International Journal of Applied Engineering and Technology ISSN: 2277-212X (Online)
An Online International Journal Available at http://www.cibtech.org/jet.htm
2011 Vol. 1 (1) October-December, pp.41-47/Chavan and Rasal
Research Article

SEQUESTERED CARBON POTENTIAL AND STATUS OF *EUCALYPTUS* TREE

***Chavan B. L. and Rasal G. B.**
Department of Environmental Science, Dr. Babasaheb Ambedkar Marathwada University,
Aurangabad-431 004, (M.S.) India
**Author for Correspondence*

ABSTRACT
Carbon sequestration in terrestrial ecosystem is referred as the absorption of CO_2 from the atmosphere by photosynthesis. In the present investigation aboveground and belowground carbon sequestration potential of *Eucalyptus ssp.* from nine sectors of Aurangabad city was measured. The total standing aboveground biomass and belowground biomass of *Eucalyptus ssp.* is 509.01 tha^{-1} and 132.34tha^{-1} respectively while, total standing biomass of *Eucalyptus ssp.* in 2847 hectares of Aurangabad is 641.35tha^{-1}. The sequestered carbon stalks in aboveground and belowground standing biomass of *Eucalyptus ssp.* is 254.50 tha^{-1} and 66.17 tha^{-1} respectively while, total sequestered carbon of *Eucalyptus ssp.* in 2847 hectares area is 320.67 tha^{-1}. The average carbon dioxide of *Eucalyptus ssp.* intake is 1176.85 tCO_2 in Aurangabad city. The highest carbon sequestration of *Eucalyptus ssp.* in sector 6th and 7th it 31% each while, lowest carbon sequestration in 1st sector it (1%).

Key Words: *Aboveground Carbon, Belowground Carbon, CDM, Carbon Sequestration Potential, Climate Change, Carbon Stock, Total Biomass*

INTRODUCTION
Photosynthesis transfers carbon dioxide from the atmosphere and the carbon is stored in wood and other plant tissues Dilling *et al.*, (2006) many efforts are being made to reduce atmospheric carbon dioxide (Hairiah, 2009). In the global carbon cycle biomass is an important building block, significally carbon sequestration and is used to help quantify pools and changes of Green House Gases from the terrestrial biosphere to the atmosphere associated with land-use and land cover changes (Cairns *et al.*, 2003; IPCC, 2001). Biomass production in different forms plays important role in carbon sequestration in trees. These carbon pools are composed of live and dead above and below ground biomass, and wood products with long and short life and potential uses. Above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter are the major carbon pools in any ecosystem (FAO, 2005; IPCC, 2003; IPCC, 2006). The increasing carbon emission is of major concerns for entire world as well addressed in Kyoto protocol (Chavan, and Rasal, 2010; Ravindranath, et. al., 1997). The Kyoto Protocol, prepared by the United Nations in the Framework of Convention on Climate Change stipulates Clean Development Mechanisms (CDM) and its Joint Implementation whereby storage of carbon in various terrestrial sinks may be acceptable for insertion in national greenhouse gas inventories of each nation.
The CO_2 removal by India's forests and tree cover is enough to neutralize 11.25% of India's total GHG emissions at 1994 level (Jasmin, 2011). It is clear that India's forest is serving as a major mode of carbon sequestration in India (SFR, 2009). Reducing greenhouse gas emissions including carbon dioxide can be achieved by controlling emissions and avoiding unadvisable land use changes. Carbon sequestration in growing forests is known to be a cost-effective option for mitigation of global warming and global climatic change. Estimates of carbon stocks and stock changes in tree biomass (above and belowground) are necessary for reporting to the United Nations Framework Convention on Climate Change (UNFCCC) and will be required for Kyoto Protocol reporting (Green et al. 2007; Almgir and Al-Amin, 2007). The objective of this paper is to estimate sequestered carbon of *Eucalyptus ssp.* from Aurangabad.

Research Article

Experimental Methodology

Study area

The study is located in the state of Maharashtra, in India. Aurangabad is located at the latitude 19^{0}53'47''N and longitude 75^{0}23'54'' E. The average day temperature ranges from 27.7^{0}C to 38.0^0 C while it falls from 26.9^{0}C to 20.0^{0}C during night. The average annual rainfall in Aurangabad city and adjoining area is 725.8 mm (28.57"). Relative humidity is extremely low in this region for major part of the year which ranges between 35 to 50%, while it is highest (85%) during monsoon. The total land portion under forest cover is about 557 km^2 which is only 7.6% area of total land area in Aurangabad (SFR, 2009). The total 28.47 sq.km area of Aurangabad city is selected for the carbon sequestration study.

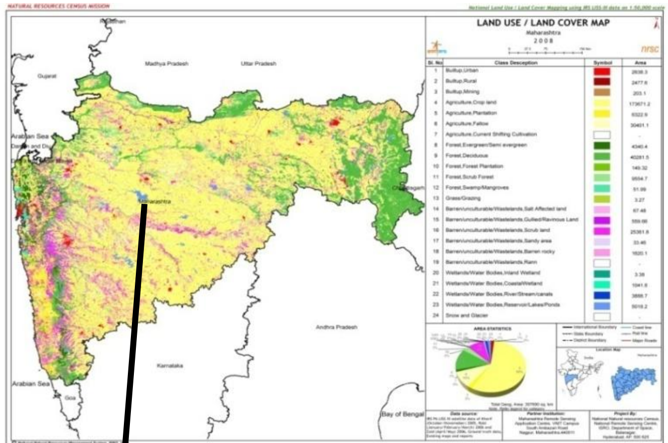

Fig. 1a: Land cover and Land use map of Maharashtra state showing location of Aurangabad (Source: *http://bhuvan-noeda.nrsc.gov.in/theme/thematic/tools/2008)*

Figure 1b: GPS location of Aurangabad city city. (Source: *http://bhuvan-noeda.nrsc.gov.in)*

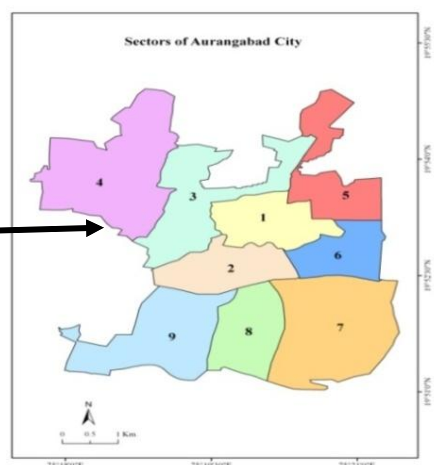

Figure 1c: Location of study sites in Aurangabad

The total 2847 hectares of study area from Aurangabad was selected for the carbon sequestration study. The fifig.1c shows the 9 sectors from Aurangabad as sampling locations for *Eucalyptus ssp.* trees studied. The samples were collected from a representative tree of each species from each sampling plot from the study region.

Biophysical measurements

The height and diameter at breast height (DBH) are two main biophysical measurements which measured for each tree sample. The height of *Eucalyptus ssp.* tree were measured by Theodolite instrument follower the procedure given elsewhere (Chavan and Rasal, 2009; 2010; 2011). The tree diameter was measured at breast height (DBH) by using diameter measure tape.

Estimation of Aboveground biomass

Above-ground biomass includes all living biomass above the soil. The aboveground biomass (AGB) has been calculated by multiplying volume of biomass and wood density (Ravindranath and Ostwald, 2008). The volume was calculated based on diameter and height. The wood density value for the *Eucalyptus* species obtained from web (*www.worldagroforestry.org*).

AGB (g) = Volume of biomass (cm3) X wood density (g/cm3)

The biomass of all samples of *Eucalyptus ssp.* trees in all the sample plots (t) was calculated and extrapolating it for total area (tha^{-1}).

Estimation of Belowground biomass

The Below Ground Biomass (BGB) includes all biomass includes all biomass of live roots excluding fine roots having <2mm diameter (Chavan and Rasal, 2011). Biomass estimation equations for tree roots are relatively uncommon in the literature. The belowground biomass (BGB) has been calculated by multiplying above-ground biomass taking 0.26 as the root to shoot ratio (Cairns et al. 1997; Ravindranath and Ostwald, 2008).

Belowground biomass (tha^{-1}) = 0.26 X above-ground biomass (tha^{-1})

RESULT AND DISCUSSION

Biomass estimation

The estimation of the aboveground and belowground biomass in the selected tree species was performed by estimating carbon percentage and by measuring the tree height, DBH and wood density. The carbon concentration of different tree parts was rarely measured directly, but generally assumed to be 50% of the dry weight on the basis of literature (Losi et al., 2003; Jana et al., 2009) as the content of carbon in woody biomass in any component of forest on average is around 50% of dry matter (Paladinic et al., 2009; Chavan and Rasal, 2011).

Table 1: The sector wise aboveground biomass and belowground biomass of *Eucalyptus ssp.* in Aurangabad

Sectors	No. of tree	Aboveground biomass tha^{-1}	Belowground biomass tha^{-1}	Total Standing Biomass tha^{-1}
1	39	4.84	1.26	6.10
2	199	24.71	6.42	31.13
3	159	19.74	5.13	24.88
4	370	45.94	11.94	57.89
5	225	27.94	7.26	35.20
6	1265	157.08	40.84	197.93
7	1265	157.08	40.84	197.93
8	267	33.15	8.62	41.77
9	310	38.49	10.01	48.50
Total	4099	509.01	132.34	641.35

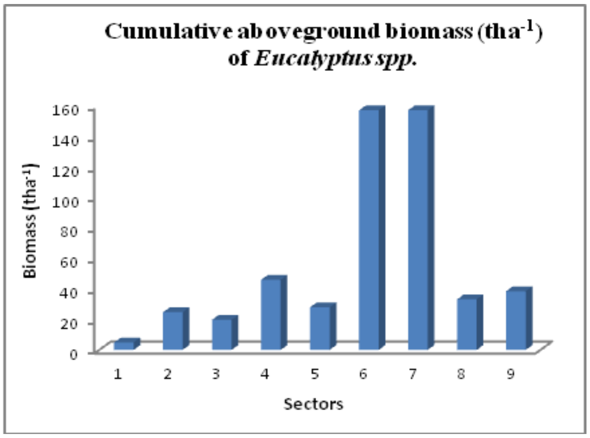

Figure 2: Aboveground biomass (tha^{-1}) of *Eucalyptus sp.* from 9 sectors of Aurangabad

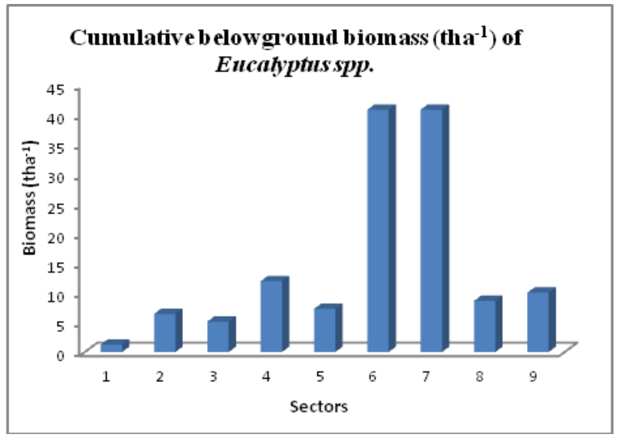

Figure 3: Belowground biomass (tha^{-1}) of *Eucalyptus sp.* from 9 sectors of Aurangabad.

The standing biomass stalks in *Eucalyptus ssp.* trees in Aurangabad are shown in Table 1. It was observed that in sector no. 6 & 7 the *Eucalyptus ssp.* tree containing highest and same aboveground biomass, belowground biomass and total standing biomass (157.08 tha^{-1}, 40.84 tha^{-1} and 197.93 tha^{-1} each) followed in sector no. 4 (45.94 tha^{-1}, 11.94 tha^{-1} and 57.89 tha^{-1}), sector no. 9 (38.49 tha^{-1}, 10.01 tha^{-1} and 48.50 tha^{-1}), sector no. 8 (33.15 tha^{-1}, 8.62 tha^{-1} and 41.77 tha^{-1}), sector no. 5 (27.94 tha^{-1}, 7.26 tha^{-1} and 35.20 tha^{-1}), sector no. 2 (24.71tha^{-1}, 6.42 tha^{-1} and 31.13 tha^{-1}), sector no. 3 (19.74 tha^{-1}, 5.13 tha^{1} and 24.88 tha^{-1}) and lowest at sector no. 1 (4.84 tha^{-1}, 1.26 tha^{-1} and 6.10 tha^{-1}). The total standing aboveground biomass and belowground biomass of *Eucalyptus ssp.* were 509.01 tha^{-1} and 132.34 tha^{-1} respectively while, total standing biomass of *Eucalyptus ssp.* in 2847 hectares area were 641.35 tha^{-1}.

Carbon stock estimation

The Aboveground and Belowground carbon Total carbon stalk of a tree has been evaluated by sum of Aboveground and belowground carbon stalk of *Eucalyptus ssp.* in (tha^{-1}).

Table 2: The sector wise aboveground and belowground carbon of *Eucalyptus ssp.* in Aurangabad

Sectors	No. of tree	Aboveground carbon tha^{-1}	Belowground carbon tha^{-1}	Total Carbon sequestered tha^{-1}
1	39	2.42	0.63	3.05
2	199	12.35	3.21	15.57
3	159	9.872	2.56	12.44
4	370	22.97	5.97	28.94
5	225	13.97	3.63	17.60
6	1265	78.54	20.42	98.96
7	1265	78.54	20.42	98.96
8	267	16.57	4.31	20.89
9	310	19.247	5.00	24.25
Total	4099	**254.50**	**66.17**	**320.67**

The sequestered carbon stalks in *Eucalyptus ssp.* trees in Aurangabad are shown in Table 2. It was observed that in sector no. 6 & 7 the *Eucalyptus ssp.* tree containing highest and same carbon stalk in aboveground, belowground and total carbon sequestered (78.54 tha^{-1}, 20.42 tha^{-1} and 98.96 tha^{-1} each)

followed in sector no. 4 (22.97 tha^{-1}, 5.97 tha^{-1} and 28.94 tha^{-1}), sector no. 9 (19.24 tha^{-1}, 5.0 $tha^{-1}$and 24.25 tha^{-1}), sector no. 8 (16.57 tha^{-1}, 4.31 $tha^{-1}$and 20.89 tha^{-1}), sector no. 5 (13.97 tha^{-1}, 3.63 tha^{-1} and 17.60 tha^{-1}), sector no. 2 (12.35 tha^{-1}, 3.21 tha^{-1} and 15.57 tha^{-1}), sector no. 3 (9.87 tha^{-1}, 2.56 tha^{-1} and 12.44 tha^{-1}), and lowest at sector no. 1 (2.42 tha^{-1}, 0.63 tha^{-1} and 3.05 tha^{-1}). The sequestered carbon stalk in aboveground and belowground standing biomass of *Eucalyptus ssp.* were 254.50 tha^{-1} and 66.17 tha^{-1} respectively, while total sequestered carbon of *Eucalyptus ssp.* in 2847 hectares area were 320.67 tha^{-1}.
The average carbon sequestration and carbon dioxide of *Eucalyptus ssp.* intake is 320.67 tha^{-1} and 1176.85 tCO_2 in Aurangabad. The carbon sequestration is multiplied to 1tons of carbon percentage and this is converted to CO_2 per hectare by factor of 3.67 or 1tC correspondence to 3.67tCO_2 (Jindal et al., 2007; Soderblom, 2008; Hairiah; 2008; Singh, 2009; Kumar et al., 2009; Sherill and Bratkovich, 2011; Jasmin and Birundha, 2011). India is sequestrating more than 116 million tones of CO_2 per year which is equal to 32 millions of carbon sequestration, contributes to reduce atmospheric carbon of the globe (SFR, 2009; Jasmin, 2011).
The carbon storage in the 2, 4, 6 and 8 years old stands, was respectively, in the *Eucalyptus spp.* biomass 11.12, 18.55, 80.91 and 97.86 Mg ha^{-1}, understorey, 0.71, 0.54, 0.85 and 1.56 Mg.ha^{-1}, in the litter 1.65, 2.62, 4.78 and 5.50 Mg.ha^{-1} (Schumacher, et al., 2003). The total of aboveground biomass and belowground biomass together as sequestered carbon stalk per hectare as estimated from university campus of Aurangabad for *Mangifera indica* it was 30.6 Kg C ha^{-1} (Chavan and Rasal, 2011). The total aboveground biomass carbon stock per hectare as estimated for *Shorea robusta*, *Albizzia lebbek*, *Tectona grandis* and *Artocarpus integrifolia* were 5.22$tCha^{-1}$, 6.26$tCha^{-1}$, 7.97$tCha^{-1}$ and 7.28$tCha^{-1}$ respectively in selected forest stands (Jana, 2009). The average standing stock of organic carbon in *Mangifera indica* is higher than organic carbon content in selected well grown trees of Dr. B. A. M. University campus which was 1.65 t/tree (Chavan and Rasal, 2010).

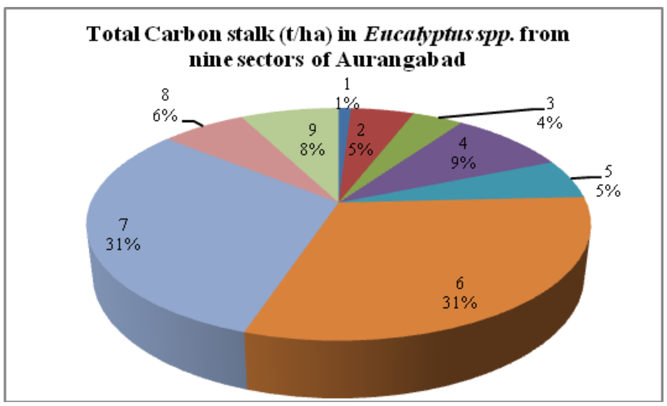

Figure 4: Total carbon stalk (tha^{-1}) of *Eucalyptus ssp.* from 9 sectors of Aurangabad

From the study it is revealed that the total carbon stalk (tha^{-1}) at *Eucalyptus ssp.* (Fig. 4) from studied nine sectors of Aurangabad the highest sequestered carbon percentage in sector 6th & 7th it was 31% each, followed by sector 4 (9%), sector 9 (8%), sector 8 (6% each), sector 2 & 5 (5% each) and lowest in sector 1 (1%).

REFERENCES

Alves, D.S., Soares, J.V.S., Amaral, E.M.K., Mello, S.A.S., Almeida, O., Fernandes, S., Silveira, A.M., (1997). Biomass of primary and secondary vegetation in Rondonia, western Brazilian Amazon. *Global change Biology*, Vol. 3: 451-462.

Birdsey, R.A. (1992). Carbon storage and accumulation in United States forest ecosystems. General Technology Report WO-59. Washington, DC: U.S. Department of Agriculture, Forest Service. pp. 51.

Brown S., (1997). Estimating Biomass and Biomass change of Tropical Forests: a Primer. Rome, Italy; FAO Forestry Paper-134, pp. 165.

Chavan B.L. and Rasal G.B., (2010). Sequestered standing carbon stock in selective tree species grown in University campus at Aurangabad, Maharashtra, India. *International Journal of Engineering Science and Technology*, Vol.2 (7), 3003-3007.

Chavan B.L. and Rasal G.B., (2011). Potentiality of Carbon Sequestration in six year ages young plant from University campus of Aurangabad, Global Journal of Researches in Engineering, Vol. 11(7) pp.15-20.

Chavan, B. L. and Rasal, G. B., (2011). Sequestered carbon stalk in young *Annona reticulata* plant in Aurangabad. Proceeding of International conference on Climate change & social issues, Sri Lanka. pp. 69-73.

Chavan, B. L. and Rasal, G. B., (2009). Carbon storage in Selective Tree Species in University Campus at Aurangabad, Maharashtra, India. Proceeding of International conference & Exhibition on RAEP, Agra, India, pp.119-130.

Chave J, Andalo C, Brown S, Cairns MA, Chambers JQ, Eamus D, Fo¨lster FH, Fromard F, Higuchi N, Lescure JP, Nelson BW, Ogawa H, Puig H, Riera B, Yamakura T., (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. Oecologia 145:87–99.

Chave J., Condit R., Aguilar S., Hernandez A., Lao S. and Perez R., (2004). Error propagation and scaling for tropical forest biomass estimates. Phil. Trans. R. Soc. Lond. B. 359: 409–420.

Clutter, J.L.; Fortson, J.C.; Pienaar, L.V.; Brister, G.H.; Bailey, R.L. (1983). Timber management: a quantitative approach. New York: John Wiley & Sons. pp.333.

Dilling, L., King, A., Fairman, D., Houghton, R., Marland, G., Rose, A., Wilbanks, T. and Zimmerman, G., (2006). What is the Carbon Cycle and Why Do We Care? Draft by SOCCR, CCSP product 2.1.

FAO. (1997). Estimating biomass and biomass change of tropical forests: a primer, Rome, Italy: FAO Forestry Paper No.134.

FAO (2005). *Support to national forest assessments*. FAO Forestry Department Available URL: http://www.fao.org/forestry/site/24673/en.

Green, R., Tobin, B., O'Shea, M., (2007). Above and below ground biomass measurements in an unthinned stand of Sitka spruce (*Picea sitchensis* (Bong) Carr.). European Journal of forest Research, 126: 179−188.

Gurmit singh, (2009). Understanding carbon credits, Aditya books Pvt. Ltd. New-Delhi.

Hairiah, K., Dewi, S., Agus, F., Noordwijk, M.V. and Rahayu, S., (2009). Measuring Carbon Stocks Across Land Use Systems: A Manual. Bogor, Indonesia. World Agroforestry Centre (ICR AF), SEA Regional Office, Brawijaya University and ICALRRD (Indonesian Center for Agricultural Lan d Resources Research and Development). Pages 127.

IPCC (2003). Good practice guidance or land use, land-use change and forestry. Institute for Global Environmental Strategies, Hayama.

IPCC (2006). Guidelines for national greenhouse gas inventories. Agriculture, Forestry and other land use. Institute for Global Environmental strategies, Hayama, Japan. Vol.4.

Jana, B. K., Biswas, S., Majumder, M., Roy, P. K., Mazumdar, A., (2009). Comparative Assessment of Carbon Sequestration Rate and Biomass Carbon Potential of Young *Shorea robusta and Albizzia lebbek, International Journal of Hydro-Climatic Engineering Assoc. Water and Enviro-Modeling,* Vol. 1(2), pp. 1-15.

Jasmin, K.S.S. and Birundha, V. D., (2011). Adaptation of climate change through forest carbon sequestration in Tamilnadu, India, *International Journal of Research in Commerce & Management,* Vol. 1(8), 36-40.

Jindal, R., Kerr, J. and Nagar, S., (2007). Voluntary carbon Trading potential for community forestry projects in India Asia-Pacific Development journal Vol. 14(2), 107-126.

Kenzo T., Furutani R., Hattori D., Kendawang J. J., Tanaka S., Sakurai K. and Ninomiya I., (2009). Allometry equations for accurate estimation of above-ground biomass in logged-over tropical rainforests in Sarawak, Malaysia. *Journal of Forestry Research*, 14: 365-372.

Kumar, S., Rosenfield, A.H., Kapoor, R., Mahajan, K., Bajpai, A. and Verma, N., (2009). Tables to convert energy (kWh) or CO_2 (saved or used) to Familiar equivalents-cars, homes or power plants (India Average plants (India Average Data), ECO- III project, pp. 1-4.

Little E. L. Jr. and Skolmen, R. G. (1989). Agriculture Handbook no. 679, The Forest Service, U.S. Dept. of Agriculture.

Losi, C.J., Siccama, T.G., Condit, R., Morales, J.E., (2003). Analysis of alternative methods for estimating carbon stock in young tropical plantations, Elsevier for *Forest Ecology & Management*, 184:355-368.

Mohammed Alamgir., M. Al-Amin., (2007). Organic carbon stock in trees within different Geopositions of Chittagaon (South) forest division, Bangladesh, Journal of Forestry Research, Vol. 18(3): 174-180.

Olsen, N. and Bishop, J., (2009). The financial costs of REDD: evidence from Brazil and Indonesia, Gland, Switzerland IUCN, pp64.

Paladinic, E.,Vuletic, D., Martinic, I., Marjanovic, H., Indir, K., Benko, M., and Novotny,V., (2009). Forest biomass and sequestered carbon estimation according to main tree components on the forest stand scale. *Periodicum Biologorum,* Vol.111, No.4, pp. 459-466.

Parresol, B.R. (1999). Assessing tree and stand biomass: a review with examples and critical comparisons. *Forest Science*. 45: 573-593.

Ravindranath, N.H., Somashekhar B.S. and Gadgil M., (1997). Carbon flows in Indian forests. Climate change. 35: 297-320.

Ravindranath, N. H. and Ostwald M., (2008). Carbon Inventory Methods Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Round wood Production Projects. Springer, Vol. 29.

Schroeder P., Brown S., Birdsey JMR., Cieszewski C. (1997). Biomass estimation for temperate broadleaf forests of the US using inventory data. *Forest Science,* 43: 424-434.

Schumacher, M. V., Witschoreck, R. and Calil, F.N., (2003). Carbon storage in Eucalyptus ssp. forests in different ages in small rural areas in South Brazil. Available at URL: (http://www.bodenkunde 2.uni-freiburg.de/eurosoil/abstracts/id260_schumacher_full.pdf).

SFR, (2009). Forest Survey of India, Dehradun.

SFR, (2001). Forest Survey of India, Dehradun.

Sherill, S., and Bratkovitch, S., (2011). Carbon and carbon dioxide equivalent sequestration in urban forest products, Dovetail partners Inc., Available at URL : (http://www.Utfi.calpoly.edu/files/pubs/urbancarbonwercr report2011sm.pdf).

Soderblom, J., (2008). Implementation of avoided deforestation in a post – 2012 clime region, SLU. Available URL: (http://www.w-program.nu/filer/exjobb/johan_soderblom.pdf).