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Carbon Stock Potential of Coconut Plantations in University Campus: A Case Study from Coimbatore, India

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Authors' contributions

This work was carried out in collaboration between both authors. Author LAP contributed by conceptualization, statistical analysis, supervision and writing of the manuscript. Author MK contributed by field survey and data collection. Both authors read and approved the final manuscript.

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ABSTRACT

The urgent need to mitigate climate change has prompted researchers to explore various avenues for carbon sequestration. One such avenue is the utilization of natural ecosystems like forests and plantations. Coconut plantations in university campuses play a vital role in carbon sequestration in mitigation of climate change. In this case study, we report the potential of coconut plantation from Bharathiar University campus, India. Four plots of 50 m × 50 m were randomly sampled from the coconut plantation in Bharathiar University campus. Carbon stock of the coconut plantation was calculated based on field survey and allometric equations. A total of 171 trees were recorded from the four plots totalling one hectare (ha) area. The total carbon stock determined for the one ha of coconut plantation sampled from Bharathiar University campus was 31.69 tonne/ha and the mean carbon stock per tree was 0.19 ± 0.06 tonne/tree. We have discussed the carbon stock of coconut tree allocation by above-ground and below-ground parts. This case study highlights the importance

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of coconut plantations in university campuses in support of curbing the atmospheric carbon concentration. We suggest for plantation of coconut trees in university campuses, that can serve not only as carbon sinks but also contribute to fulfilling the sustainable development goals of the nation.

Keywords: Agroforestry; carbon stock; coconut tree; climate change; university campus.

1. INTRODUCTION

As India advances its development at a rapid pace, addressing the substantial and escalating emission of CO_2 within the country will be crucial in the global fight against climate change. Currently, human activities, such as the burning of fossil fuels, deforestation, and livestock farming, are increasingly exerting influence on the climate and Earth's temperature. These activities contribute significant amounts of greenhouse gases to those naturally present in the atmosphere, intensifying the greenhouse effect and exacerbating global warming [1,2].

The United Nations Framework Convention on Climate Change (UNFCCC) aims to stabilize the greenhouse gases in the atmospheres [1]. The Kyoto Protocol acknowledges forestry as a sink measure under the Clean Development Mechanism, specifically recognizing afforestation and reforestation as eligible forms of forestry activities. The Kyoto Protocol stands as a landmark international treaty that, upon ratification by the requisite number of countries, imposes legally-binding emission reduction targets on carbon and other greenhouse gases implicated in global warming. Carbon sequestration has garnered significant attention in the past due to its commodification.

Plantation programs can be used to create carbon credits which can generate significant income for developing countries. Plantation trees are particularly important as a carbon reservoir because trees hold much more carbon per unit than other types of vegetation. Niles et al. [2,3] assert that estimating carbon stocks and changes in tree biomass (both above and below ground) is essential for studying climate change within the framework of the UNFCCC.

According to the IPCC 2000 report [4], the majority of the observed rise in global average temperatures can be attributed to the steady increase of CO_2 in the atmosphere. The atmospheric CO_2 concentration has rose from 280 parts per million (ppm) in 1850 (at the beginning of industrial revolution) to 426 ppm in 2024 [5]. And, it has been predicted that the mean global temperature will increase by 1.1°C to 6.4°C by the year 2100 (IPCC, 2007) [6,7].

Trees act as a sink for CO_2 by fixing carbon during photosynthesis and storing excess carbon as biomass. Forestry has been recognized as a means to reduce CO_2 emission as well as enhancing carbon sinks. The introduction of carbon credits through programs such as the United Nations initiatives for global Reforestation and Reducing Emissions from Deforestation and Forest Degradation underscores the significant financial implications associated with the accuracy of carbon stock estimates in tropical landscapes [8].

Tree plantations and agroforests are widely believed to enhance the terrestrial carbon pool, and reforestation with native species could potentially yield a range of additional benefits, including increased bird populations, seed deposition, and enhanced understory diversity [9].

Earlier, carbon sequestration research focused mostly on the natural forest vegetation [10], and very little information is available on the plantations [11,12,13]. Plantations in university campuses are completely neglected in understanding their carbon sequestration potential. Hence, the present study was aimed to fill the knowledge gap with a case study. The main objective of this study is to estimate the total carbon stock of coconut plantation in Bharathiar University campus.

1.1 Description of Study Area

1.1.1 Study area

The present study was carried out in Bharathiar university campus located at the foot hills of Maruthamalai, a mountain forest that forms a part of Westhern Ghats and falls in the Coimbatore district of Tamil Nadu state, India (Fig. 1). The university campus covers an area of 1000 acres, and located 15km west of Coimbatore on Maruthamalai road. The university campus has a predominant red soil impregnated with organic matter, and granite, bed rock is overlaid with shallow, sandy loam, and glacial soil are moderate to well drained.

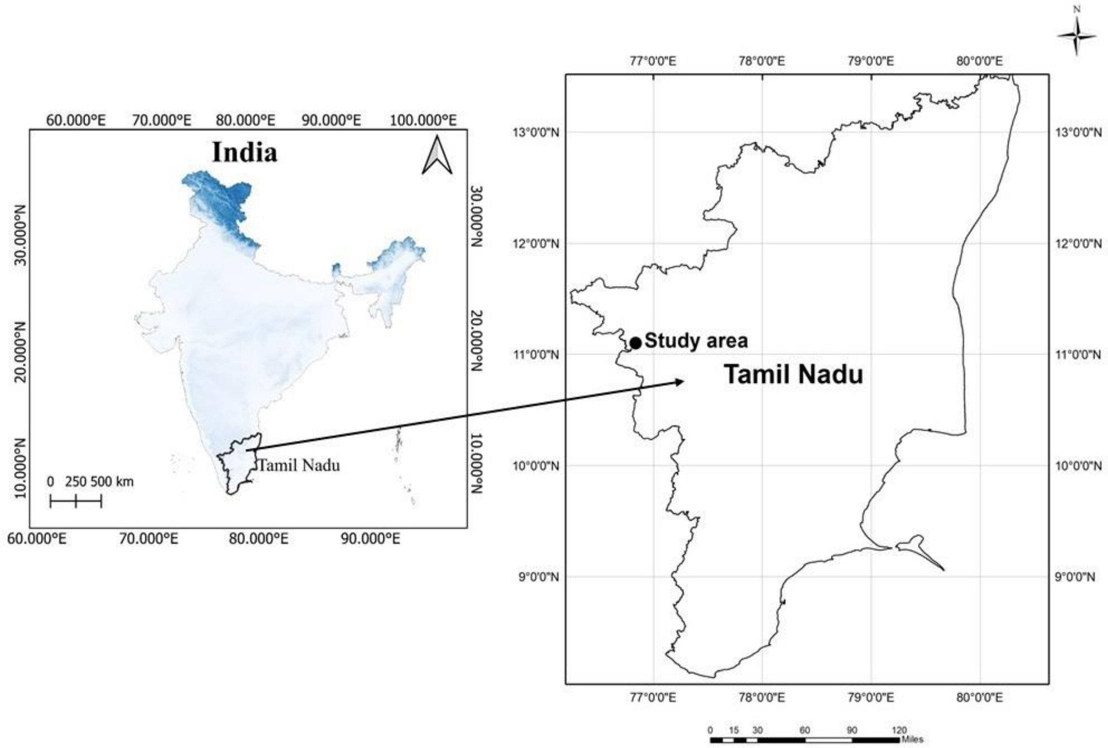

Fig. 1. Location map of study area

1.1.2 Climate

According to climate data covering the period from 1991 to 2021, the study area experienced an average annual rainfall of 952 mm. Notably, the majority of this rainfall, accounting for 77% of the total, occurred during the months from June to November. For the same period, the average monthly temperature was recorded at 25°C. The minimum and maximum temperatures were observed during January (18°C) and April (35°C), respectively.

2. MATERIALS AND METHODS

2.1 Study Species

In this study, we focused to understand the carbon sequestration potential of coconut plantation located in Bharathiar University Campus. The carbon stock of the coconut plantation was calculated based on field survey and allometric equations. The scientific name of coconut plant species is *Cocus nucifera* L. and it belongs to the plant family Arecaceae. The coconut tree is considered the only living species of the Cocos genus. Coconuts are expected to have originated from the Indonesia – India region. The trunk is unbranched, erect, stout and cylindrical, and reach an approximate height of 20 m. In India coconut finds significance in religion and culture, it is most commonly used for various rituals. Tamil Nadu accounts for the largest production in the country of about 28.9 % [14].

2.2 Methods

For field survey, four plots of 50 m × 50 m were randomly sampled from the coconut plantation in Bharathiar University campus during March 2024. Girth at breast height (GBH) of each tree was measured at 1.5 m from the ground level using measuring tape. Allometric equations were adopted for determination of biomass and carbon stock of each tree, by using the GBH data. Total biomass of each tree was calculated as the sum of above-ground and below-ground biomass. Above-ground biomass was determined using allometric equation, $Y = 34.4703 - 8.0671D + 0.6589 D^2$, where Y is above-ground biomass and D is diameter at breast height in cm [15]. Below-ground biomass was calculated as 15% of the above-ground biomass following MacDicken [16]. Total carbon stock of each tree was calculated as 50 % of its biomass following Timilsina et al. [17].

2.3 Statistical Analysis

One-way analysis of variance (ANOVA) was performed to check for significant variation in total carbon stock value between the four plots of coconut plantation in Bharathiar university campus.

3. RESULTS AND DISCUSSION

3.1 Field Survey

A total of 171 trees were sampled from the four randomly placed plots of 50 m × 50 m from the coconut plantation in Bharathiar University campus. The mean density of trees in the coconut plantation of the study area was 43.25 trees/0.25 ha. It ranged from 42 trees/0.25 ha to 44 trees/0.25 ha (Table 1). The mean tree GBH value was 86.91 ± 10.37 cm/tree and it ranged from a minimum value of 65.20 cm to a maximum value of 114.80 cm for the coconut plantation in Bharathiar University campus.

Table 1. Density of trees in the coconut plantation in the study area

Plot number	Density (trees/0.25 ha)
Plot 1	42
Plot 2	44
Plot 3	43
Plot 4	42
Total for 1 ha	**171**

3.2 Biomass

The total biomass determined for the one ha of coconut plantation sampled from Bharathiar University campus was 63.39 tonne/ha. Among the four plots, the total biomass value ranged from 13.71 tonne/0.25 ha to 19.14 tonne/0.25 ha (Table 2). The total biomass value per tree was 0.37 ± 0.11 tonne/tree, and the value ranged from a minimum value of 0.17 tonne/tree to a maximum value of 0.71 tonne/tree. The mean above-ground biomass per tree value was 0.32 ± 0.10 tonne/tree, and it ranged from a minimum value of 0.15 tonne/tree to a maximum value of 0.62 tonne/tree. Similarly, the mean below-ground biomass per tree value was 0.05 ± 0.01 tonne/tree, with a minimum value of 0.02 tonne/tree to a maximum value of 0.09 tonne/tree.

3.3 Carbon Stock

The total carbon stock determined for the one hectare of coconut plantation sampled from Bharathiar University campus was 31.69 tonne/ha (Table 3). The total carbon stock value ranged from 6.86 tonne/0.25 ha (Plot 1) to 9.57 tonne/0.25 ha (Plot 3). Statistically, one-way ANOVA revealed a significant variation in total carbon stock value among the four plots ($F_{(3,167)} = 14.219$, $p<0.0001$). We determined that the mean carbon stock per tree was 0.19 ± 0.06 tonne/tree, and the value ranged from a minimum value of 0.09 tonne/tree to a maximum

Table 2. Biomass of trees in the coconut plantation in the study area

Plot number	Above-ground biomass (tonne/0.25 ha)	Below-ground biomass (tonne/0.25 ha)	Total biomass (tonne/0.25 ha)
Plot 1	11.92	1.79	13.71
Plot 2	12.33	1.85	14.18
Plot 3	16.64	2.50	19.14
Plot 4	14.22	2.13	16.35
Total for 1 ha	**55.12**	**8.27**	**63.39**

Table 3. Carbon stock of trees in the coconut plantation in the study area

Plot number	Above-ground carbon stock (tonne/0.25 ha)	Below-ground carbon stock (tonne/0.25 ha)	Total carbon stock (tonne/0.25 ha)
Plot 1	5.96	0.89	6.86
Plot 2	6.16	0.92	7.09
Plot 3	8.32	1.25	9.57
Plot 4	7.11	1.07	8.18
Total for 1 ha	**27.56**	**4.13**	**31.69**

value of 0.36 tonne/tree (Fig. 2). The mean above-ground carbon stock per tree was 0.16 ± 0.05 tonne/tree, and it ranged from a minimum value of 0.08 tonne/tree to a maximum value of 0.31 tonne/tree. While, the mean below-ground carbon stock per tree was 0.02 ± 0.01 tonne/tree, with a minimum of 0.01 tonne/tree to a maximum of 0.05 tonne/tree.

Carbon is sequestered through plant photosynthesis and stored as biomass in various parts of the tree. The results of present study conclude that the total carbon stock of the coconut plantation in Bharathiar University campus was 31.69 tonne/ha. The mean carbon stock per tree was 0.19 ± 0.06 tonne/tree, and the mean carbon stock allocation in the above-ground and below-ground parts of the coconut tree was 0.16 tonne/tree and 0.02 tonne/tree, respectively.

Although, there are studies available on the carbon sequestration potential of coconut plantations from other regions comparison of the present study is not possible since those are with different aspects or methodology. For example, Ranasinghe and Thimothias [11], have reported the carbon sequestration potential in coconut plantations in Sri Lanka under different agro-ecological regions and land suitability classes.

Shinde et al. [18] conducted a field experiment to study the productivity and carbon sequestration potential as influenced by integrated nutrient management practices in coconut based cropping system from Maharashtra, India. They have reported that intercropping spice and fruit crops in coconut gardens, combined with integrated nutrient management practices, has been shown to enhance carbon stock and system productivity over time compared to monocropping coconut systems. Further, Bhagya et al. [13], studied on the carbon sequestration potential in coconut-based cropping systems from Kerala, India, and they have reported that among different cropping systems, coconut + jamun system sequestered the highest above-ground carbon (60.93 tonne/ha). While, the present study is a unique report, first study on carbon sequestration potential of coconut plantation inside the university campus.

When compared, the carbon stock recorded in the coconut plantation in Bharathiar University campus (31.69 tonne/ha) is greater than the carbon stock value reported for the tropical forests in Bodamalai hills (10.94 tonne/ha [19]), mixed species plantation forest (22.25 tonne/ha) and Eucalyptus plantation forest (27.72 tonne/ha [12]), and Pachaimalai tropical forests (29.14 ± 6.50 tonne/ha [10]). This highlights the importance and potential of coconut plantations, particularly in terms of carbon stocking they are on par with some of the tropical forests.

Carbon sequestration by trees represents a truly win-win situation. Improving biomass productivity mitigates climate change by reducing the rate of atmospheric CO_2 enrichment. Coconut plantations in university campuses potentially

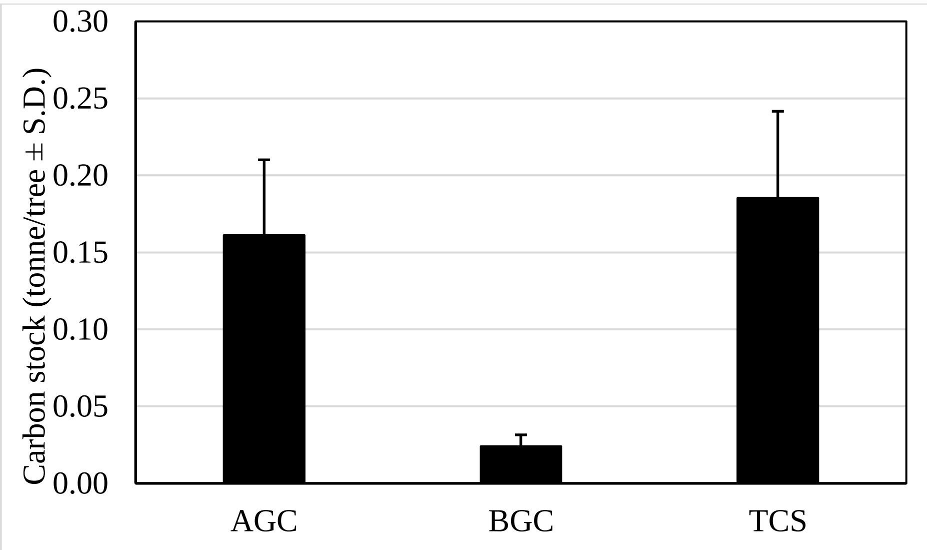

Fig. 2. Distribution of carbon stock for the study species *Cocus nucifera* L

can serve not only as carbon sinks but also contribute to fulfilling the sustainable development goals of the country. Afforestation and reforestation are crucial in mitigating the global climate crisis. Further, the selection of native trees for plantation is essential for the conservation of indigenous species and to protect the environment from the invasion of alien species.

4. CONCLUSION

The present study provides valuable insights into the carbon sequestration potential of coconut plantations in Bharathiar University campus, India. We conclude that the coconut plantation in Bharathiar university campus stocks carbon at the rate of 31.69 tonne per ha on par with other tropical forests. This study creates an awareness that the university coconut plantations can play a significant role in mitigating climate change by effectively sequestering carbon while simultaneously promoting sustainable agriculture and biodiversity conservation. Further, this study offers baseline information for tree plantation programs aimed at mitigating global warming through carbon sequestration. Additionally, we suggest policymakers should promote carbon-friendly goods and services to reduce carbon emissions in the atmosphere, thereby mitigating climate change and global warming.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. UNFCCC. The Kyoto Protocol to the convention on climate change. United Nations Framework Convention on Climate Change; 1997.
2. Niles JO, Brown S, Pretty, Ball AS, Fay J. Potential carbon mitigation and income in developing countries from changes in use and management of agricultural and forest lands. Philosophical Transactions: Mathematical, Physical and Engineering Sciences. 2002;360:1621-1639.
3. Berenguer E, Ferreira J, Gardner TA, Aragão LE, De Camargo PB, Cerri CE, Durigan M, Oliveira RC, Vieira IC, Barlow J. A large-scale field assessment of carbon stocks in human-modified tropical forests. Global change biology. 2014;20(12):3713-26.
4. IPCC. Land use, land-use change and forestry. Summary for Policymakers. A Special Report of the Intergovernmental Panel on Climate Change; 2000.
5. NOAA. National oceanic and atmospheric administration, US; 2024. Available:http://www.esrl.noaa.gov/gmd/ccgg/trends/
6. IPCC. Climate Change 2007 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC; 2007.
7. Pragasan LA. Assessment of carbon stock of tree vegetation in the Kolli Hill forest located in India. Applied Ecology and Environmental Research. 2016;14(2):169-83.
8. Canadell JG, Raupach MR. Managing forest for climate change mitigation. Science. 2008;320:1456-1457.
9. Dixon RK, Wisniewski J. Global forest system: An uncertain response to atmospheric pollutants and global Climate change. Water Air Pollution. 1995;85:101-110.
10. Pragasan LA. Tree carbon stock and its relationship to key factors from a tropical hill forest of Tamil Nadu, India. Geology, Ecology, and Landscapes. 2022;6(1):32-39. Available:https://doi.org/10.1080/24749508.2020.1742510
11. Ranasinghe CS, Thimothias KSH. Estimation of carbon sequestration potential in coconut plantations under different agro-ecological regions and land suitability classes. Journal of the National Science Foundation of Sri Lanka. 2012; 40(1):77-93. Available:http://dx.doi.org/10.4038/jnsfsr.v40i1.4171.

12. Pragasan LA, Karthick A. Carbon stock sequestered by tree plantations in university campus at Coimbatore, India. International Journal of Environmental Sciences. 2013;3(5):1700-1710.
13. Bhagya HP, Maheswarappa HP, Bhat R. Carbon sequestration potential in coconut-based cropping systems. Indian Journal of Horticulture. 2017;74(1):1-5. Available:https://doi.org/10.5958/0974-0112.2017.00004.4.
14. Devi M, Ghatani K. The use of coconut in rituals and food preparations in India: A review. Journal of Ethnic Foods. 2022 Sep 5;9(1):37.
15. Brown S, Gillespie A, Lugo AE. Biomass estimation methods for tropical forest with applications to forest inventory data. Forest Science. 1989;35:881-980.
16. MacDicken K. A guide to monitoring carbon storage in forestry and agro forestry projects. Forest carbon Monitoring Program. Winrock International Institute for Agricultural Development (WRI); 1997.
17. Timilsina N, Escobedo FJ, Staudhammar C, Brandeis T. Analyzing the causal factors in a subtropical urban forest. Ecological Complexity. 2014;20:23-32.
18. Shinde VV, Maheswarappa HP, Ghavale SL, Sumitha S, Wankhede SM, Haldankar PM. Productivity and carbon sequestration potential of coconut-based cropping system as influenced by integrated nutrient management practices. Journal of Plantation Crops. 2020;48(2):103-110. Available:https://doi.org/10.25081/jpc.2020.v48.i2.6368.
19. Pragasan LA. Tree carbon stock assessment from the tropical forests of Bodamalai hills located in India. Journal of Earth Science & Climate Change. 2015; 6:314. Available:https://doi.org/10.4172/2157-7617.1000314.

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