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Estimation of Carbon Storage in the Tree Growth of Solapur University Campus, Maharashtra, India

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Abstract: ***Urban forest, which includes trees in streets, gardens and parks provide valuable ecosystem services. Several university campuses having large vegetative areas support excellent plantation of tree cover. These types of forest cover counterbalance carbon emissions through carbon storage and sequestration from urban areas. The present study deals with the estimation of tree biomass and carbon storage and sequestration in the Solapur University. To estimate the carbon stock in the tree growth, non-destructive and allometric method was used. It is recommended for both sustainable planning of forest resources and for studies on the energy and nutrients flows in ecosystems. Total 30 species including 1230 individuals of trees were recorded in the present study. The maximum carbon storage was found in the Azardirichta indica for both the above and below components. However, in the saplings of these trees, Ploythia longifolia has good shown potential for the sequestration of carbon. Although Tamarindus indica has highest wood density (900.2 kg/m^3) among the trees species found the study area, it has lower abundance in comparison to other species. Vegetation in well managed conditions such as university campuses and built environment are likely to have a greater impact per area of tree canopy cover in comparison to other non-urban forests due to faster growth rates and increased proportions of large trees.***

Keywords: Carbon, Climate change, Biomass, Sequestration, Urban forest.

1. Introduction

Trees have good potential of tapping atmospheric carbon through photosynthesis. The sequestrated carbon is stored in the plant tissues which results in the growth. Carbon sequestration phenomenon is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time. Plants store carbon in terms of live biomass, which becomes a part of the food chain and enters the soil as soil carbon. Subsequently, it renters into the atmosphere upon burning and decomposition. Worldwide concern about global climate change has created increasing interest in trees to help reduce the level of atmospheric CO_2. Urban forests sequester carbon and affect the emission of CO_2 from urban areas. Thus, urban forests can play a major role in managing the increase in CO_2 levels. Urban trees store carbon derived from CO_2, which is the major gas contributing to global climate change.

The estimation of stem volume and tree biomass forms the part of non-destructive and allometric methods for the estimation the carbon storage. It is recommended for both sustainable planning of forest resources and for studies on the energy and nutrients flows in ecosystems [1]. In addition, the United Nations Framework convention on climate change and in particular the Kyoto Protocol recognize the importance of forest carbon sink and the need to monitor, preserve and enhance terrestrial carbon stocks, since changes in the forest carbon stock influence the atmospheric CO_2 concentration [2].

India being a tropical country, it has very high potential for tree growth and carbon sequestration. More than 116 million tons of CO_2 per year is sequestered contributing to reduce atmospheric carbon [3]. Urban forest [4] includes trees in streets, gardens and parks provide ecosystem services such as removing air-borne pollutants [5], reducing the urban heat island effect [6] and counterbalancing carbon emissions through carbon storage and sequestration [7]. In India, several studies have successfully shown the carbon storage potential for urban forests [8] and trees planted in the university campuses [9] [10]. The present study deals with the estimation of tree biomass, carbon storage and sequestration in the Solapur University campus.

2. Study Area

Solapur University is located on a plateau that supports dry grassland biodiversity. The campus lies between North latitudes $17^0$43' and $17^0$44' and East longitudes $75^0$50' and 75^0 05'with the total area of Vidhya Vihar campus being 38.5 acres. It is on the northern side of the city, towards west of the national highway NH-65. The maximum temperature ranges from 45^0C during summer months of March-May and the minimum temperature is 10^0C during the winter months of November-January. The average rainfall is about 750 mm received during the rainy season from June to the end of September. The climate of the region supports the vegetation that can be conveniently divided into tropical dry deciduous forests, thorny forests and vast tracts of grasslands [11].

3. Methodology

3.1 Sampling technique

Quadrant method was used to estimate the population of all the tree species. They were made department wise. All the species located around that department and entire tress on the campus was counted. The following parameters were measured to estimate biomass and carbon content:

3.2 Tree height and Diameter at Breast Height (DBH)

To estimate biomass of different trees, non-destructive method was used. The biomass of trees was estimated on the basis of DBH (Diameter at Breast Height) and tree height.

DBH can be determined by measuring tree Girth at Breast Height (GBH), approximately 1.3 meter from the ground. The GBHs of trees having diameter greater than 10 cm were measured directly by measuring tape.

3.2 Above the Ground Biomass of the trees (AGB)

It includes all living biomass above the soil. The above ground biomass (AGB) has been calculated by multiplying the volume of biomass and wood density. The volume was calculated based on diameter and height. The wood density value for the species obtained from world agroforestry database [12]. Wherever the wood density of tree species was unavailable, the standard average value of 0.6 gm/cm3 was taken.

AGB include all living biomass above the soil. The aboveground biomass (AGB) has been calculated by multiplying volume of biomass and wood density the volume was calculated based on diameter and height [13].
AGB (g) = volume of biomass (cm^3) × wood density (g/ cm^3).

3.3 Below the Ground biomass (BGB)

This includes all biomass of live roots excluding fine roots having, less than 2 mm diameter. The below ground biomass (BGB) has been calculated by multiplying above ground biomass taking 0.26 as the root shoot ratio [14].

BGB (g) = 0.26 × above ground biomass (ton).

3.4 Total Biomass (TB)

Total biomass is the sum of the above and below ground biomass.

TB = Above Ground Biomass + Below Ground Biomass.
Generally, for any plant species 50% of its biomass is considered as carbon. [15].

Carbon Storage = Biomass × 50% or Biomass/2

4. Result and Discussion

There were total 30 Species including 1230 individuals recorded in Vidhya Vihar campus of Solapur University. Table no. 1 shows the details of various species, their frequency and other parameters required for the present investigation. The comparison between saplings of various species is illustrated in figure 1. It is noticed from the said figure that Neem (*Azardirichta* indica) has maximum carbon contain i.e. 1242.816 tons. Table no.1 also show maximum AGB & BGB of *Azardirichta indica* is 1972.723 kg/tree and 512.908 kg/tree respectively, followed by Scholar tree *Alstonia scholoris* having carbon content of AGB and BGB as 1017.142 tons, 1614.511 kg/tree, 419.772 kg/tree. The other major carbon sequestration saplings were Gooseberry E*mblica officinalis* (724.611tons), Ber *Zizypus jujube (*688.743 tons), Bidi leaf tree *Bauhinia racemosa* (658.901 tons) and Coconut *Cocus nucifera* (616.7 tons).

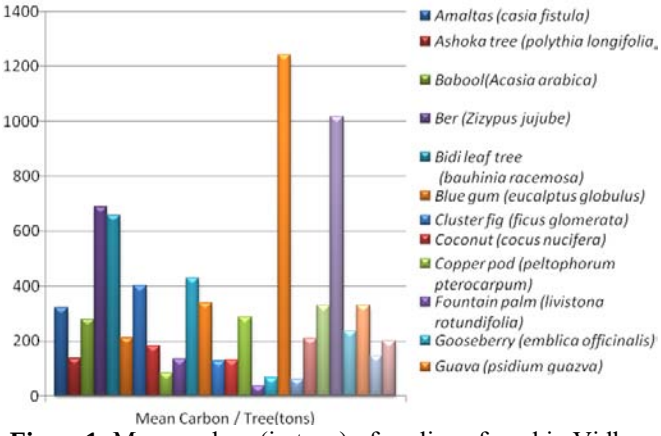

Figure1: Mean carbon (in tons) of saplings found in Vidhya Vihar Campus of Solapur University

Figure No.2 shows that the carbon estimation of adult trees and the carbon sequestration for Neem *Azardirichta indica* is maximum i.e. 42761.534 tons AGB & BGB is 836683.066 kg/tree, 17647.61 kg/tree, followed by Gulmohar D*elonix regia* carbon sequestration, AGB & BGB 32535.75 tons, 51644.05 kg/tree, 13427.452kg/tree respectively. The other tree with maximum carbon sequestration were Bidi leaf tree B*auhinia racemosa* (22043.291 tons), Peacock flower *Caesalpinia pulcherima* (12242.758 tons), Peepal *Ficus religiosa (*8749.556 tons).Trees with minimum carbon sequestration were Bael *Aegle marmelos* (391.4 tons), Shevari S*esbania sesban* (216.716 tons), Prajakta *Nyctanthes arbortristis* (425.862 tons).

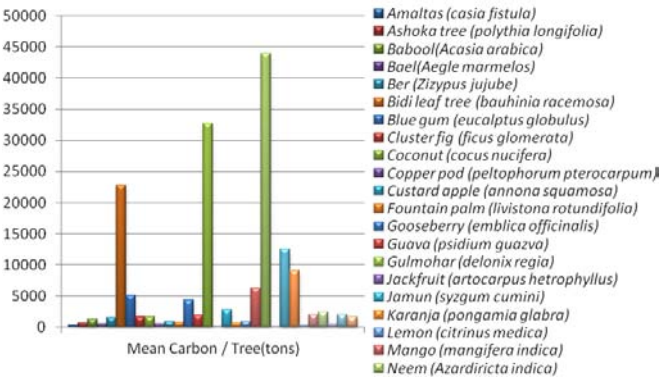

Figure 3: Combined Graph of Mean Carbon Content per tree found in Solapur University Campus

Table 1: Carbon estimation of both saplings & trees found in Vidhya Vihar Campus of Solapur University

Speices Name	*No. Of Individual*	*Mean AGB (kg/tree)*	*Mean BGB (kg/tree)*	*Total Biomass (kg/tree)*	*Wood Density (kg/m^3)*	*Mean Carbon / Tree (kg/tree)*	*Mean Carbon in total Speices (kg/tree)*
Casia fistula	5	510.385	132.7	643.1	829.3	321.5425	1607.713
Polythia longifolia	94	1248.33	249.1	1207	563.5	603.612	56739.53
Acasia arabica	9	1740.88	498.7	2472	700	1235.966	11123.69
Aegle marmelos	1	814.901	211.9	1027	782.8	513.3875	513.3875
Zizypus jujube	22	2373.1	617	2990	610	1495.055	32891.21
Bauhinia racemosa	19	36035.2	9369	45404	634	22702.19	431341.7
Eucalptus globulus	52	8093.17	2104	10197	709.3	5098.699	265132.3
Ficus glomerata	6	2703.36	702.9	3406	375.8	1703.117	10218.7
Cocus nucifera	22	2663.25	692.4	3356	616.7	1677.85	36912.69
Peltophorum pterocarpum	12	816.81	212.4	1029	660	514.59	6175.08
Annona squamosa	1	1384.61	360	1745	613.5	872.305	872.305
Livistona rotundifolia	77	1190.95	309.6	1501	795	750.2965	57772.83
Emblica officinalis	53	6817.77	1773	8590	728.8	4295.196	227645.4
Psidium guazva	57	3081.05	801.1	3882	671.3	1941.06	110640.4
Delonix regia	156	51849	13481	65330	510	32664.85	5095717
Artocarpus hetrophyllus	2	211.123	54.89	266	535.9	133.0075	266.015
Syzgum cumini	6	4461.05	1160	5621	701.1	2810.462	16862.77
Pongamia glabra	43	1023.89	266.2	1290	619.8	645.0525	27737.26
Citrinus medica	1	1439.02	374.1	1813	769.7	906.5845	906.5845
Mangifera indica	12	9922.44	2580	12502	597.7	6251.138	75013.66
Azardiricta indica	197	838656	18161	88009	727.5	44004.35	8668857
Nerium indium	2	100.161	26.04	126.2	600	63.1015	126.203
Caesalpinia pulcherima	92	19765.6	5139	24905	840	12452.3	1145612
Ficus religiosa	18	14412.1	3747	18159	443	9079.646	163433.6
Nyctanthes arbortristis	1	675.972	175.8	851.7	880	425.8625	425.8625
Alstonia scholoris	104	3138.9	816.1	3955	397.3	1977.505	205660.5
Terminlia catapp	9	3890.35	1011	4902	540.4	2450.921	22058.29
Sesbania sesban	30	868.613	226.1	1096	430	547.7925	16433.78
Tamarindus indica	61	3310.38	860.7	4171	990.2	2085.542	127218
Tectona grandis	66	2657.6	691	3349	612.7	1674.29	110503.1

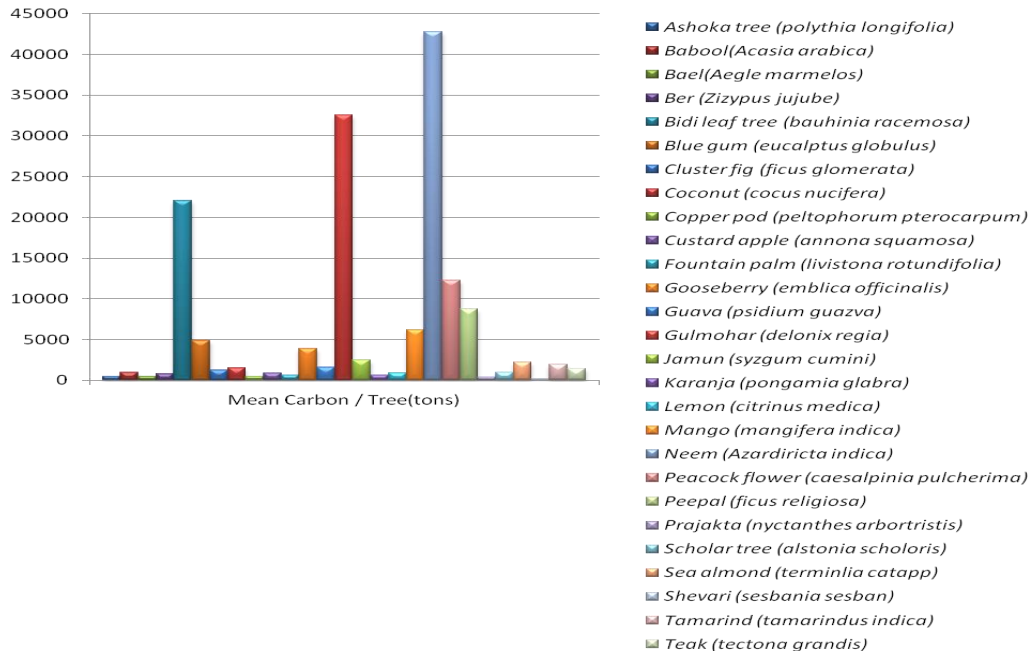

Figure 2: Mean carbon of trees species found in Solapur University campus

Table no.1 and figure no.3 shows both combine carbon sequestration of saplings and trees. In this graph, it is shown that Neem *Azardirichta indica,* Gulmohar *Delonix regia,* Bidi leaf tree *Bauhinia racemosa* have maximum carbon sequestration i.e. 44004.35 tons, 32664.85 tons, 22702.192 tons respectively. Tree with minimum carbon sequestration were Oleander *Nerium indium,* Jackfruit *Artocarpus hetrophyllus,* Prajakta *Nyctanthes arbortristis* with 63.101 tons, 133.007 tons, 425.862 tons respectively.

5. Conclusion

Carbon sequestration could play an important role in reducing greenhouse gas emissions. Forest areas and plantations in urban areas can play a significant role in carbon storage and sequestration. Vegetation in preperly managed conditions such as university campuses and other built environments are likely to have a greater impact per area of tree canopy cover in comparison to non-urban forests due to faster growth rates and increased proportions of large trees. However, urban tree maintenance emissions can offset some of the carbon gained by urban forest systems [16]. The Carbon sequestration capacity of tree increases as the age of the tree increases. Therefore, it can be concluded that the older have higher carbon content than younger trees. However, it is also observed that saplings have more capacity of absorbing carbon than old trees as they are growing and require more carbon to grow. Moreover, old trees are the reservoirs of carbon. It is noticed that Neem (*Azardirichta indica*) tree act as the best carbon absorbing agent in the present study area. The challenges of climate change can be efficiently overcome by the storage of carbon in terrestrial carbon sinks viz. plants, plant products and soils for longer periods of time. The plantation programme of Solapur University strives to achieve zero carbon emission and to reduce iys carbon footprint.

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