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A Quantitative Investigation on Carbon Sequestration at Jorhat Kendriya Mahavidyalaya, Jorhat

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Abstract

Carbon, as the most abundant element in all living organisms, plays a crucial role in the formation of essential biomolecules such as proteins, nucleic acids, and carbohydrates. Green plants act as primary reservoirs of carbon on Earth, contributing significantly to the carbon cycle by removing carbon dioxide from the atmosphere through the process of carbon sequestration. Carbon sequestration undeniably plays a pivotal role in mitigating climate change. In a recent study conducted on the college campus of Jorhat Kendriya Mahavidyalaya, the carbon storage of various plant species was estimated using a meticulous, non-destructive approach. The findings revealed that factors such as tree age, size, canopy cover density and tree species significantly influence carbon storage capacity. Understanding these relationships can aid in optimizing urban carbon sequestration efforts by strategically selecting tree species and enhancing green spaces within urban environments. Among the 11 plant species studied, *Terminalia arjuna* demonstrated the highest carbon storage accounting for a remarkable 22.06 metric tons of carbon (tC), while *Cassia fistula* displayed the lowest estimated carbon storage at 0.097 tC. The research aims to assess the contribution of these plants to carbon sequestration by strategically selecting tree species and enhancing green spaces within urban environments.

Key words: Green plants, Carbon sequestration, Climate change, *Terminalia arjuna,* Urban

Carbon dioxide, the major greenhouse gas, is important for plants because it is used in the synthesis of polysaccharides, proteins, and lipids, among other things, during photosynthesis. In plants and animals, the photosynthetic process is critical for biomass formation. Carbon di oxide is present in the atmosphere in trace amounts, i.e. 0.03 percent. However, due to human activities, the carbon-dioxide concentration has recently increased, amplifying the Earth's natural greenhouse effect. Human activities, such as the combustion of fossil fuels, have unequivocally released carbon dioxide into the atmosphere. Carbon sinks are reservoirs that hold carbon and prevent it from entering the Earth's atmosphere. This process is vital for regulating the Earth's climate by lowering the overall carbon dioxide levels in the atmosphere, thus effectively mitigating the impact of human-induced greenhouse gas emissions on global warming. Throughout the preceding six decades, the yearly rate of augmentation in atmospheric carbon dioxide levels has been roughly 100 times more rapid than the prior natural increments [1]. Their accumulation in the atmosphere is likely to cause climate change (USDA 2000). This extent and impact of increasing atmospheric CO_2 on Climate Change (IPCC) leads to an agreement in Kyoto, Japan, in December 1997, to reduce greenhouse gas emissions.

Carbon sequestration demonstrably plays a crucial role in mitigating climate change by decisively reducing the concentration of greenhouse gases in the atmosphere. This assertive process significantly contributes to combating global warming and its associated impacts on the environment. It aids in the stabilization of carbon in both solid and dissolved forms, preventing it from warming the atmosphere. There exist two distinct categories of carbon sequestration: biological and geological. Biological carbon sequestration refers to the mechanism of sequestering carbon dioxide within various ecosystems, including oceans, soils, forests, and grasslands, among other environments. Conversely, geological carbon sequestration entails the capture of carbon dioxide emissions originating from industrial processes and their subsequent injection into subterranean rock formations, where they can be securely confined for extended durations. Both methodologies are integral to the alleviation of climate change; however, they necessitate meticulous management and oversight to guarantee their efficacy and safety over time [2].

Forests are one of the most significant sequesters. The trees can be used as a method of carbon sequestration directly or indirectly. In the direct method standing trees act as a storehouse of carbon, while the indirect method means the substation of forest product for fossil fuels. Carbon offset is achieved in both the methods. Although it is not feasible for them to completely sequester all surplus carbon dioxide released through the utilization of fossil fuels, their potential to

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effect positive change can be significantly enhanced through our support and encouragement.

Consequently, effectively managed forests have the capacity to contribute to the purification of our atmosphere and aquatic systems, safeguard habitats for diverse wildlife, offer recreational opportunities, and maintain the aesthetic integrity of trees in their natural environment for the benefit of future generations [3-4]. The selection of appropriate species for reforestation represents a pivotal component in the rehabilitation of the compromised ecosystem. Although the significance of biomass from tree species in the sequestration of carbon has been recognized for an extended period, limited initiatives have been undertaken to quantify biomass growth and its contribution to carbon sequestration. The efficiency of carbon capture exhibits variability contingent upon factors such as tree species, soil composition, regional climate, topographical characteristics, and management methodologies. The main objective is to survey the tree species on the college campus and determine their total carbon sequestration potential through our research.

MATERIALS AND METHODS

Jorhat is positioned in the northern hemisphere and exhibits a climate characterized as warm and temperate. Our research was conducted at Jorhat Kendriya Mahavidyalaya in Kenduguri, Assam (Fig 1). Jorhat Kendriya Mahavidyalaya is located between 26.77030 N latitude and 94.24350 E longitude in Jorhat, Assam, India. The average temperature of the area is about 23.7 °C (74.7 °F) and the annual precipitation is about 2699 mm (106.3 inch). It encompasses approximately 6 acres. The region encompasses a diverse range of tree species that have been planted over time through different plantation initiatives coordinated by the college administration and have subsequently become a crucial component of the college. The arboreal entities situated within the college grounds serve to uphold both ecological and aesthetic values, facilitate carbon sequestration, and promote soil stabilization; furthermore, they have significantly enhanced the quality of life for not only the academic community but also the inhabitants of the adjacent regions by generating oxygen, ameliorating air quality, contributing to climate regulation, conserving water, preserving soil integrity, supporting biodiversity, and moderating climatic conditions through the attenuation of solar radiation, precipitation, and wind effects.

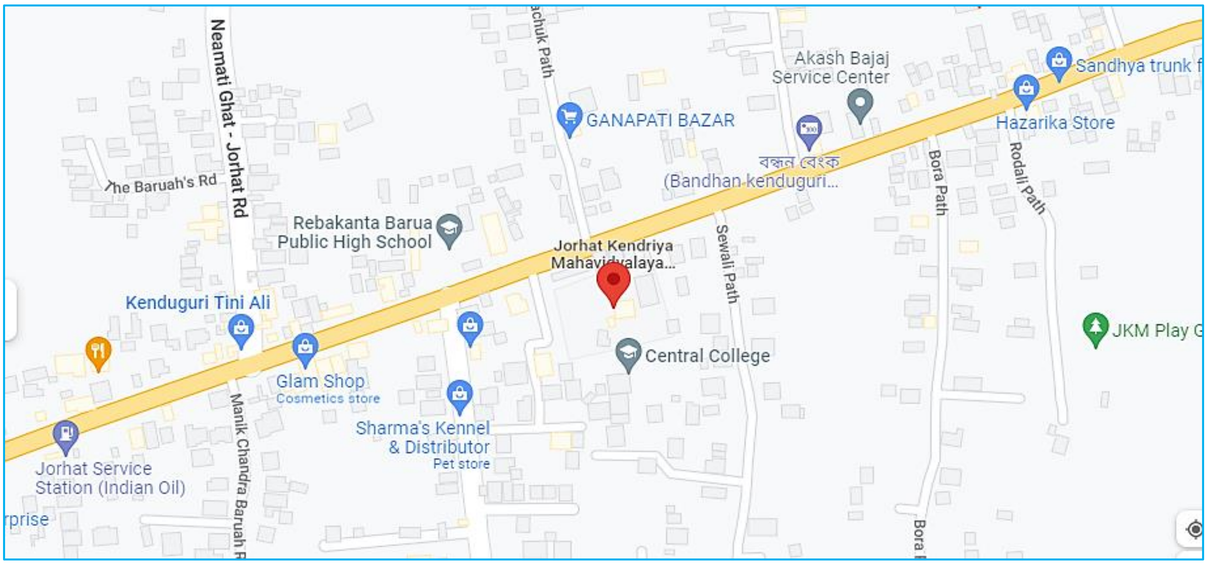

Fig 1 Study area (Jorhat Kendriya Mahavidyalaya)

There exist two distinct methodologies for the estimation of carbon content within arboreal species. These methodologies encompass both destructive and non-destructive approaches [5]. We opted for the non-destructive approach for carbon estimation, as it circumvents the necessity of harvesting the complete biomass and thereby preserves the integrity of the tree. This approach allows us to gather essential data while ensuring the trees continue to thrive and contribute to the ecosystem. Additionally, this method enables us to monitor growth patterns over time, providing insights into the long-term health of the forest and its ability to sequester carbon effectively. The current manuscript investigates the processes of biomass accumulation and carbon sequestration by considering 11 trees. The specimens were chosen in an arbitrary manner from plantations of varying ages, exemplifying a range of diameters and heights. The tree's girth was measured at 1.32m above ground surface at the girth at breast height (GBH). The diameter (D) of the tree was measured in relation to the actual marked girth of the species [5-6] i.e. GBH/3.14. Therefore; D = (GBH/π), diameter (meter) calculated from GBH, assuming the trunk to be cylindrical, H = Height (meter). The biomass of the selected tree species is calculated using biostatistics-based allometric equations. The tree bio-volume (TBV) value is determined through the multiplication of the tree species' diameter and height, subsequently adjusted by a factor of 0.4. Above ground biomass (AGB) are estimated by multiplying the bio-volume to the green wood density of tree species. Wood density is used from Global wood density database [6]. The normative average density of 0.6 grams per cubic centimeter is utilized in instances where the specific density value for particular tree species is not accessible. The subterranean biomass has been derived by applying a multiplication factor of 0.26 to the above-ground biomass (AGB), reflecting the root-to-shoot ratio. [7-8]. Thus, the total biomass is calculated as the sum of the above and below the ground biomass.

Bio-volume (T) = $0.4 \times (D)^2 \times H$ (Eq......... 1)

AGB = Wood density × T (Eq……… 2)

BGB = AGB × 0.26 (Eq……… 3)

Total Biomass (TB) = Above Ground Biomass + Below Ground Biomass (Eq………. 4)

The carbon content in the biomass ranges between 35%-65%. But generally, for any plant species 50% of its biomass is considered as carbon [9]. Therefore, carbon storage can be calculated as:

Carbon Storage = Biomass × 50% or Biomass/2 **(**Eq………… 5)

RESULTS AND DISCUSSION

The quantification of carbon dioxide sequestration by the matured tree present on the Campus are listed in table 1 and table 2. According to the data presented the trees on the college campus store approximately 30.597 tonnes of carbon. *Casia fistula* shows the lowest carbon storage value (097 tC), while *Terminalia arjuna* has the highest carbon storage (22.06 tC). Our investigation further indicates that an increase in the diameter of a species correlates with an augmentation in its biomass and carbon storage potential, thereby enhancing its ability to sequester greater quantities of carbon and mitigate the concentration of carbon dioxide in the atmosphere. The ramifications of these results underscore the critical necessity of conserving a diverse array of tree species to optimize the carbon sequestration potential throughout the campus ecosystem [10-11].

Table 1 Selected tree species of Jorhat Kendriya Mahavidyalaya, Jorhat with their GBH and height

S. No.	Common name	Scientific name	GBH (meter)	Height (meter)
1.	Arjun	*Terminalia arjuna*	3.99	15.24
2.	Arjun	*Terminalia arjuna*	1.46	18.29
3.	Arjun	*Terminalia arjuna*	1.02	12.19
4.	Kodom	*Neolamarckia cadamba*	1.21	12.19
5.	Coconut	*Cocos nucifera*	0.737	8.53
6.	Coconut	*Cocos nucifera*	0.701	8.53
7.	Xonaru	*Cassia fistula*	0.356	9.14
8.	Xonaru	*Cassia fistula*	0.356	9.14
9.	Xonaru	*Cassia fistula*	0.356	9.14
10.	Devodaru	*Polyalthia longifolia*	0.61	9.14
11.	Acacia	*Acacia* sp.	1.21	13.71

Table 2 List of the tree species with their above ground, below ground and total biomass with carbon

S. No.	Scientific name	AGB (Kg)	BGB (Kg)	TB (Kg)	C (Kg)	CO_2 (Kg)	CO_2 C(tons)
1.	*Terminalia arjuna*	10054.45	2614.15	12668.61	6017.59	22060.48	22.06
2.	*Terminalia arjuna*	1263.85	328.60	1592.45	756.41	2772.99	2.772
3.	*Terminalia arjuna*	408.13	106.11	514.24	244.264	895.57	0.895
4.	*Neolamarckia cadamba*	347.04	90.23	437.27	255.074	935.10	0.935
5.	*Cocos nucifera*	113.47	29.50	142.97	127.48	467.34	0.467
6.	*Cocos nucifera*	104.22	27.09	131.31	76.59	280.77	0.280
7.	*Cassia fistula*	36.38	9.45	45.83	26.73	97.99	0.097
8.	*Cassia fistula*	36.38	9.45	45.83	26.73	97.99	0.097
9.	*Cassia fistula*	36.38	9.45	45.83	26.73	97.99	0.097
10.	*Polyalthia longifolia*	73.81	19.19	93.00	44.17	161.92	0.162
11.	*Acacia* sp.	53.06	13.79	66.85	31.75	116.42	0.116

AGB: Above-ground biomass; BGB: Below-ground biomass; TB: Total biomass (AGB + BGB); C: Carbon content; CO_2: Equivalent carbon dioxide

The (Table 2) presents a detailed analysis of the biomass components and carbon metrics for different tree species, highlighting their potential in carbon sequestration. The tree species listed include *Terminalia arjuna*, *Neolamarckia cadamba*, *Cocos nucifera*, *Cassia fistula*, *Polyalthia longifolia*, and *Acacia sp*. For each species, data includes above-ground biomass (AGB), below-ground biomass (BGB), total biomass (TB), carbon content (C), equivalent carbon dioxide (CO_2), and CO_2 equivalent in metric tons [1].

Above-ground biomass (AGB): This refers to the weight of all living parts of the tree above the soil, such as trunks, branches, and leaves, measured in kilograms (Kg). It is a significant contributor to the tree's overall biomass, often representing a large portion of the total. For example, *Terminalia arjuna* in row 1 has an AGB of 10,054.45 Kg.

Below-ground biomass (BGB): The biomass present in the root system, also measured in kilograms, typically forms a smaller part of the total biomass compared to the AGB but is essential for overall carbon storage. In the case of *Terminalia arjuna* in row 1, the BGB is 2,614.15 Kg.

Total biomass (TB): This metric is calculated by adding AGB and BGB, representing the total biomass of the tree, combining both above and below-ground portions. For *Terminalia arjuna* in row 1, the TB is 12,668.61 Kg.

Carbon content (C): Trees sequester carbon as they grow, storing it in their biomass. The carbon content in Kg is calculated as a portion of the total biomass, as carbon typically makes up approximately 47–50% of dry biomass. For instance, *Terminalia arjuna* has a carbon content of 6,017.59 Kg.

Carbon dioxide (CO_2) equivalent

This represents the amount of CO_2 that would equate to the carbon stored in the biomass. It is derived from the carbon content, with CO_2 being approximately 3.67 times the weight of carbon. For *Terminalia arjuna* in row 1, this results in 22,060.48 Kg of CO_2.

CO_2 equivalent in metric tons

This provides the CO_2 equivalent in metric tons, which is a standardized measure for reporting carbon sequestration potential. Here, *Terminalia arjuna* in row 1 stores approximately 22.06 metric tons of CO_2.

Terminalia arjuna: Appearing multiple times with varying above-ground biomass and below-ground biomass values, it is one of the largest biomass accumulators in the list. In row 1, it has an AGB of 10,054.45 Kg and a total biomass of 12,668.61 Kg, making it a significant carbon sink with 22.06 tons of CO_2.

Neolamarckia cadamba: With a lower above-ground biomass of 347.04 Kg, this species has a more moderate carbon storage capacity of 0.94 metric tons of CO_2.

Cocos nucifera: This species has a smaller total biomass, with above-ground biomass values of 113.47 Kg and 104.22 Kg in rows 5 and 6, respectively. Its CO_2 storage ranges from 0.28 to 0.47 metric tons, making it a more modest carbon sink compared to larger trees.

Cassia fistula: The repeated entries for *Cassia fistula* (rows 7-9) reflect a consistent above-ground biomass and below-ground biomass of 36.38 Kg and 9.45 Kg, respectively. Each instance contributes around 0.10 metric tons of CO_2.

Polyalthia longifolia and *Acacia sp*.: These species show relatively low biomass but still contribute to carbon sequestration. For example, *Polyalthia longifolia* in row 10 has a CO_2 equivalent of 0.16 metric tons, while *Acacia sp.* in row 11 stores 0.12 metric tons of CO_2.

The (Table 2) serves as an essential resource for understanding the carbon sequestration potential of various tree species. Larger species like *Terminalia arjuna* play a substantial role in carbon storage, while smaller species still contribute to the overall carbon pool, underscoring the importance of a diversity of species in afforestation and carbon offsetting programs. This data can inform forest management practices and climate mitigation strategies by providing insights into the species-specific biomass and carbon sequestration capabilities [12].

CONCLUSION

This study discovered species-specific variation in tree volume, biomass, and carbon stocks across plots in Jorhat Kendriya Mahavidyalaya, Kenduguri, Assam. Because of increased intraspecific competition, biomass and carbon stocks decreased with narrower spacing compared to more widely spaced plantations. The tree species with the highest carbon dioxide sequestration capability in the studied area is *Terminalia arjuna.* The species had higher volumes and biomass accumulated higher carbon stocks than many of its counterparts, making it a prime candidate for targeted planting efforts. The preservation of a diversified assemblage of species has the potential to augment resilience, thereby guaranteeing the sustained vitality and well-being of the ecological framework. Furthermore, the involvement of the campus populace in tree plantation endeavors can significantly bolster carbon sequestration initiatives and cultivate a profound sense of guardianship towards the ecological milieu.

Conflicts of interest

The authors declare no conflicts of interest.

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