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Carbon Sequestration in Plantations of Forest Trees In Latehar District, Jharkhand

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***Abstract**: The growing pollutants in the atmospheric air, marine aqua system and depletion in the ozone layer are the major causes of concern, since the resultant effects are the global temperature increase, diminishing polar ice glaciers and elimination of millions of varieties of biotic flora and fauna from the creation. As per the study by FAO, the rate of deforestation was 13 million hectares per annum assessed in the year 2007. The present study has been carried out to quantify the carbon sequestered and the resultant emission of oxygen along with calculating the monetary values thereof in the Latehar district of Jharkhand State, India. This study is confined to the artificial regeneration of forestry species. This district faces better rainfall than the Garhwa district, which was taken up in my previous study. Comparative analysis has been done for both the areas. In the present study the result shows that 27.0 tC ha^{-1} yr^{-1} has been sequestered including the soil organic carbon.*

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I. Introduction

The major cause of concern throughout the world now has become the growing pollutants in the atmospheric air and marine aqua system, including the depletion in the Ozone layer. Due to heavy population growth, the major pressure is on the terrestrial ecosystem mainly in the developing and under developed countries. In the developed countries due to the growing industrial activities large amounts of atmospheric and water pollutants are causing heavy damages to the biodiversity with simultaneous other negative factors accelerating ozone depletion. The major question faced by the present civilisation is about the negative impact on the wellbeing of present and future generations.

A.Chiabai, C.M.Travisi et al.,2009 in Economic evaluation of Forest Ecosystem Services: Methodology and Monetary estimates, has cited that forests are critically important habitats in terms of the biological diversity they contain and in terms of the ecological functions they supply(e.g., Miller et al., 1991; Mendelshon and Balick, 1995; Pearce, 1996, 1998, 1999). Similarly, the ecological and anthropocentric services of forest are many, although the area-species and the species-species services relationships are still debated (e.g. Pimm and Raven,2000) and the loss of forest ecosystem services driven by deforestation is expected to be serious if the rate of deforestation is maintained at the current alarming level of approximately 13 million hectares per year (FAO,2007). Till date, ecological life-support systems are declining worldwide (Ewing et al.,2010; MA,2005), biodiversity loss remains unabated (Butchard et al.,2010), and anthropogenic pressures have reached a scale where the risk of abrupt global environmental disruption can no longer be excluded (Rockstrom et al.,2009). The conservation movement has thereby failed to prevail upon the economic and socio-political drivers of change that are at the root of many present environmental problems (MA,2005; Steffen et al.,2004). Stabilization of Green House Gas emissions, though was not officially included in the Kyoto Protocol, it got its place in COP13 in Bali on December 2007. In a review promoted by the European Commission (Markandya et al.,2008), available values trend is site specific and forest type specific. Chiabai et al.,2009 has cited that forest area is expected to decrease by around 76 million hectares by 2050 worldwide. The Millenium Ecosystem Assessment(2005) became the real milestone achievement because for the first time it stressed the need to quantify and value the ecosystem services. As published in the report of LEAD India in 2007, the forests of Uttarakhand can accumulate Carbon at rate that ranges from 5-9 t C ha^{-1} yr^{-1} for good forests to 1.5-3 t C ha^{-1} yr^{-1} for poor quality forests (Singh et al.,1985). This translates to Carbon Sequestration values of almost US $ 65- US $ 125 ha^{-1} yr^{-1} . Kumar M., 2011 cited that "The Global forests cover 3870m. hectare according to Global Forest Resource Assessment 2000, and contain a total standing volume of 386 billion m^3 of wood. The stock of mass woody vegetation is estimated at 422 billion tonnes dry matter in the above ground biomass including stems, branches and foliages (Anon,2001). Kauppi,2003 calculated the average standing stock at 10.9kg per m^2 in terms of dry biomass and 5.45 kg per m^2 in terms of carbon. The carbon absorbing capacity of plants is very high in initial stages of growth because of high metabolic rate. One half of a tree's dry weight is carbon (Nowak,1994). Kumar M. has stated that "Thus carbon storage is directly related to size. Annual carbon sequestration is related to tree size and growth rates."

The India State of Forest Report,2017 estimated the total carbon stock in forests of India in 2017 that is 7082 million tonnes. The total carbon stock of Jharkhand State, India is 222.882 million tonnes and per hectare carbon stock is 94.6 tonnes. This report has not identified the differences of carbon stock in naturally regenerated forests and artificially regenerated forests. My last study reported in IOSR journal Volume II, Issue 5 Ver.II (May298), pp 01-06 was on the artificially regenerated forests of Garhwa district of Jharkhand State, India. The present study has been carried out in Latehar district of Jharkhand State with some differences in geo climatic factors. In order to compare the carbon stock in the same type of artificially regenerated forests, same formulae has been used in this study. This showed that 27.02 tC ha^{-1} yr^{-1} has been sequestered.

II. Materials and Methods

Study Area: The study area lies between Latitude $23^0$35'N to $24^0$5'N and Longitude $84^0$20'E to $84^0$55'E. The forests are more or less in compact blocks except for a few isolated patches in the North and North- Eastern part. The area comes under Latehar District and part of Lohardaga district.

Configuration of the Ground: The vast majority of the forests lie on the hills with the exception of a part of Chandwa, Balumath and Latehar ranges wherein they occur on the plains and undulating grounds. The slopes of the hills are moderate to steep with various aspects. For want of adequate ground cover, sheet and gully erosion has become a continuous process even in apparently well-stocked forests. The entire area of Latehar forest division is drained by two principal rivers, namely, the North-Koel and the Damodar. The principal rivers and their main tributaries are (a) Auranga (b) Deonad (c) Sukri (d) Chaupat (e) Amanat (f) Ghagri and others. The river beds are generally rocky in most parts.

Geology, Rock and Soil: This region forms a part of the Chhotanagpur Plateau comprising granitic rocks associated with large areas of sedimentary rocks. The elevation of the area around Latehar varies from 375m to 550m. above Mean Sea Level. The major part of the Latehar district is occupied by the Granitic rocks of Archean Age. The remnants of the earlier sedimentary and igneous rocks are known from the inclusion of phyllites and schists of varying dimensions in the granite mass. The inclusions are disposed along the gneissic foliation. The granite gneiss of this area is a part of the enormous intrusive mass known as Chottanagpur Granite gneiss. Among the various modifications of this rock the porphyritic types with varying coarseness and shape of the pheenocryste occur. The different Gondwana coalfields present in Latehar Forest Division are Auranga coal field and North Karanpura coal field. Southern part of this Division having Lohardaga forests has exploitable Bauxite deposits. Occurrences of coal, limestone, iron ore, lead, fireclay and bauxite are known in the Latehar division. A complex series of highly calcareous gneisses and schists with impure, granular, crystalline limestone occur in Diridag area. There is apparently no well defined zone of good quality lime stone. Lenticles and nodules of iron-ore are present in the Auranga coal field, but these are now not mined as a normal source of iron-ore.The dependence of dominant forest crops on underlying rock and soil is summarized as i) Poor Sal forest above Laterite rocks; ii) Sal and Mixed forest over Quartzite rocks; iii) Sal, Mixed & Bamboo forest on Gneiss rocks; iv) Mixed and Bamboo forest on Amphibolite rocks; v) Sal & mixed forest on Gondwana rocks and vi) Sal with bamboo and mixed forest on Alluvial rocks. Soil is often found mixed with boulders and pebbles. Often strata of Murom are found beneath the top soil. Soil is loam, sandy-loam, clayey-loam and at places clayey. Mineral contents and water holding capacities are poor.

Climate: Mean annual temperature is 25.6^0C and mean annual rainfall is 1433mm. The hottest months are May and June and the coolest months are December and January. During the hot weather, high dry westerly westerly winds known as 'Lohar' causes desiccation of soil and poses great impediment to the success of plantations.

Methods: The principles are adopted as used in my previous study of Garhwa forest division. The plantation areas taken up for this study is block plantation that extends from 30 hectares to 50 hectares patch depending on the availability of blank areas and depending on the finance involved. In these block plantations; the blocks are kept secured from biotic interferences by digging trenches around the periphery. Besides that, cattle watchers are kept temporarily to protect the plantations from grazing. Still grazing by cattle, goats are not prevented absolutely. The plantations also remain at the mercy of wild animals such as Nilgai, Sambhars, Wildboars etc.

Sampling Method:

Objective: The objective of survey is to measure the sample plots in each successive year of plantation carried out in different areas within the same district boundary. The different sites, though face equal climatic factors, do differ in geological patterns and configuration of the soil. In view of the hard task and both time and money factors, trees in these sample plots have been measured. Almost same varieties of species have been planted and the spacing of plantation is also same in the planted areas.

Population: In this study population has been selected starting from the first year of plantation to the tenth year of plantation. All the areas have been planted with mixed varieties of species. Altogether 1666 plants have been planted per hectare with spacing of 3m * 2m.

Sample size: The size of individual block plantation area varies from 30 to 50 hectares. The entire block area is planted with the same species in mixed manner. For this study each sample area is limited to 150ft. * 150ft. or 47m. * 47m.

Sampling design: In this cross sectional study method has been adopted so that one sample is drawn from the relevant population and studied once. In this study, measurements of a population attaining same year of growth have been taken. In this design as my previous study, purposive sampling has been taken so that samples are selected deliberately to constitute a sample on the basis that the small mass that has been selected out of a large one is representative of the mixed population planted for the same year. Since peripheral areas are more susceptible to damage by various biotic factors hence sample has been selected perceptibly away from the peripheral areas of the blocks.

Biomass study: All available trees in the sample plot have been measured. Due to the small size of plants in its first two years of growth, the GBH could not be taken at 4.5ft. However girths have been measured above 1ft. in first year plantation and at 2ft. for the second year plantation through tape. Height was measured using measuring stick. From the third year onwards girth was measured at 4.5ft. height. Tree heights were measured basing on shadow and similar triangles method. For trees attaining better heights, height measurements were calculated through tangent formula by using spirit level app. Trees forked below 4.5ft. have been measured just below the forking and were considered as two trees. From gbh and height, biomass has been calculated. Biomass calculations have been done by using similar formula that was used in the study of Kumar M.'s work "Assessment of carbon sequestration potential in trees of Jnanabharathi campus – Bangalore University, Karnataka, India" published by LAP LAMBERT Academic Publishing in 2011.

Parameters: The parameters taken and formulae used for different calculations are as below:

Basal Area = $(GBH)^2 / 4\pi = (GBH)^2 / 12.56$

Stem Volume = Basal Area * Height

Above Ground Biomass (AGB) = Stem volume * density factor

Density factor is taken as constant = 0.45.

Below Ground Biomass (BGB) = AGB * 0.26

The default conversion factor as per IPCC, 2003 = 0.26

Biomass dry weight = Live Biomass * 0.6

0.6 has been taken as default conversion factor.

AGC = (AGB * 0.6) * 0.5

BGC = (BGB * 0.6) * 0.5

CO_2 calculations have been done as per Ajay Kumar & Singh, 2003:

Quantum of CO_2 = Quantum of Carbon * 44/12 (or 3.67)

Where 44 is the molecular weight of CO_2 & 12 is the Atomic weight of Carbon.

Quantification of O_2 has been done as per international standard 1 Kg. Carbon = 32/12 = 2.66 kg. of O_2 i.e. 38 Kg. of Carbon is equivalent to 100 Kg. of Oxygen.

Soil Organic Carbon: In this study one more parameter of soil organic carbon has been added. Soil has been collected up to a depth of 10 cm. after proper mixing of the soil. The standard formula for this used is:

e.g. 1.5% soil organic carbon = 15 gm. Carbon Kg^{-1} of soil

Weight of soil calculated per hectare:

$10{,}000m^2$ * 0.1m. soil depth * $1.3gm/cm^3$

Bulk density = 1300t ha^{-1} soil.

15gm. C * 13,00,000 kg. = 19,500,000 gm. C ha^{-1} or 19,500gm.C ha^{-1} or 19,500 kg. Carbon ha^{-1}.

Dry weight of soil organic carbon = 19,500 * 0.6 = 11,700 kg.

Carbon content per Hectare = 11,700 * 0.5 = 5850 kg.

O_2 Quantity = 5850 * 2.66 = 15,561kg.

The method used for determining soil organic carbon is according to IS2720(P-22).

Use of statistical analysis has not been done since the study area is artificially chosen in more or less particular type of rock and soil composition along with same climatic pattern. Seedlings have been planted in equal spacing of 3m * 2m. So it is assumed that equal amount of light, water and soil fertility is available to the plants of any particular block. However strictly saying, there are differences in geology, rock, soil and elevation pattern. The study shows the combined growth in the entire district.

Limitations of the study: Shrubs, herbs, grasses, branches and leaves have not been taken in to account as per my earlier study for Garhwa district. Since no indigenous variety as per the adjacent forest area has been planted, so there is also no remarkable growth of herbs and shrubs met with. As an additional factor, soil organic carbon has been included in this study because soil organic carbon percentage is better in Latehar than Garhwa. The soil chemical tests were conducted in State Pollution Control Board certified laboratory.

III. Results

The summary data is prepared as per the actual existing number of plants. According to the summary data over a period of ten years the AGC is 19227 kg. & the BGC is 4999kgs. per sample plot. Due to biotic interference over successive periods, some plants were either taken away or destroyed. In the normalized summary data it was considered as if in all the sample plots total number of 1666 plants exist so that per hectare carbon can be calculated. According to the normalized summary data, the total carbon sequestered per hectare is: AGC = 204464.97 kg. and BGC = 53160.89 kg. i.e. AGC = 204 tC and BGC = 53 tC. So over a period of ten years, total carbon sequestered is 257 tC ha^{-1} accumulated in a growing period of ten years.

The quantity of carbon dioxide used in the process is 257 tC ha^{-1} * 44/12 = 257 * 3.7 = 950.9 or 951 tonnes of CO_2 ha^{-1}. This means 951 tonnes of carbon dioxide from atmosphere has been sequestered. The value of sequestered carbon per hectare of plantation worked out to be (Kumar M.2011) 257 tC ha^{-1} * \$20 = \$5140 * 64.94 = INR 3,33,790/10 = INR 33,379.

Result of quantification of oxygen produced is 257tC ha^{-1} * 32/12 = 685.33 or 685t CO_2 ha^{-1} or 68.5 t O_2 $ha^{-1}yr^{-1}$. In my previous study for Garhwa district the cost of oxygen in India was taken as INR 650 for six litres of oxygen or 7.5kg of oxygen. Since the market price is not constant hence cost of 10kg oxygen has been calculated as INR 650. So total cost of oxygen produced $ha^{-1}yr^{-1}$ = 68.5t = 68,500kg/10 = 6850kg * INR 650 = INR 44,52,500.

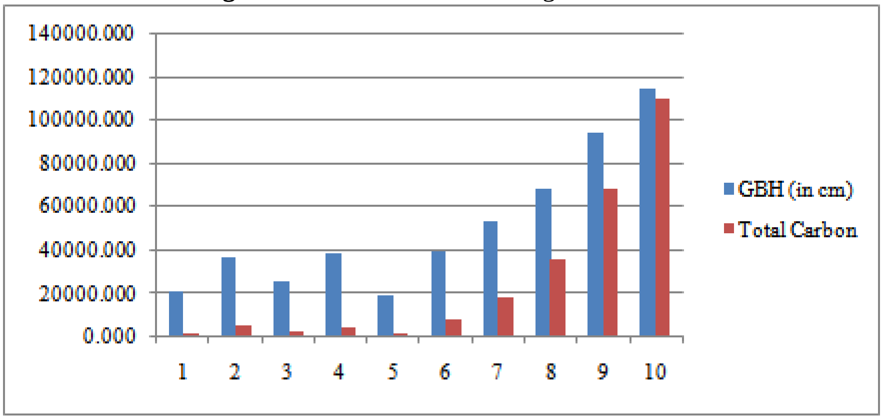
In these sample plots soil organic carbon content has been measured. All together nine values i.e. pH, conductivity, calcium, total moisture, total organic carbon, organic matter, Potassium, Phosphorus and Nitrogen has been measured. For cost calculation, only total soil organic carbon is considered in this paper. Soil samples were collected randomly from six sample plots out of the total number of ten plots. The organic carbon contents are sample plot-1 = 1.96%, sample plot-2 = 6.18%, sample plot-3 = 0.40%, sample plot-4 = 0.32%, sample plot-5 = 0.32% and sample plot-6 = 11.27%. From these figures the average soil organic carbon is 3.40% which is equivalent to 34gm of carbon kg^{-1} of soil. As per the methods of calculations described under parameters; when soil organic carbon is 1.5%, the carbon content per hectare is 5850 kg and quantity of oxygen is 15,560 kg. Taking in to account the average carbon as 3.40% the carbon content $hectare^{-1}$ is 13,260 kg or 13.26 tC ha^{-1}. The derived cost of soil organic carbon is 13.26 * \$ 20 = \$ 265 = INR 17,209/ 10 = INR 1721 ha^{-1} yr^{-1}. The quantity of O_2 emitted from 13.26 tC = 13.26 * 32/12 = 35.36 tO_2 $hectare^{-1}$ or 35,360 kg of O_2 $hectare^{-1}$. The cost of oxygen is 35,360/10 * INR 650 = INR 22,98,400 ha^{-1} or INR 2,29,840 ha^{-1} yr^{-1}.

Taking in to account all derived individual monetary benefits: cost of carbon ha^{-1} yr^{-1} + cost of oxygen ha^{-1} yr^{-1} + cost of soil organic carbon ha^{-1} yr^{-1} + cost of oxygen from soil organic carbon ha^{-1} yr^{-1} = INR 33,379 + INR 44,52,500 + INR 1721 + INR 2,29,840 = INR 47,17,440. The value of carbon and oxygen only from trees is INR 44,85,879 ha^{-1} yr^{-1}.

IV. Discussions

Sample plots have been measured for each year of plantation beginning from 2006-07 to 2015-16. On the basis of three considerations plantations done in ten different but successive years were selected: (i) to obtain different species wise growth (ii) to find out the variations in sequestered carbon in different sites and (iii) it is the standard principle of the State Govt. to restock the area after tenth year on the major basis of assumption that the trees shall be gradually utilised by the local people for their daily needs and the survived trees shall be cut and sold. In the present study, as per my previous work done for Garhwa district, two aspects are considered i.e. (i) gbh vs. carbon sequestered and (ii) height vs. carbon sequestered. As per Figure-1 it shows that the average carbon content started growing in almost uniform manner from the sixth year to the tenth year. The growth in GBH as well as carbon increases rapidly from the seventh year to the tenth year.

Figure No 1 Girth at Breast Height vs Carbon



From figure-1 it is also clear that the plantation accumulated more carbon in the second year and the fourth year Less growth is observed in third and fifth year. In my earlier study published in IOSR Journal of Agriculture and Veterinary science(IOSR-JAVS) e- ISSN:2319-2380, P-ISSN: 2319-2372. Volume II, Issue 5 ver.II (May 2018), pp 01-06 the work was carried out in Garhwa district. Comparing the corresponding gbh vs. carbon in Garhwa it is interesting to note that the same second year plantation has attained better carbon growth. But in Garhwa ninth and tenth year plantation has shown greater carbon deposits whereas in Latehar the growth of carbon is almost excellent right from sixth to the tenth year. In Garhwa carbon growth in the seventh and eighth year plantation is very less.

From the summary sample plot field data Table No.1, it is evident that the seventh year plantation has attained good gbh growth but in the eighth and ninth year plantation though gbh value is less, carbon growth is more. It may be because of the survival percentage of the plantations because corresponding growth in height is also observed.

Table No 1 Summary sample plot field data

Year of plantation	GBH (in Metre)	Diameter (in Metre)	Height (in metre)	Basal area (in m²)	Volume of stem (In m³)	Biomass Fresh wt. (In Kg)	Biomass dry wt. (in kg) AGB	BGB	AGC	BGC	Total Carbon
1	2	3	4	5	6	7	8	9	10	11	12
2015-16	45.949	14.633	1004.573	0.557	2.185	983.324	589.994	153.398	294.997	76.699	371.696
2014-15	54.712	17.424	996.341	1.061	4.862	2187.852	1312.711	341.305	656.356	170.652	827.008
2013-14	45.542	14.504	1302.439	0.589	2.719	1223.647	734.188	190.889	367.094	95.444	462.539
2012-13	57.607	18.346	1439.024	0.803	3.613	1626.042	975.625	253.663	487.813	126.831	614.644
2011-12	57.937	18.451	1377.439	0.710	2.852	1283.464	770.078	200.220	385.039	100.110	485.149
2010-11	64.770	20.627	1465.854	1.302	7.586	3413.811	2048.286	532.554	1024.143	266.277	1290.420
2009-10	85.852	27.341	1778.354	2.386	17.483	7867.499	4720.499	1227.330	2360.250	613.665	2973.915
2008-09	62.535	19.916	1212.500	2.239	19.357	8710.823	5226.494	1358.888	2613.247	679.444	3292.691
2007-08	55.778	17.764	840.854	2.607	23.861	10737.498	6442.499	1675.050	3221.249	837.525	4058.774
2006-07	102.565	32.664	1452.439	5.742	57.908	26058.381	15635.029	4065.107	7817.514	2032.554	9850.068
Total	**633.247**	**201.671**	**12869.817**	**17.995**	**142.427**	**64092.340**	**38455.404**	**9998.405**	**19227.702**	**4999.203**	**24226.905**

The summary field data has been normalized to per hectare and assuming that all the 1666 number of plants exist i.e. the survival percentage is 100%. As per the normalized data, the gbh and height growth is poor in the fifth year plantation i.e. plantation done in 2011-12. Another remarkable observation is that the growth of gbh though slows in third year, from sixth year onwards the growth is very good and consistent. Comparing with Garhwa data, it clearly depicts that the most relevant factor that had played in growth of carbon is the change in the amount of rainfall.

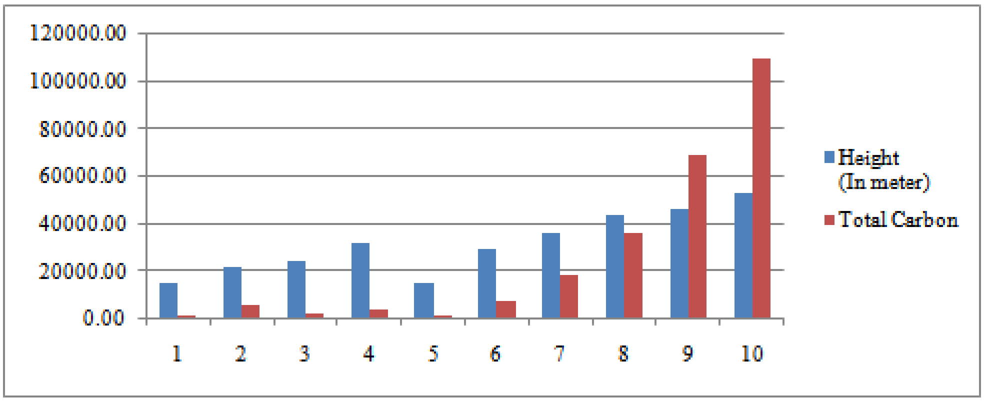
Table No 2 Normalized sample plot field data

Year of plantation	GBH (in Metre)	Diameter (in Metre)	Height (in metre)	Basal area (in m²)	Volume of stem (In m³)	Biomass Fresh wt. (In Kg)	Biomass dry wt. (in kg) AGB	BGB	AGC	BGC	Total Carbon
1	2	3	4	5	6	**7**	8	9	10	11	12
2015-16	216.856	69.062	4741.13	2.628	10.312	4640.842	2784.505	723.971	1392.252	361.985	1754.238
2014-15	369.026	117.524	6720.262	7.159	32.793	14756.928	8854.156	2302.080	4427.078	1151.040	5578.118
2013-14	260.733	83.036	7456.575	3.372	15.567	7005.485	4203.291	1092.855	2101.645	546.427	2648.073
2012-13	393.334	125.266	9825.469	5.486	24.672	11102.403	6661.441	1731.974	3330.720	865.987	4196.708

2011-12	196.586	62.607	4673.754	2.407	9.677	4354.889	2612.933	679.362	1306.466	339.681	1646.148
2010-11	402.637	128.228	9112.358	8.092	47.159	21221.673	12733.004	3310.581	6366.502	1655.290	8021.792
2009-10	535.690	170.602	11096.394	14.886	109.090	49090.834	29454.500	7658.170	14727.250	3829.085	18556.335
2008-09	685.414	218.285	13289.638	24.537	212.167	95475.202	57285.121	14894.132	28642.560	7447.065	36089.626
2007-08	948.233	301.985	14294.512	44.311	405.639	182537.470	109522.482	28475.845	54761.241	14237.923	68999.164
2006-07	1146.803	365.224	16240.023	64.199	647.476	291364.181	174818.509	45452.812	87409.254	22726.406	110135.661
Total	**5155.314**	**1641.82**	**97450.118**	**177.08**	**1514.555**	**681549.911**	**408929.946**	**106321.79**	**204464.973**	**53160.893**	**257625.866**

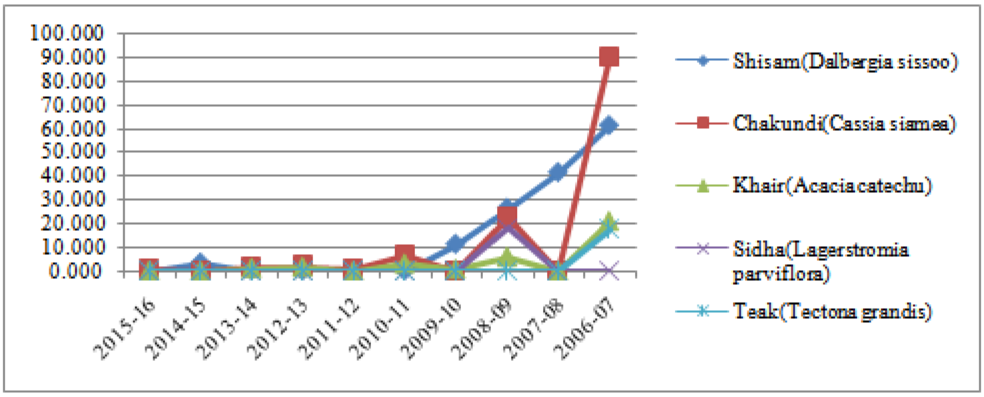
Coming to the height vs. Carbon (Figure-2) similar pattern of growth in height is seen which corresponds to the growth in gbh. But in Garhwa the proportionate growth in height were less than the growth of gbh.

Figure No 2 Height vs Carbon



In Garhwa five species: 1. *Cassia siamea* (Chakundi), 2. *Holoptelia integrifolia* (Chilbil), 3. *Gmelina arborea* (Gamhar), 4. *Acacia catechu* (Khair) and 5. *Dalbergia sisso* (Shisam) showed appreciable amount of carbon sequestration. But in Latehar instead of Chilbil and Gamhar, more carbon deposits were found in *Lagerstromia parviflora* (Sidha) and *Tectona grandis* (Teak). This variation is mostly due to the variation in rocks, minerals and soil composition. Figure-3 shows the species vs carbon deposits. The highest carbon deposit is seen in *Cassia siamea* (Chakundi) and *Dalbergia sisso* (Shisam) comes next in Latehar whereas in Garhwa maximum growth was seen in Shisam and next highest was Gamhar. This study also reflects about the species to be prioritised for the artificial regeneration with the aim to achieve better air quality.

Figure No 3 Species vs Carbon sequestration



Considering the physical characteristics, prominent rocks and minerals found in Garhwa are granite gneiss and associated migmatites. These are generally leucocratic and have gneissose fabric. Crystalline lime stones are also present in Garhwa. More so soil is lateritic clay or clayey loam in plateau areas & elsewhere shallow loam mixed with quartz pebbles and sand are present. Whereas in Latehar, the granitic rocks are associated with large areas of sedimentary rocks. Coal, Bauxite, iron ores along with lime stones are seen in Latehar. Soil is loam, sandy-loam and clayey-loam often found mixed with boulders, pebbles and murram. The average chemical characteristics of soils of Garhwa and Latehar also varies to some extent: pH value in Garhwa is 5.88 and Latehar is 6.17, Calcium percentage in Garhwa is 3.33 and Latehar is 2.66, Total organic carbon in Garhwa is 0.49% and Latehar is 3.40%, Phosphorus in Garhwa is < 1.66 Kg/acre and in Latehar it is <

5.80Kg/acre, Nitrogen in Garhwa is < 100 Kg/acre and in Latehar it is < 66 Kg./acre. Quantity of Potassium is same in both the districts. The overall soil quality in Latehar seems to be better. Latehar gets better rain fall in comparison to Garhwa district. Hence carbon sequestration is better in Latehar.

Himlal Baral, Manuel R. Guariguata, Rodney J. Keenan in their work "A proposed frame work for assessing ecosystem goods and services from planted forests" published in ELSEVIER Ecosystem Services 22(2016) 260-268 has prepared a framework for assessing Ecosystem Services having three components: (1) Silviculture and Management: species composition, stand structure, rotation length, previous land use, position in catchment, natural forest conservation (2) Provision of ES: Wild foods, Raw materials like fire wood, fodder, small timber, regulation of local climate and air quality, water regulation, habitat for species (3) Tools for assessing ES: Biophysical quantification using field measurements. From their study only the subcomponents which fit to the present study are being outlined. R.Costanza et al. / Global Environmental Change 26(2014) 152-158 has outlined four levels of ecosystem service value aggregation i.e. (1) Basic value transfer Costanza et al. (1997), Liu et al. (2010), (2) Expert modified value transfer Batker et al. (2008), (3) Statical value transfer deGroot et al. (2012) and (4) Spatially explicit functional modelling Boumans et al. (2002), Costanza et al. (2008), Nelson et al. (2009). The literature study regarding analysis of monetary valuation of carbon was given in my earlier paper, so these are not repeated.

V. Conclusions

The problem of green house gas emissions, increase in temperature and changing seasonal pattern are the major risk factors faced by the present world. Demand for energy to improve quality of life has added to the diminishing value of air and water quality, soil fertility and organic productivity of agricultural farming. The prevailing indiscipline in the modern society is a direct derivative of the above factors. The people are ignorant about the ecosystem values received from the natural forests. To a great extent they are only concerned about the depletion of materials needed for their day to day economic needs. The rapid urbanisation has contributed enormously to the negative factors of environment qualities. To make the people and the local government aware of the hidden values, this study has been carried out. Though ecosystem services from forestry plantations are manifold, for the present, this study has focussed only to the value of carbon sequestered and consequent value of emission of oxygen. Though the Government spends only INR 1,35,965 per hectare of such plantation, the resultant benefit only from carbon and oxygen touches more than INR 44,85,000 in Latehar. Only on these accounts the social cost benefit is thirty two times more than the investment. So it is advisable that such short rotation plantation activities are to be given further boost not only to improve the air and water quality but also for myriads of other tangible and intangible benefits.

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