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A Comparative empirical assessment of native deciduous and evergreen trees on carbon stock potential for regulating ecosystem services in tropical dry evergreen forest, Coromandel coast, Tamil Nadu, India

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ABSTRACT

Vegetation, particularly trees, provides a wide spectrum of regulating ecosystem services, which include up keeping of air quality, stabilizing temperature, reduction in ultraviolet radiation, oxygen generation, and carbon sequestration. Carbon Stock, called “C-stock”, is one of the most common benefits of trees in today’s scenario on climate change and anthropogenic disturbance all over the world. The purpose of this technical paper is to compare empirically and assess the total C-stock (TCS) of ten dominant native deciduous trees (NDT) and native evergreen trees (NET) for 10-ha area distributed 1-ha in each of ten tropical dry evergreen forest sites of Coromandel Coast of Tamil Nadu, India. The data obtained from a recent research publication is analyzed for total c-stock potential between NDT and NET trees through the application of the statistical tool. The **Chi-square, Goodness of fit between Above Ground Biomass of NDT and NET is 30733.80**, The p-value is < 0.00001. The result is significant at $p < .05$ (standard level for analysis). Hence, native evergreen trees have a higher c-stock capacity, when compared to native deciduous trees. Thus, prove the higher carbon sequestration potential of native evergreen trees.

Keywords: above ground biomass, below ground biomass, total biomass, carbon stock

Introduction

Forests, the largest carbon pool on earth, act as a major sink of carbon in nature. Woodland plays an important role in regulating ecosystem services, especially in carbon sequestration. Woody plant species sequester atmospheric carbon into their biological system during photosynthesis and storing excess carbon as “biomass”. Especially, tropical forest ecosystems have the potential to hold and sequester large amounts of carbon than the other biomes. Living biomass of trees plays as main carbon pool in tropical forest ecosystem. Study of literature reveals that tropical forests comprise of 40% of the total terrestrial carbon stock on the planet. Carbon sequestration refers to the annual rate of Carbon-di-oxide storage, called as C-stock in above and below-ground biomass. The carbon stored in the AGB of trees is the largest pool. The estimation of AGB carbon is therefore, the most critical step in quantifying carbon stocks and fluxes from tropical forests. Increasing the number of trees can therefore slow the accumulation of atmospheric carbon, a contributor to climate change. The ability of a tree to sequester carbon changes over time as it grows. The key urban forest parameters reported to improve carbon sequestration and storage

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are summarized in Table 1. Net oxygen production by trees is a function of the amount of oxygen produced during photosynthesis minus the amount of oxygen utilized during respiration. If the carbon dioxide uptake during photosynthesis exceeds carbon dioxide release by respiration during the year, the tree will accumulate carbon (carbon sequestration). Thus, a tree that has a net accumulation of carbon during a year (tree growth) also has a net production of oxygen. The net carbon sequestered is estimated as per the following expression:

Net Carbon sequestration (Kg/year) = Net Oxygen release (Kg/year) / 2.66

The aim of this technical paper is to address the following goals. First, through literature review identify the recorded values of ABG, BGB, TB and Total Carbon Stock of ten dominant native deciduous and evergreen trees. Second, analyze the values using statistical software Chi-square, Goodness of fit to perform comparative empirical assessment for carbon stock storage significance between ten dominant native deciduous and evergreen trees of Tropical Dry Evergreen Forest of Coromandel coast of Tamil Nadu, India.

Table 1: Forest parameters that are reported to improve the ecosystem service of carbon sequestration and storage

Scale and Management	The total amount of carbon-di-oxide stored and sequestered is influenced by the area of existing tree canopy (Mc Pherson,1998)
	Carbon storage increases with tree density; hence woodland are more effective than more sparsely planted urban land (Nowak and Crane, 2002). However thinning can encourage growth.
	Patch size of deciduous woodlands in an urban environment is positively correlated with carbon density (Godwin et al,2015)
Urban forest structure	On a per tree basis, carbon storage and sequestration is significantly greater is greater in urban areas than in forests due to large proportion of large trees and fastest growth rates resulting from the more open urban forest structure (Nowak and Crane, 2002).
	Ensuring diversity in species and canopy and understory layers will increases carbon sequestration (Zhao et al, 2010).
	Larger trees tend to sequester and store more carbon-di-oxide; indeed carbon-di-oxide storage is proportional to tree’s biomass and diameter (McPherson,1998).
	Carbon storage and sequestration depends also on tree’s growth rate and age class, with rates increasing to middle age and then diminishing towards post-maturity (Nowak and Crane, 2002).
	Trees with longer lifespan will have a greater positive effect on carbon-di-oxide uptake than short-lived trees as the frequency at which trees require planting, maintenance and removal (activities with associated fossil fuel carbon emission) will be reduced (Nowak and Crane, 2002).

	Healthy trees will sequester and store more carbon(Nowak and Crane, 2002).
	Evergreen broadleaved forests have been found to sequester more carbon-di-oxide than coniferous forest due to their faster growth rate (Zhao et al., 2010)
Location and proximity to people	Trees that are subject to a greater level of anthropogenic disturbances (eg. fragmented by roads) are found to store less carbon (Godwin et al,2015)
	Poor rooting conditions, exposure to air pollution and heat, and severe pruning can lower biomass accumulation and carbon storage (Jo and McPherson,1995)
Land use and ownership	Carbon-di-oxide by the urban forest in residential areas has been shown to be greater than for other urban land-use types due to the higher density of trees (McPherson,1998).

Source: Davies, H., Doick, K., Handley, P., O'Brien, L., and Wilson, J. (2017). Delivery of ecosystem services by urban forests, Forestry Commission Research Report, Forestry Commission, Edinburgh.

Methodology

1.0 Ten dominant NDT and NET trees biomass and carbon stock values from literature review :

The aboveground biomass (AGB) of trees was estimated following the Allometric equation of Chave et al. (2005) using two variables, the diameter and wood specific density (WSD):

$$\textbf{AGB est} = \rho \times \exp(-1.499 + 2.148 \ln(D) + 0.207(\ln(D))2 - 0.0281(\ln(D))3) \qquad (1)$$

Where, **D** is the diameter and **ρ** is the wood specific density of tree species.

The belowground biomass (BGB) of trees was calculated by **multiplying the aboveground biomass value with 0.26** (Cairns et al. 1997, IPCC 2003).

The total carbon stock (TCS) was estimated to be **50 % of the total biomass** (AGB + BGB) (IPCC 2005).

Table 2 : AGB, BGB, TB and TCS values of ten dominant Native Deciduous Trees (NDT)

S.No	Native Deciduous Trees	AGB (Kg/tree)	BGB (Kg/tree)	TB (Kg/tree)	TCS (Kg/tree)
1	Abizia amara (Roxb.) Boivin	374.80	97.45	472.25	236.12
2	Bauhinia racemosa Lam.	213.50	55.50	269.00	134.50
3	Cassia fistula L.	180.87	47.02	227.9	113.95
4	Chloroxylon sweitenia DC.	155.23	40.36	195.59	97.79
5	Commiphora caudata (Wight & Arn.)	279.56	72.68	352.25	176.12
6	Dalbergia paniculata Roxb.	1775.07	461.51	2236.59	1118.29
7	Ficus religiosa L.	84.40	21.90	106.30	53.10
8	Gardenia resinifera Roth	202.45	52.63	255.08	127.54
9	Lannea coromandelica (Houtt.) Merr.	96.71	25.14	121.85	60.92
10	Ochna obtusata DC.	150.22	39.05	189.27	94.63
	Total	**3512.81**	**913.24**	**4426.08**	**2212.96**

Source: Vivek P & Parthasarathy N (2015) Diversity and carbon stock assessment of trees and lianas in tropical dry evergreen forest on the Coromandel Coast of India. *Tropical Plant Research 2(3): 230–239*

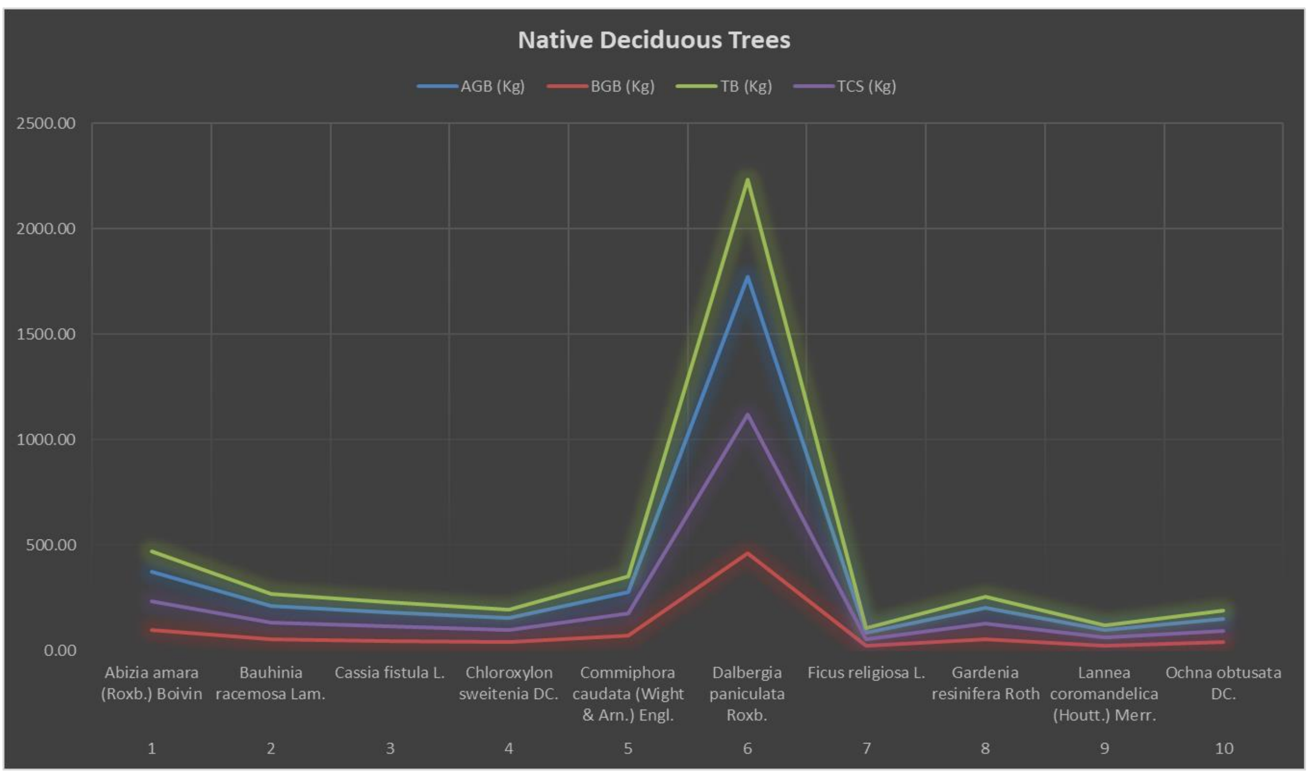

Figure 1: Graphical representation of AGB, BGB, TB and TCS values of ten dominant Native Deciduous Trees (NDT)

Table 3: AGB, BGB, TB and TCS values of ten dominant Native Evergreen Trees (NET)

S.No	Native Evergreen Trees	AGB (Kg/tree)	BGB (Kg/tree)	TB (Kg/tree)	TCS (Kg/tree)
1	Azadirachta indica A.Juss.	839.98	218.39	1058.37	529.18
2	Ficus amplissima Sm.	4238.40	1102.00	5340.40	2670.20
3	Ficus benghalensis L.	10122.22	2631.78	12754	6377.05
4	Ficus microcarpa L.f.	1278.65	332.44	1611.1	805.55
5	Lepisanthes tetraphlla (Vahl.)Radlk	490.75	127.59	618.35	309.17
6	Manilkara hexandra (roxb.) Dubard	1318.17	342.72	1660.89	830.44
7	Pongamia pinnata (L.) Pierre	1325.53	344.64	1670.17	835.08
8	Syzygium cumini (L.) Skeels	4153.87	1080.00	5233.88	2616.94
9	Tamarindus indica L.	15600.52	4056.12	19656.65	9828.32
10	Vitex altissima L.f.	773.47	201.10	974.58	487.29
	Total	**40141.56**	**10436.78**	**50578.39**	**25289.22**

Source: Vivek P & Parthasarathy N (2015) Diversity and carbon stock assessment of trees and lianas in tropical dry evergreen forest on the Coromandel Coast of India. *Tropical Plant Research 2(3): 230–239*

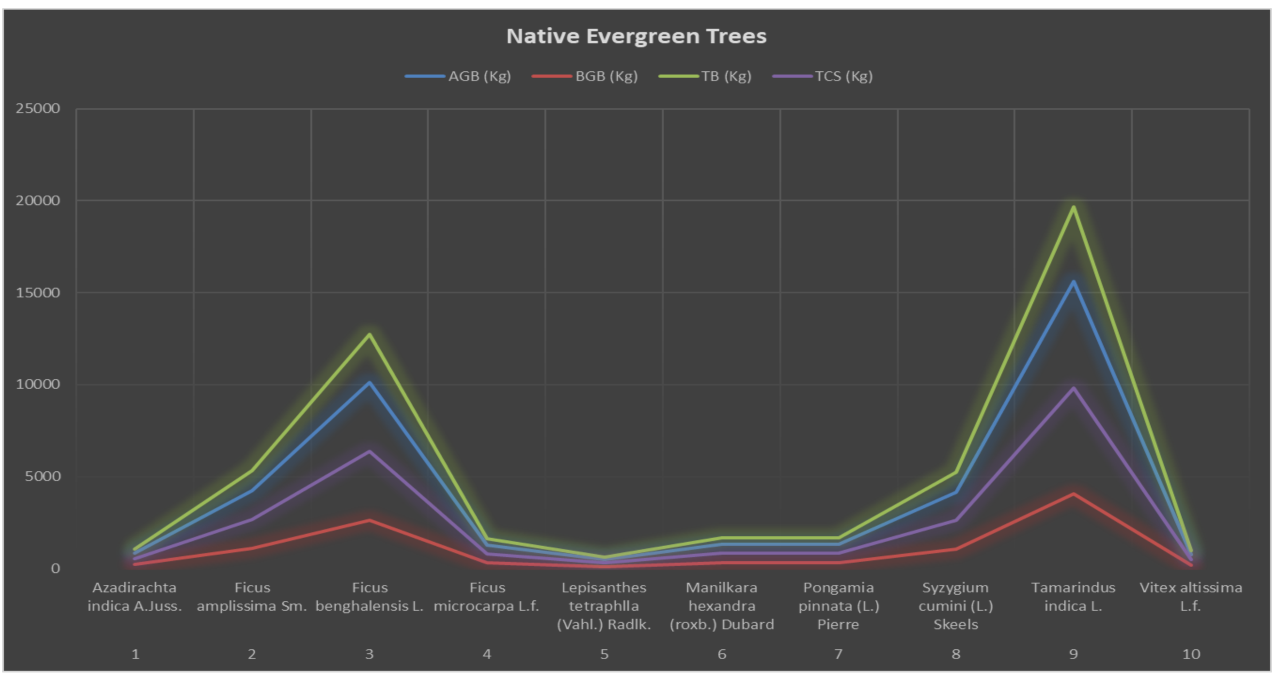

Figure 2: Graphical representation of AGB, BGB, TB and TCS values of ten dominant Native Evergreen Trees (NET)

2.0 Chi-square, Goodness of fit between AGB's of the ten dominant NDT and NET for carbon stock potential:

The chi-square, Goodness of fit is performed using the Equation – 2. The Table 4, reveals BGB, TB and TCS are 0.26, 1.26 and 0.63 times AGB. *(BGB=0.26xAGB, TB=1.26xAGB, TCS=0.63xAGB).*

Table 4 : Tabulation of AGB, BGB,TB and TCS

Species	Above Ground Biomass (Kgs)	Below Ground Biomass (Kgs)	Total Biomass (Kgs)	Total Carbon Stock (Kgs)
Native Deciduous Trees	3512.81	913.24	4426.08	2212.96
Native Evergreen Trees	40141.56	10436.78	50578.39	25289.22

Equation :

$$X^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{i,j}-E_{i,j})^2}{E_{i,j}}. \qquad (2)$$

Where, **O** stands for the Observed frequency, **E** stands for the Expected frequency

Table 5 : Tabulation of Chi -square Goodness of fit between AGB of NDT and NET

Species	Observed	Expected	Difference	Difference Sq.	Difference Sq./Expected Fr.
AGB (NDT)	3513	21827.50	-18314.50	335420910.25	15366.90
AGB (NET)	40142	21827.50	18314.50	335420910.25	15366.90
					30733.80

3.0 Conclusion:

The **Chi-square,** Goodness of fit between **Above Ground Biomass of NDT** and **NET** is **30733.80,** The ***p*- value** is **< 0.00001. The result is significant at *p* < .05** (standard level for analysis). Hence, native evergreen trees have higher c-stock capacity, when compared to native deciduous trees. Thus, prove the higher carbon sequestration potential of native evergreen trees for regulating ecosystem services.

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