a reservoir. Another healthy trend of this aspect is that these forests conserve more biodiversity and probably this is the reason for better survival against the different biotic disturbances.

The Open canopy and scrub forest occupying, 140744 and 30299 ha respectively, have great potential for sequestering more carbon as they are still sequestering less carbon than that of the dense canopy forests.

It seems that gap filling plantation inside the open canopy forest may be one of the potential carbon – mitigation strategy for future because it does not require additional land for future carbon sequestration projects.

In the district, the life increase due to wood preservation treatments would result in increase of the service life of about 166962.5 m^3 of wood used under different application from an average of 1855123.8 m^3 years to more than 5698005.7 m^3 years, thus causing an increase of 3.07 times more life as compared to untreated wood.

A very sound silvicultural management (through integrated approach) can help the growing stock position in lower diameter class.

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