Above-ground Biomass stockpile of Trees in Southern Tropical Region of G. Venkataswamy Naidu College Campus in Kovilpatti taluk, Thoothukudi district, Tamil Nadu

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ABSTRACT

This study aims to assess the density, species richness, basal area (BA) and estimate the above-ground biomass (AGB) stockpile of trees on the G. Venkataswamy Naidu College campus located in Kovilpatti taluk, Thoothukudi district, Tamil Nadu. The study area has been categorized as the Southern Tropical Region (STR). A total of 29.1 hectares (72 acres) were randomly surveyed. All the living trees with >10 cm diameter at breast height (DBH) was measured at 1.37 cm above the ground. A total of 116 individual trees >10 cm DBH were documented. In the study area, a total number of ten species were recorded from ten genera and six families. The Fabaceae family has the maximum number of species (5 species), whereas the other 5 families each have one species. The total basal area was recorded as 91.497 m^2 ha^{-1}. The total amount of AGB 51.944 Mg ha^{-1} were found in the STR. The contribution of different species in terms of total AGB varied significantly. *Syzygium cumini* stocked 18.25% (9.483 Mg ha^{-1}) of AGB followed by *Tamarindus indica* 18.01% (9.358 Mg ha^{-1}) and *Albizia lebbeck* 15.12% (7.855 Mg ha^{-1}), whereas remaining 7 species collectively stocked 48.60% (25.247 Mg ha^{-1}) of AGB. It is comparable with the range of biomass stockpiles recorded in Indian dry forests. The study area experiences lesser mean annual rainfall and >6 months dry season. Further, endowed with large-trunk and medium size leaved trees, hence stocked a relatively median AGB in trees.

Key words: Quantitative ecological survey, Above-ground biomass, Southern Tropical Region, Tamil Nadu.

1. INTRODUCTION

The majority of forests found around the world are in tropical regions with 42% of them being dry forests (Holdridge, 1967). Dry forests are intimately linked to human life hence they are relatively high utilized and are threatened (Murphy and Lugo, 1986). The forest ecosystem is a significant source of carbon storage in the terrestrial ecosystem, and constitutes around 80% of all living terrestrial biomass (Chapin *et al*., 2005; Thomas and Martin, 2012). The forest ecosystem, including its massive carbon storage plays a vital role in mitigating environmental implications (Lamlon and savidge, 2003).

Several thousand years we have been used biomass as an energy sources because it contributes sustainable development and land based biomass. These have high economic value and employment potential which helps in building green economics in a sustainable way (Hoogwijk *et al*., 2003). Most activities related to forest biomass assessments focus on the aboveground biomass (AGB) of living trees because AGB represents the largest amount of total biomass in forests. The accurate assessment and evaluation of forest AGB stores and their spatio temporal patterns are important for the sustainable management of forests (Pandit *et al*., 2018).

Estimating AGB is one of the most important steps in measuring and evaluating the carbon stocks and carbon sequestration of forests (Eggleston *et al.,* 2006). The tree species richness, diameter, height, basal area, bark thickness, density and above-ground biomass are required to determine the yield and volume of timber (Krishna Giri *et al*., 2019). There is a low level of quantitative ecological data about the density and above-ground biomass stockpile of trees in Tamil Nadu's dry forests (Nagaraj and Udayakumar, 2021). The current study aimed to assess the density, species richness basal area and above-ground biomass stockpile of trees on the G. Venkataswamy Naidu College Campus in Kovilpatti taluk, Thoothukudi district, Tamil Nadu.

2. MATERIAL AND METHODS

2.1. Study area

This study was conducted on the campus of G. Venkataswamy Naidu College in Southern tropical region of Kovilpatti taluk, Thoothukudi district, Tamil Nadu (Fig. 1). A wide variety of plant species may be seen on the College campus. This area of study known as Southern Tropical Region (STR), spans 29.1 hectares (72 acres). The campus has a moderate plant diversity of both native and introduced species. The study area's geographic coordinates are 9.11°40' Northern latitude and 77.50°3' Eastern longitude. The annual rainfall of study area is 734.8 mm. The study area receives most part of the annual rainfall during October-December. The study area experiences from March to June four months of dry season. The annual mean and maximum temperatures in the study area 27.5˚C and 36.5˚C, respectively. STR plants have drought tolerance and may thrive in arid environments. Furthermore, tropical regions are generally warmer and experience more rainfall. Moreover, trees lose their leaflets during the dry season. The tropical trees have large leaves and smooth edges that improve their absorption of light energy. Tropical plants such as *Aegle marmelos, Ficus religiosa, Polyalthia longifolia, Pongamia pinnata, Syzygium cumini, and Tamarindus indica* are found in STR (Fig. 2).

2.2. Field Survey

A total number of 72 acres (2.47 m²) (100m x100m) were randomly selected and sub-gridded for tree commodities. All the living trees >10cm girth at breast height (Which is equivalent to 3.14 cm DBH) was measured with the help of measuring tape at 1.37 m above the ground as per Center for Tropical forest Science, Panama guidelines (Condit, 1988). All the species identified with the help of regional floras (Gamble and fisher, 1921-35 and Manickam *et al*., 2008). The cross sectional area of tree at 1.37 m above the ground defined as Basal Area. The Basal Area (BA) of trees calculated using the formula $BA = 0.005454 \times (DBH)^2$, where BA is a basal area (cm²); DBH is the diameter at breast height (cm) (Jim Elledge, 2010). The data sheet included details of species name, locality and uses in different period of time. Primary data was randomly collected by visiting the field sites.

2.3. Estimation of Above-ground Biomass

A tropical region of specific allometric equation developed by destructive sampling method was used to estimate the AGB in the study area (Udayakumar *et al*., 2018). $AGB\ Dry = \exp(1.9724 * LN(DBH) - 1.0717)$; Where, AGB is the total dry above-ground biomass (kg); D is stem diameter at breast height (cm); LN is natural logarithm; 1.499, 2.148, 0.207 and 0.0281 are factors.

3. RESULTS AND DISCUSSION

3.1. Density and Species Richness

A total number of 116 trees >10cm DBH were recorded from 29.1 hectares area of STR. The density of represented species differed considerably from across study area. *Azardirachta indica* dominated the STR with 47 (62.67%) individuals followed by *Polyalthia longifolia* 20

(26.66%), *Tamarindus indica* 10 (13.33%) and *Delonix regia* 8 (10.66%), while *Cassia fistula, Ficus religiosa* and *Syzygium cumini* was represented by just single individual each. Likewise, contribution of families used to total stand density also differed considerably. The Family Meliaceae constituted 62.67% (47 trees) of tree community followed by Fabaceae 52.86% (42 trees) and Annonaceae 26.66% (20 trees), while rest of three families constituted 9.33% in STR (Table 1).

The diameter classes largely differ among the six diameter classes. The DBH class 15-30 cm stored a largest number (42 trees), followed by 30 - 45 cm (40 trees), 45-60 cm (17 trees) and 60-75 cm (nine trees). The smallest DBH class 75-90 cm was measured in one tree. The population structure based on diameter class frequency is an expanding and showing a reverse V shaped pattern in Southern tropical regions. The study revealed that more number of trees present in-between classes 15-30 cm. The study plot had greater number of smaller trees with low diameter girth classes (Fig 3). In the study area, a total number of ten species recorded from ten genera and six families. The family Fabaceae (= sub family Caesalpinioideae) had five species followed by Meliaceae, Annonaceae, Moraceae, Rutaceae and Myrtaceae had just single species' each in STR.

The density, basal area, and biomass are varying based on the environmental condition especially the Parameters of soil (pH, nutrient, WHC etc.). The tree density, girth diameter, and basal area are essential factors to assess above-ground biomass (Sainge *et al*., 2020). The density of trees in STF (Southern Tropical Forest) 116 individuals ha^{-1} is comparable with tropical dry evergreen forests of Tamil Nadu, 671 ha^{-1} (Pandian *et al*., 2021) and dry deciduous forest of Western Ghats, India, 3,376 individuals ha^{-1} (Anitha *et al*., 2009). Tree density of STR (Southern Tropical Region) is lower compared to tropical dry evergreen forests of Peninsular India (Mani and Parthasarathy, 2007). Therefore, the tree cutting for fire wood and poaching are prohibited. The bird community of STF (Southern Tropical Forest) depends upon the fleshy fruits of dominant tree species like, *Azardirachta indica, Syzygium cumini*. The STR trees are produce fruit close to the rainy season. These are the possible reasons for the high density of trees in STR.

The species richness (10 species ha^{-1}) of STR is lower than in tropical dry evergreen forests of Arasadikuppam (46 species ha^{-1}) (Venkateswaran and Parthasarathy, 2003) and Anaikatty reserve forest in Tamil Nadu, India (106 species ha^{-1}) (Anitha *et al*., 2010). Tree species richness of STR is comparable with tropical dry forests of Tamil Nadu. Furthermore, 60 species found in tropical dry deciduous forest (Gandhi and Sundarapandiyan, 2014). Similarly, species richness of STR is lower compared to tropical dry forests (128 species ha^{-1}) in Bannerghatta National Park in Eastern Ghats, Southern India and parts of India such as Lalitpur (59 species ha^{-1}), Chitrakoot (54 species ha^{-1}) and Mahoba (50 species ha^{-1}) (Verma and Pal, 2019).

3.2. Basal area

The total Basal Area (BA) of tree community recorded as 91.497 m^2 ha^{-1}. The contribution of basal area by species varied significantly. *Syzygium cumini* has a larger basal area (16.918 m^2 ha^{-1}) afterward, *Tamarindus indica* (16.675 m^2 ha^{-1}), *Albizia lebbeck* (13.960 m^2 ha^{-1}) and *Delonix regia* (13.589) in STR. The Six species had < 13 m^2 ha^{-1} (1.524 to 12.403) (Table 2), Similarly, Myrtaceae, Fabaceae, and Annonaceae had greater basal areas 16.918, 13.289, and 2.049 m^2 ha^{-1} respectively.

The contribution of the diameter classes varied considerably. The largest diameter class > 92 cm DBH had the largest BA (51.90 m^2 ha^{-1}) followed by 0-5 cm (16.918 m^2 ha^{-1}) 5-10 cm (16.675 m^2 ha^{-1}) and 10-15 cm (13.960 m^2 ha^{-1}), whereas the diameter class 45-50 cm had the least BA (1.524 m^2 ha^{-1}) in the study area (Fig. 4).

The basal area of tree stands in STR is 91.497 m^2 ha^{-1}, which is more than that found in tropical dry evergreen forests of Kuzhanthaikuppam, (14.9 m^2 ha^{-1}) (Mani and Parthasarathy, 2009). Additionally, the current study area contains a medium number of trees, which is related with a higher basal area when compared to other dry forests. Previously, it was discovered that tree density was positively linked to dry tropical forest in northern India (Sagar, 2006).

3.3. Above-ground Biomass

In total, 51.94 Mg of above-ground biomass (AGB) was recorded in 29.1 hectares of STR. The contribution of every species to total AGB differed significantly. *Syzygium cumini* stocked 9.483 Mg ha^{-1} of AGB, followed by *Tamarindus indica* (9.358 Mg ha^{-1}) and *Albizia lebbeck* (7.855 Mg ha^{-1}). Whereas the remaining 7 species stored 25.247 Mg ha^{-1} of AGB in STR. The Fabaceae family stocked largest AGB (29.229 Mg ha^{-1}), followed by Myrtaceae (9.483 Mg ha^{-1}) and Moraceae (6.989 Mg ha^{-1}), the remaining three families cumulatively stored 6.217 Mg ha^{-1} in STR. The greatest diameter class >90 cm DBH stored the most AGB 80-90 cm (23.54 Mg), followed by 70-80 cm (15.88 Mg ha^{-1}) and 60-70 cm (15.88 Mg ha^{-1}) (12.89 Mg ha^{-1}). The smallest DBH class (0.751 Mg) stored the lowest quantity in STR (Fig. 5).

Above-ground biomass (AGB) stockpile of trees in STF (51.94 Mg ha^{-1}) is comparable with tropical dry deciduous forests Vindhyan range of Central India (118.9 Mg ha^{-1}) (Pati *et al*., 2022) comparable with tropical dry forests of Mexican (108.76 Mg ha^{-1}) (Jaramillo *et al*., 2003). Conversely, AGB stock of STR is lower than in tropical dry forests of Cachar district, Assam (65.12 Mg ha^{-1}) (Borah *et al*., 2013). The mean annual rainfall is positively associated with tree density, AGB and species richness in semi-arid forest ecosystems in Gujarat, India (Mehta *et al.,* 2014). The study area have lesser mean annual rainfall >6 months dry season, short-bole trees and smaller leaves. These are some of the important factors could be behind a relatively lesser AGB stockpile of trees in study area. A substantial amount of AGB was found in dry forests in Thoothukudi, Tamil Nadu, composed of tree species such as *Acacia leucophloea*, *Aegle marmelos*, *Albizia lebbeck*, *Azadirachta indica*, *Delonix regia*, *Ficus religiosa*, and *Syzygium cumini* (Nagaraj and Udayakumar *et al*., 2021). The above-ground biomass was determined to find out their production rate, the high above-ground biomass directly proportional to high photosynthetic rate. The atmospheric carbon is directly absorb by the plant and stored in the vacuoles of various parts, the high biomass ratio indicates storage of atmospheric carbon (Anna Dey *et al*., 2014). The Density, species composition, diversity, height, wood density, age, growth condition, length of growth period, mean annual precipitation and temperature, soil moisture contents, and nutrient availability are some of the influencing factors that heavily influence AGB stockpile of trees in forests. The above-ground biomass was determined to find out their production rate, the high above-ground biomass directly proportional to high photosynthetic rate.

4. CONCLUSION

The current study area had a modest number of trees compared to some tropical dry forests within Tamil Nadu and other states of India. The aboveground biomass stockpile of trees is within the range documented in the Southern tropical region. The study area has a lower mean yearly rainfall and six-month dry season. It was also endowed with large-trunk and median-leaf trees, resulting in a comparatively median AGB in trees. Above-ground biomass, density, basal area, DBH, species richness as well as carbon sequestration and environmental factors were studied. Further studies are required to assess the entire biomass stockpile, which includes biomass from all living species both above and below ground.

5. ACKNOWLEDGEMENTS

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Table 1: Tree species, Family and Density (number of Individuals) recorded on G.V.N.College Campus, Kovilpatti

S.No	Species	Family	Density
1	*Syzygiumcumini*(L.) Skeels	Myrtaceae	2
2	*Tamarindusindica*(L.)	Fabaceae	10
3	*Albizialebbeck* (L.) Benth.	Fabaceae	10
4	*Delonixregia*(Bojer) Raf.	Fabaceae	8
5	*Ficusreligiosa*L.	Moraceae	3
6	*Azadirachtaindica*L.	Meliaceae	47
7	*Pongamiapinnata*(L.) Pierre	Fabaceae	8
8	*Cassia fistula*L.	Fabaceae	6
9	*Polyalthialongifolia*(Sonn.) Thwaites	Annonaceae	20
10	*Aeglemarmelos* (L.) Correa	Rutaceae	2
	Total	**10**	**116**

Table 2: Tree Species, No. of trees, DBH, Basal Area and Above-Ground Biomass stockpile of trees in G.V.N.College Campus, Kovilpatti

S.No	Species	No. of trees/ha	DBH (cm)	BA (m^2/ha)	AGB (Mg/ha)
1	*Syzygiumcumini*	2	53.025	16.918	9.483
2.	*Tamarindusindica*	10	53.773	16.675	9.358
3	*Albizialebbeck*	10	49.363	13.960	7.855
4	*Delonixregia*	8	44.506	13.589	7.616
5	*Ficusreligiosa*	3	46.496	12.403	6.984
6	*Azadirachtaindica*	47	35.231	7.370	4.179
7	*Pongamiapinnata*	8	28.702	4.639	2.659
8	*Cassia fistula*	6	22.558	3.037	1.741
9	*Polyalthialongifolia*	20	18.041	2.049	1.183
10	*Aeglemarmelos*	2	16.719	1.524	0.885
	Total	**116**	**36.841**	**91.497**	**51.94**

(S-Sample) S-1. *Aegle marmelos,* **S-2.** *Albizia lebbeck,* **S-3.** *Azadirachta indica,* **S-4.** *Cassia fistula,* **S-5.** *Delonix regia,* **S-6.** *Ficus religiosa,* **S-7.** *Polyalthia longifolia* **S-8.** *Pongamia pinnata,* **S-9.** *Syzygium cumini,* **S-10.** *Tamarindus indica.*

Fig. 1: Map of the study area where in quantitative investigation was carried out to estimate the Above-ground biomass stockpile of trees (Google Earth pro-Version 7.1)

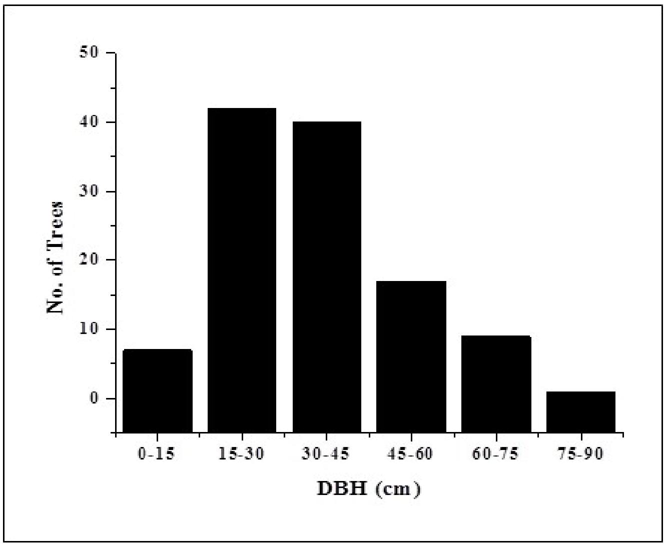

Fig.3: Population structure of (>10cm) trees inG.V.N. College Campus, Kovilpatti(Origin Version 6.0).

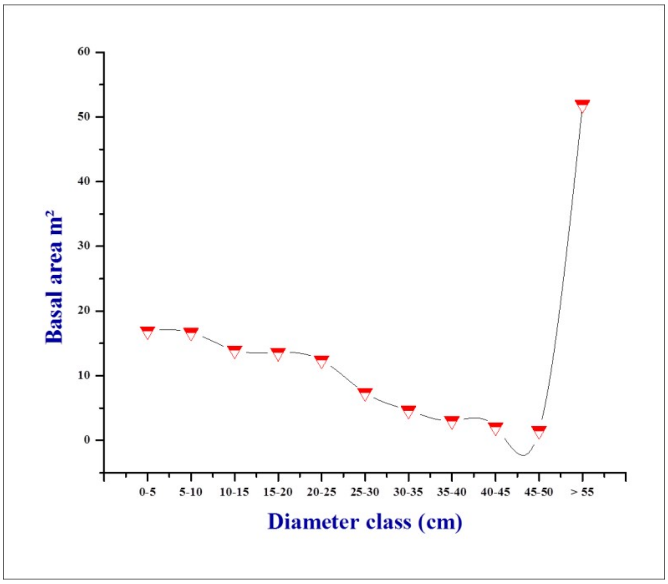

Fig. 4: Basal area of various diameter classes oftrees in G.V.N.CollegeCampus,Kovilpatti(Origin Version 6.0).

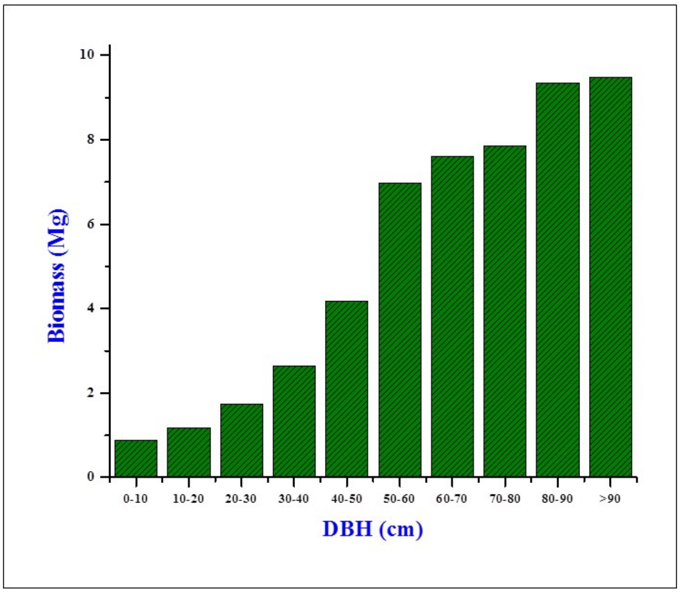

Fig. 5: Above-ground biomass stockpile of diameter classes in G.V.N.College Campus, Kovilpatti(Origin Version 6.0)

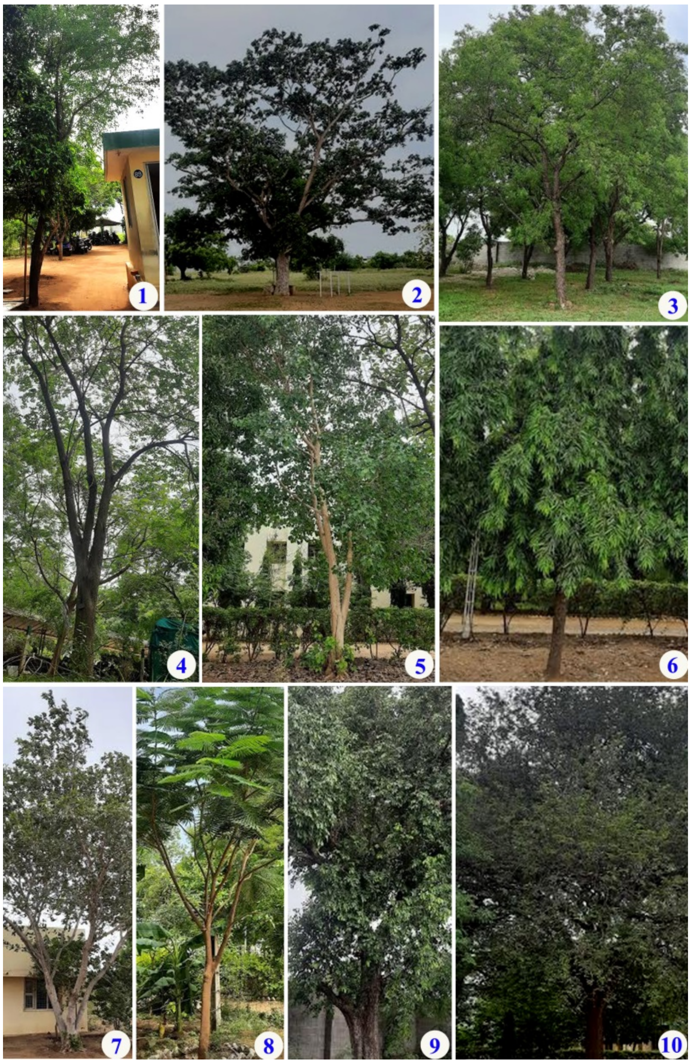

Fig. 2: Photograph of ten different plant species taken for ecological fieldsurveys at G.V.N.College Campus, Kovilpatti

1.*Aeglemarmelos,* **2.** *Albizialebbeck***3.***Azadirachtaindica***4.** *Cassia fistula* **5.***Delonixregia* **6.***Ficusreligiosa***7.***Polyalthialongifolia* **8.***Pongamiapinnata* **9.***Syzygiumcumini* **10.***Tamarindusindica.*