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Allometric model to determine carbon stock from DBH of major tree species in Mansa Range, Gandhinagar Forest Division, Gujarat, India.

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Abstract- Allometric models are important for quantifying biomass and carbon storage in terrestrial ecosystems. This study was conducted in the forest area of Mansa Range, Gandhinagar Forest Division, Gujarat, India to estimate carbon storage and carbon dioxide (CO_2) sequestration by non-destructive method using DBH, height, wood density of fifteen dominant tree species in Mansa Range. Generalised allometric models exist for tropical trees, but species and site-specific models are more accurate to predict carbon stock in fifteen major tree species in Mansa forest range. In the present investigation, the maximum average above ground biomass (AGB), below ground biomass (BGB), total biomass (TB), Carbon stock and CO_2 Sequestration potential shared by *Vachelia nilotica, V. leucophloea, V. tortilis, Prosopis cineraria* and *Holoptelea integrifolia* in the range; *while V. farnesiana, Balanites aegyptiaca, Diospyros montana, Nyctanthes arbor-tristis* and *Anogeissus sericea* showed least. However, the general regression models developed for estimation of carbon stock for major tree species and except *V. tortilis, Anogeissus sericea* and *Azadirachta indica* all showed a good fit. The R^2, p value and Pearson r value indicated that the models developed were good and useful for estimating the carbon stock of tree species in the range.

Keywords: Allometric model; Diameter at Breast Height (DBH); Non-destructive method; Carbon stock and Carbon dioxide sequestration.

1. INTRODUCTION

Carbon management methodology in forest is one of the objectives of the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol at worldwide level and National activity anticipate Climate Change in India to alleviate the environmental change [11]. Accordingly, there is a dire need to evaluate carbon stock and to upgrade carbon sequestration in woods biological communities and to alleviate environmental change through management. Along these lines, plant species with a high CO_2 settling limit are of expanding interest around the world [36]. Estimation of carbon content in timberland tree biomass is critical with respect to nursery impact moderation and in regards to compulsory report about CO_2 outflows and evacuations in ranger service segment nations which marked the Kyoto settlement. CO_2 is one of the Greenhouse gases which trap the long wave radiation reflected from earth prompting the working of the world's air and impacts the atmosphere. CO_2 in the air has been expanding consistently from 280 ppm since preindustrial times to 396.80 ppm as recorded in February-2013 [4].

Forest frame a noteworthy part of the carbon holds on the planet's biological communities [20]. The world timberland carbon stock was assessed to be 861 Pg C in 2011 with soil to a profundity of 1 m being the fundamental pool (44%), trailed by biomass (42%), deadwood (8%) and litter (5%) [31]. The expanding level of CO_2 in the climate can be decreased by in two ways (i) controlling emissions and (ii) expanding capacity of carbon. Forest ecosystem goes about as normal stockpiling for carbon and direct worldwide atmosphere. The reaction of forest to the rising environment CO_2 focuses is significant for the worldwide carbon as they have tremendous potential in sequestering and putting away more carbon than some other earthbound biological system [1, 22].

Phytosequestration of Carbon in developing forest is known to be a financially effective option for relief of an unnatural weather change. Tree development might be subjected to natural inclination related with rise, giving helpful situations to research the potential reactions of forest development [25]. Carbon storage in tree is advantageous for both natural and financial points of view. The ecological point of view incorporate the expulsion of CO_2 from the environment, the change of soil quality and increment in biodiversity; while financial advantages incorporate expanded yields and money related wages from potential carbon exchanging plans [27].

Regardless of their wide achieving hugeness, current deforestation and degradation are diminishing the capacity of forested land to help the conveyance of the crucial biological system framework administrations [3]. Moreover, expansive scale deforestation can prompted a decrease in nearby precipitation and an expansion in arrive surface temperature [14]. These adjustments in arrive cover trigger a chain of input circles in the atmosphere framework concerning example vegetation efficiency and soil decay react to changes in barometrical CO_2 and atmosphere designs [7] and in this way, impacts earthbound carbon stockpiling. Deforestation contributes around 5.9 Gt CO_2 every year on the planet [15]. The present rate of deforestation and clearing of tropical forest could discharge and extra 87-130 Gt of CO_2 to the environment by 2100 [33].

In India around 24% of the geological region is under vegetation cover in which tropical forest contribute about 83% of the vegetation territory. It is evaluated 53% of the aggregate geological zone of the nation is subjected to disintegration and land degradation [34]. The primary ranger service systems went for moderating environmental change [6, 11, 29] are to (i) keep up the forest area or increment it through reforestation; (ii) stay away from deforestation and degradation (iii) to keep up or increment the carbon density of existing forest (iv) energize the utilization of forest products. Numerous creating nations have decentralized the full or halfway forest administration expert to neighbourhood groups in quest for supportable woodland administration [5].

Among the different techniques accessible, allometric equations are the most widely recognized and dependable strategy for deciding tree biomass [18] and carbon storage and sequestration [12, 17] and a substantial number of allometric biomass conditions have been created for various forest tree species in numerous parts of the world. Among the tree development factors, width and tallness are most regularly utilized, because of their accessibility and simple to gauge in timberland inventories. Nearly, diameter at breast height (DBH) can be all the more precisely estimated and in this way, is generally more solid when utilizing a solitary free factor to create biomass condition [28], albeit other development factors, for example, tree height (H) [21], basal diameter (BD), or even wood specific gravity (WSG) are likewise utilized [10].

The forest type in Mansa range is Tropical Dry deciduous forest (TDF), which contains lesser number of species than rain forests, but the structural and physiological diversity in life forms is conspicuously greater compared to the rain forests. The majority of woody species in the TDF exhibit drought deciduousness as a response to the long dry period in the annual cycle [16]. The range is dominated by *Vachellia tortilis* (Forssk.) Galasso & Banfi (2,74,810), *Anogeissus sericea* Brandis (1,45,410), *Prosopis juliflora* (Swartz.) DC (1,14,050), *Senegalia senegal* (L.) Britton (88,600), *Diospyros montana* Roxb. (81,410), *Salvadora persica* L. (38,530), *Balanites aegyptiaca* (L.) Del. (35,310), *Azadirachta indica* A. Juss. (31,070), *Vachelia nilotica* (L) P J H Hurter & Mabb (23,520) and *Holoptelea integrifolia* (Roxb.) Planch (19,900), which cover individually approx. 30.31%, 16.04%, 12.58%, 9.77%, 8.98%, 4.25%, 3.9%, 3.43%, 2.59 and 2.19% (Tabel-1). The main objective of the study is (i) to estimate the carbon stock and CO_2 sequestration potential of fifteen dominant tree species in the range by non-destructive method (ii) Developing model to determine carbon stock from diameter at breast height (DBH) by linear regression correlation equation by non-destructive approach.

2. MATERIALS AND METHODS

2.1. *Study area characteristics*

The Forest area covers Deep Ravine Forest lies between $23^0$27'03.6" North latitudes and $72^0$48'16.4" East longitudes Elavation-349 Ft. & Deep Ravine, Thorny and Dense forest lies between $23^0$34'50.9" North latitudes and $72^0$48'07.1" East longitudes. The Total forest area of Mansa range is 2,031.10 hactare, which covers about 18.03% of total area of Gandhinagar Forest Division i.e. 11,263.31 hactare. The Mansa range forest is situated at west side of Sabarmati River in Gandhinagar District and starting point of range is Rampur village to ending point of Lakroda village. Agricultural and revenue lands are laying in some part of the range. The climate of the tract is characterized by hot summer, cool winter, and general dryness except in the south-west monsoon months. The cold season from December to February is followed by the hot season from March to May. The period from June to September is the monsoon season followed by the post-monsoon period of October-November. There is considerable variation among different parts of the tract and between the summer and winter months. The average annual rainfall of the last decade in the district is about 630 mm, generally increasing from west to east. On an average, there are about 30 rainy days in a year. The period from March to May is one of continuous increase in temperatures. May is generally the hottest month with a mean daily maximum temperature of about 41.7°C and mean daily minimum of about 26.2°C. The weather is intensely hot in summer and on some days the day temperature may reach up to 45°C.

2.2. *Methods*

The total forest area covered by Mansa range forest is 2,031.10 hactare, out of which only 1% of the total forest area (20.31 Ha.) is considered for study. Totally 84 sampling plots of 50 m x 50 m were set up for tree species. In each sampling plot of trees, DBH and height of each tree species were measured for standing woody biomass and carbon stock estimation. The following main steps involved in tree species biomass, CO_2 sequestration measurement and allometric equation development.

2.2.1. Determination of Carbon Stock

The Above Ground Biomass (AGB) of tree was estimated on the basis of DBH and height. DBH can be determined by measuring tree DBH (diameter at breast height), approximately 1.3 meter from the ground. The DBH of trees measured for trees having ≥ 10 cm and tallness of the trees were estimated by utilizing Haga's altimeter [23]. The wood densities were obtained from wood density database of world agroforestry centre; wherever the wood density of tree species was unavailable, the standard average value 0.6 gm/cm^3 were taken [8, 32]. The Below Ground Biomass (BGB) incorporates all biomass of live roots barring fine roots having < 2 mm distance across. The BGB has been computed by duplicating AGB by 0.26 factors as the root: shoot proportion [26]. Total biomass of trees was calculated by sum of AGB and BGB of trees. The Total Biomass of trees was calculated by following method [19]. A mass-based carbon concentration of 50% in dry wood is widely accepted as a constant factor for conversion of biomass to carbon stock [24]. According to Yeboah (2011) increasing carbon storage in intact African tropical forests carbon concentration varies with tree species. Since carbon concentration and specific wood density of tree species were known, the specific values were used to convert total biomass to estimated carbon stock [35]. Generally, for any plant species 50% of its biomass is considered as carbon [9, 30]. The weight of carbon dioxide sequestered (CO_2 is composed of one molecule of Carbon and 2 molecules of Oxygen and the atomic weight of Carbon is 12 g/mol; The atomic weight of Oxygen is 16 g/mol). Hence, weight of CO_2 is C + (2 x O) = 44 g/mol, while the ratio of CO_2 to C is 44/12 = 3.67. Therefore, to determine the weight of carbon dioxide sequestered in the tree, we multiplied the Weight of carbon in the tree by 3.67 [2].

AGB (kg/tree) = Volume of tree (m3) x WD (kg/m3)

AGB (kg/tree) = $\pi r^2 H$ (m^3) x WD (kg/m^3)

AGB (kg/tree) = $(DBH)^2/4\pi$ (m^2) x H (m) x WD (kg/m^3) Eq. (1)

BGB (kg/tree) = 0.26 x AGB (kg/tree) Eq. (2)

Total Biomass (kg/tree) = AGB + BGB Eq. (3)

Total Carbon Stock (ton/tree) = 0.5 x TB (ton/tree) Eq. (4)

CO_2 Sequestered (ton/tree) = 3.67 x TCS (ton/tree) Eq. (5)

Where, r = radius of the tree (in m)

r = DBH/2π

H = Height of tree (m)

WD = Wood Density (kg/m^3)

2.2.2. Statistical Analysis

Allometric equations were developed using Graph prism (version 6.0) and SPSS linear regression relations. Equation performance was carried out using various goodness-of-fit statistics, namely the coefficient of determination (R^2), correlation, Pearson r, to fit the biomass models, linear equations with additive error term were evaluated for each dry biomass weight compartment. R^2 is the fraction of the total variation in yield that is explained by the model. It is a statistical measure of how close the data are to the fitted regression line. It is also known as the coefficient of determination or the coefficient of multiple determinations for multiple regressions. A value of $R^2 = 1$ means that all of the variation in the response variable is explained by variation in the explanatory variable, while a value of $R^2 = 0$ means none of the variation in the response variable is explained by variation in the explanatory variable.

A *p* value is an estimate of the probability that a particular result or a result more extreme than the result observed could have occurred by chance. In short, the *p* value is a measure of the credibility of the null hypothesis. The *p* value is a number between 0 and 1. A small *p* value (at $\alpha \leq 0.05$) for this study indicates strong evidence of statistical significance of the work.

3. RESULTS

In the present investigation, the greatest normal AGB, BGB, TB and CO_2 Sequestration potential shared by species *Vachelia nilotica* (L) P J H Hurter and Mabb, *Vachelia leucophloea* (Roxb) Maslin, Seigler and Ebinger, *Vachellia tortilis* (Forssk.) Galasso and Banfi, *Prosopis cineraria* (Linn.) Druce and *Holoptelea integrifolia* (Roxb.) Planch in the

Table-1: Average AGB, Average BGB and Average TB (in kg) of tree species in Mansa Range

Sr. No.	Scientific Name	Wood Density (kg/m^3)	No. of tree measured in field (*n*)	Average AGB ± SE	Average BGB ± SE	Average TB ± SE
1.	*Anogeissus sericea* Brandis	740.00	1357	29.18 ± 2.56	7.59 ± 0.66	36.77 ± 3.22
2.	*Azadirachta indica* A. Juss.	660.00	663	32.15 ± 4.06	8.36 ± 1.05	40.51 ± 5.11
3.	*Balanites aegyptiaca* (L.) Del.	695.40	645	13.15 ± 0.73	3.42 ± 0.19	16.57 ± 0.92
4.	*Diospyros montana* Roxb.	647.47	976	20.44 ± 0.85	5.31 ± 0.22	25.75 ± 1.07
5.	*Holoptelea integrifolia* (Roxb.) Planch	500.00	474	58.98 ± 8.89	15.33 ± 2.31	74.31 ± 11.20
6.	*Nyctanthes arbor-tristis* L.	880.00	363	26.80 ± 1.47	6.97 ± 0.38	33.77 ± 1.85
7.	*Prosopis cineraria* (Linn.) Druce	630.00	306	62.90 ± 7.14	16.36 ± 1.86	79.26 ± 9.00
8.	*Prosopis juliflora* (Swartz.) DC	707.00	1736	33.42 ± 2.77	8.69 ± 0.71	42.11 ± 3.48
9.	*Salvadora persica* L.	594.00	827	49.67 ± 4.93	12.92 ± 1.28	62.59 ± 6.21
10.	*Senegalia senegal* (L.) Britton	600.00	2142	35.08 ± 1.56	9.12 ± 0.41	44.20 ± 1.97
11.	*Vachellia farnesiana* (L.) Wight & Arn.	600.00	162	7.93 ± 0.42	2.06 ± 0.11	9.99 ± 0.53
12.	*Vachelia leucophloea* (Roxb) Maslin, Seigler & Ebinger	711.20	707	110.25 ± 8.56	28.67 ± 2.22	138.92 ± 10.78
13.	*Vachelia nilotica* (L.) P. J. H. Hurter & Mabb.	762.90	677	135.33 ± 10.02	35.18 ± 2.60	170.51 ± 12.62
14.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	600.00	3546	79.14 ± 2.63	20.58 ± 0.68	99.72 ± 3.31
15.	*Wrightia tinctoria* (Roxb.) R. Br.	800.00	211	47.84 ± 4.51	12.44 ± 1.17	60.28 ± 5.68

AGB = Above Ground Biomass; BGB = Below Ground Biomass; TB = Total Ground Biomass

Table-2: Total Carbon stock (in ton) of major tree species in Mansa Range

Sr. No.	Scientific Name	Total No. of tree	Average carbon stock (in ton)	SD	SE	Total carbon stock (in ton)
1.	*Anogeissus sericea* Brandis	145410	0.018385	0.059368	0.0016	2673.37
2.	*Azadirachta indica* A. Juss.	31070	0.020254	0.065836	0.0026	629.29
3.	*Balanites aegyptiaca* (L.) Del.	35310	0.008286	0.011755	0.0005	292.58
4.	*Diospyros montana* Roxb.	81410	0.012878	0.016719	0.0005	1048.44
5.	*Holoptelea integrifolia* (Roxb.) Planch	19900	0.037155	0.121940	0.0056	739.38
6.	*Nyctanthes arbor-tristis* L.	1650	0.016884	0.017647	0.0009	27.86
7.	*Prosopis cineraria* (Linn.) Druce	14310	0.039630	0.078692	0.0045	567.11
8.	*Prosopis juliflora* (Swartz.) DC	114050	0.021057	0.072673	0.0017	2401.56
9.	*Salvadora persica* L.	38530	0.031295	0.089341	0.0031	1205.81
10.	*Senegalia senegal* (L.) Britton	88600	0.022100	0.045449	0.0010	1958.04
11.	*Vachellia farnesiana* (L.) Wight & Arn.	8420	0.004995	0.003388	0.0003	42.05
12.	*Vachelia leucophloea* (Roxb) Maslin, Seigler & Ebinger	18940	0.069459	0.143361	0.0054	1315.56
13.	*Vachelia nilotica* (L) P J H Hurter & Mabb	23520	0.085256	0.164225	0.0063	2005.21
14.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	274810	0.049862	0.098438	0.0017	13702.58
15.	*Wrightia tinctoria* (Roxb.) R. Br.	1400	0.030139	0.041254	0.0028	42.20
	Total	**897330**				**28651.04**

range; while *Vachellia farnesiana* (L.) Wight and Arn., *Balanites aegyptiaca* (L.) Del., *Diospyros montana* Roxb., *Nyctanthes arbor-tristis* L. and *Anogeissus sericea* Brandis watched least average AGB, BGB and TB in the range (Table-1 & 4). Subsequently, the geographic and climatic states of range are appropriate for previous prickly species. Notwithstanding this the previous species has incredible ability to ingest CO_2 from climate, which gives essential data about effectiveness of carbon sequestration of the tree species in the range.

The total carbon stock of the fifteen dominant trees species in Mansa range is 28,651.04 ton. Out of which range has maximum carbon stock (in ton) in *Vachellia tortilis* (Forssk.) Galasso & Banfi (13,713.20), *Anogeissus sericea* Brandis (2,675.54), *Prosopis juliflora* (Swartz.) DC (2,406.46), *Vachelia nilotica*

Table-3: Regression analysis for Diameter t Breast Height (DBH) Vs. Carbon Stock of tree species in Mansa Range

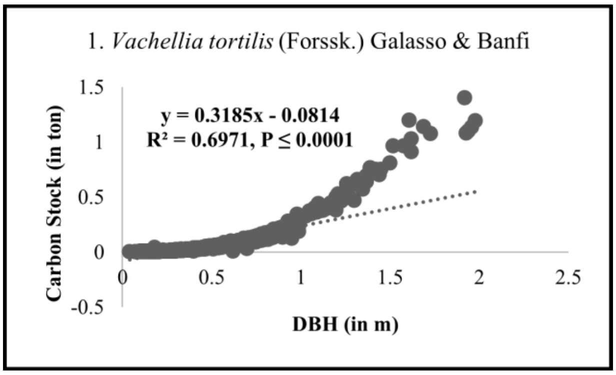
Sr. No.	Scientific Name	R^2	Equation (Model)	Slope ± SE	Pearson r	Pearson r at 95% confidence interval
1.	*Anogeissus sericea* Brandis	0.6106	Y = 0.2912*X - 0.06077	0.2912 ± 0.006318	0.7814	0.7598 to 0.8013
2.	*Azadirachta indica* A. Juss.	0.5937	Y = 0.3199*X - 0.06612	0.3199 ± 0.010290	0.7705	0.7376 to 0.7997
3.	*Balanites aegyptiaca* (L.) Del.	0.8517	Y = 0.1168*X - 0.01768	0.1168 ± 0.001922	0.9229	0.9105 to 0.9336
4.	*Diospyros montana* Roxb.	0.889	Y = 0.1247*X - 0.02020	0.1247 ± 0.001412	0.9429	0.9355 to 0.9494
5.	Holoptelea *integrifolia* (Roxb.) Planch	0.8915	Y = 0.4093*X - 0.08308	0.4093 ± 0.006573	0.9442	0.9335 to 0.9532
6.	*Nyctanthes arbor-tristis* L.	0.9213	Y = 0.1210*X - 0.01965	0.1210 ± 0.001862	0.9598	0.9508 to 0.9672
7.	*Prosopis cineraria* (Linn.) Druce	0.852	Y = 0.2456*X - 0.05757	0.2456 ± 0.005872	0.9230	0.9045 to 0.9381
8.	*Prosopis juliflora* (Swartz.) DC	0.7762	Y = 0.3296*X - 0.06085	0.3296 ± 0.004251	0.8810	0.8700 to 0.8911
9.	*Salvadora persica* L.	0.8138	Y = 0.2990*X - 0.06114	0.2990 ± 0.004979	0.9021	0.8886 to 0.9141
10.	*Senegalia* senegal (L.) Britton	0.7033	Y = 0.2132*X - 0.04419	0.2132 ± 0.002993	0.8386	0.8256 to 0.8508
11.	*Vachellia farnesiana* (L.) Wight & Arn.	0.8829	Y = 0.0570*X - 0.00607	0.05695 ± 0.00164	0.9396	0.9185 to 0.9554
12.	*Vachelia leucophloea* (Roxb) Maslin, Seigler & Ebinger	0.7888	Y = 0.4957*X - 0.12040	0.4957 ± 0.009661	0.8881	0.8715 to 0.9027
13.	*Vachelia nilotica* (L) P J H Hurter & Mabb	0.7568	Y = 0.4563*X - 0.11920	0.4563 ± 0.009955	0.8700	0.8504 to 0.8872
14.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	0.6971	Y = 0.3185*X - 0.08141	0.3185 ± 0.003527	0.8349	0.8247 to 0.8446
15.	*Wrightia tinctoria* (Roxb.) R. Br.	0.9264	Y = 0.2024*X - 0.03737	0.2024 ± 0.003946	0.9625	0.9510 to 0.9713

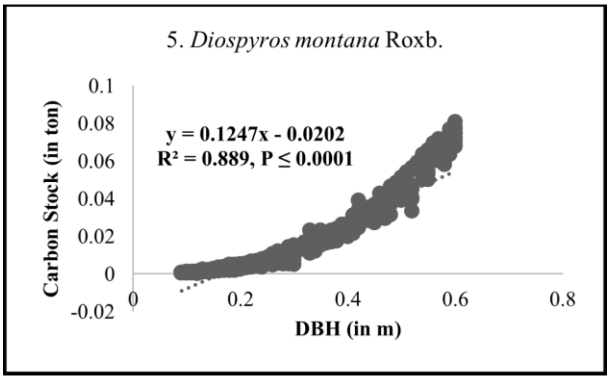
**** Level of significance $P \leq 0.0001$ (Significant at $\alpha \leq 0.05$)

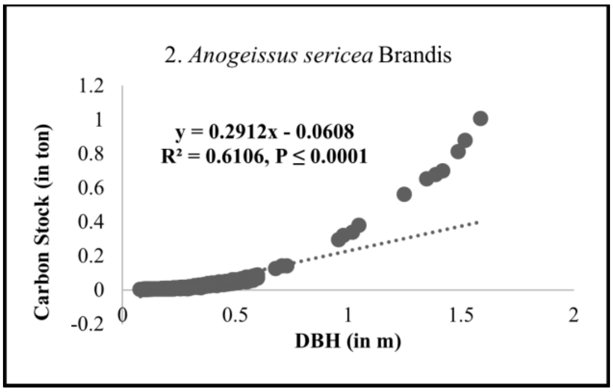
Table-4: CO_2 sequestration potential (in ton) of tree species in Mansa Range

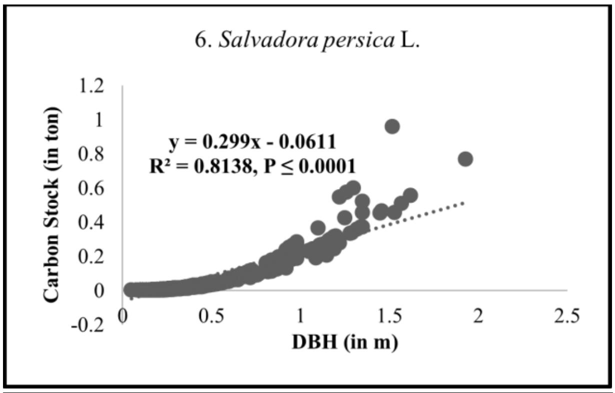
Sr. No.	Scientific Name	Avg. CO_2 sequestered/ tree (in ton)	SD	SE	Total No. of trees	Total CO_2 sequestered/ tree (in ton)
1.	*Anogeissus sericea* Brandis	0.0675	0.2179	0.0059	145410	9815.18
2.	*Azadirachta indica* A. Juss.	0.0743	0.2416	0.0094	31070	2308.50
3.	*Balanites aegyptiaca* (L.) Del.	0.0304	0.0431	0.0017	35310	1073.42
4.	*Diospyros montana* Roxb.	0.0473	0.0614	0.0020	81410	3850.69
5.	*Holoptelea integrifolia* (Roxb.) Planch	0.1364	0.4475	0.0206	19900	2714.36
6.	*Nyctanthes arbor-tristis* L.	0.0620	0.0648	0.0034	1650	102.30
7.	*Prosopis cineraria* (Linn.) Druce	0.1454	0.2888	0.0165	14310	2080.67
8.	*Prosopis juliflora* (Swartz.) DC	0.0773	0.2667	0.0064	114050	8816.07
9.	*Salvadora persica* L.	0.1149	0.3279	0.0114	38530	4427.10
10.	*Senegalia senegal* (L.) Britton	0.0811	0.1668	0.0036	88600	7185.46
11.	*Vachellia farnesiana* (L.) Wight & Arn.	0.0183	0.0124	0.0010	8420	154.09
12.	*Vachelia leucophloea* (Roxb) Maslin, Seigler & Ebinger	0.2549	0.5261	0.0178	18940	4827.81
13.	*Vachelia nilotica* (L.) P. J. H. Hurter & Mabb.	0.3129	0.6027	0.0232	23520	7359.41
14.	*Vachellia tortilis* (Forssk.) Galasso & Banfi	0.1831	0.3613	0.0061	274810	50317.71
15.	*Wrightia tinctoria* (Roxb.) R. Br.	0.1106	0.1514	0.0104	1400	154.84
	Total					**105187.61**

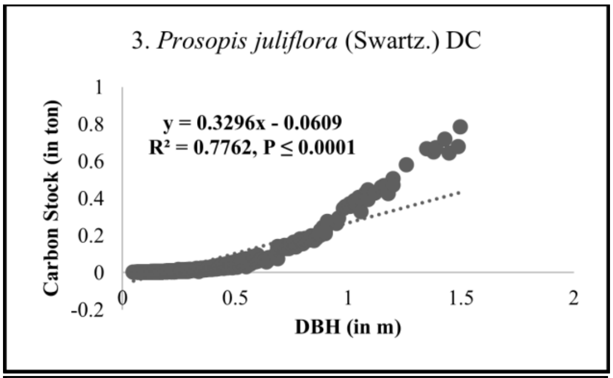
(L) P J H Hurter & Mabb (2,005.21), *Senegalia senegal* (L.) Britton (1958.04), *Vachelia leucophloea* (Roxb) Maslin, Seigler & Ebinger (1,315.56), *Salvadora persica* L. (1,205.81), *Diospyros montana* Roxb. (1,048.44), *Holoptelea integrifolia* (Roxb.) Planch (739.38) and *Azadirachta indica* A. Juss. (629.29); which indicates that the geographic & climatic conditions for these species are favourable (Table-2). Allomteric equations were developed for fifteen dominant tree species in DBH range of > 10cm.

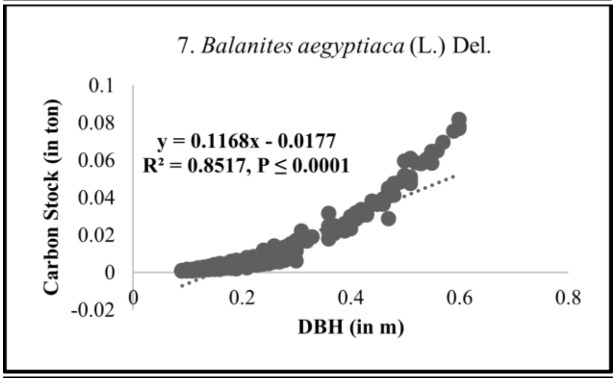

1. Vachellia tortilis (Forssk.) Galasso & Banfi
y = 0.3185x - 0.0814
R² = 0.6971, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)

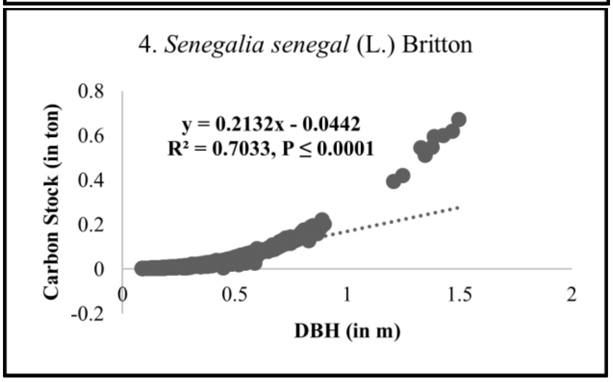

5. Diospyros montana Roxb.
y = 0.1247x - 0.0202
R² = 0.889, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)

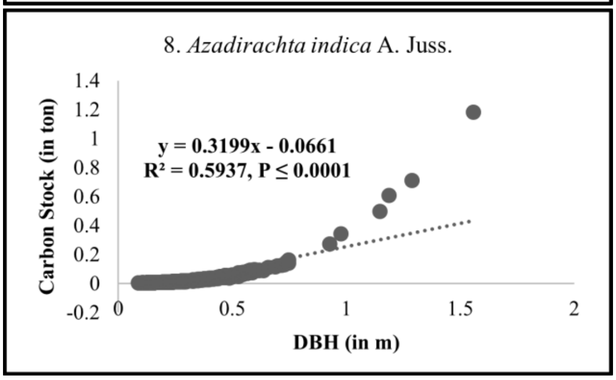

2. Anogeissus sericea Brandis
y = 0.2912x - 0.0608
R² = 0.6106, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)


6. Salvadora persica L.
y = 0.299x - 0.0611
R² = 0.8138, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)


3. Prosopis juliflora (Swartz.) DC
y = 0.3296x - 0.0609
R² = 0.7762, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)


7. Balanites aegyptiaca (L.) Del.
y = 0.1168x - 0.0177
R² = 0.8517, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)


4. Senegalia senegal (L.) Britton
y = 0.2132x - 0.0442
R² = 0.7033, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)


8. Azadirachta indica A. Juss.
y = 0.3199x - 0.0661
R² = 0.5937, P ≤ 0.0001
Carbon Stock (in ton)
DBH (in m)

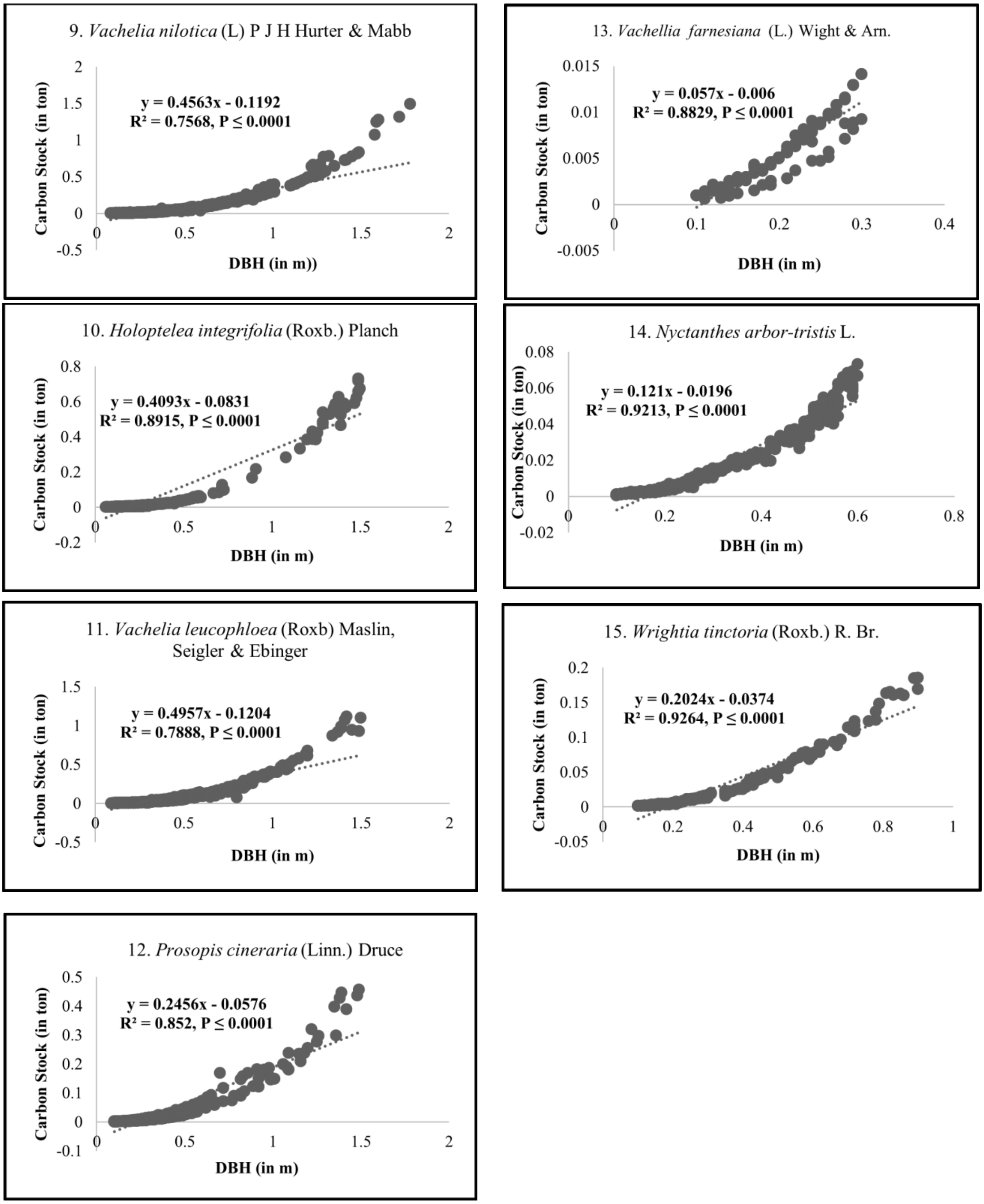


Figure-1: Linear Regression between DBH (in m) and Carbon Stock (in ton) of major tree species in Mansa Range

Regression analysis of tree species in range showed that the relationship between DBH and Height appeared to be a linear in most of the tree species in this range. The slopes of regression lines that the DBH ratio is more or less the same irrespective of the tree species and significant (P<0.0001, α=0.05, Pearson r at 95% confidence interval). Most of the tree species showed $R^2 > 0.70$, are closer to +1 which indicates that the better the line fits data. However, species like *Azadirachta indica* A. Juss. (R^2 = 0.5937, Pearson *r* = 0.7705), *Anogeissus sericea* Brandis (R^2 = 0.6106, Pearson *r* = 0.7814) and *Vachellia tortilis* (Forssk.) Galasso & Banfi (R^2 = 0.6971, Pearson *r* = 0.8349) are poor in linear regression. Tree species showed $R^2 >$ 0.70 are linear in growth; while species are non-linear in growth which shows $R^2 < 0.70$. This perception suggests that the latter has a trunk measure more than what is required to brace its stature while the last's trunk is too little to play out a similar capacity. A large portion of the species demonstrates culminate direct correlation showed increase carbon stock of trees withincrease in DBH. At the end of the day, the species watched $R^2 > 0.70$, $p < 0.0001$ and Pearson *r* at 95% certainty interim demonstrates more noteworthy i.e. as a bigger in DBH increment in carbon stock, it's phytosequestration increase with rapid rate of photosynthesis in species along with metabolic and development necessity would increment as well. In this manner, the linearity of the DBH versus carbon stock relationship is potentially an adjustment supported by characteristic choice; while the species showed $R^2 < 0.70$ demonstrates non-straight in DBH versus carbon stock relationship (Table-3, Figure-1).

4. DISCUSSIONS

In the current study, the allometric model constructed for major tree species showed highly significant relationships ($p \leq 0.0001$) with the predictor variable (DBH, Height & Wood density). The wood density at the species level is important information for accurate estimation of carbon stock from general multi-species allometric equations. However, the general regression models developed for estimation of carbon stock for major tree species and except *Vachellia tortilis* (Forssk.) Galasso & Banfi, *Anogeissus sericea* Brandis and *Azadirachta indica* A. Juss. all showed a good fit. The R^2, *p* value and Pearson *r* value indicated that the models developed were good and useful for estimating the carbon stock of tree species in the range. This indicates that robust estimates for carbon stock of tree species can be made across locations despite different spacing using general allometric regressions without the need for site-specific regressions. This study confirms that site factors have less impact on a biomass allometric equation and could be omitted when making biomass estimates. DBH is the most common predictor variable and the easiest variable to measure in the field and was strongly related to the carbon stock of tree species. Allometric equations allow aboveground tree biomass and carbon stock to be estimated from tree size.

General allometric equations that ignored species specific equations could not provide reasonable estimates of the most biomass components. It also mostly indicated the over estimation in biomass by general allometric equations. However, more precise estimation of component biomass requires species-specific equations. This has been noted in many species under divergent biomes and site conditions [13, 18]. The variation in biomass and carbon stock estimates of forests can be due to the allometric models selected to calculate the biomass and/or carbon stocks. The generalized allometric models by Brown, Gillespie, and Lugo 1989 showed the poorest results with 32–59% average deviation for AGB predictions of five tree species in Ethiopia [8]. Similarly, the model by Chave et al. 2005 was indicated to be unsuitable for three species in Ethiopia including *Allophylus abyssinicus*, *Olinia rochetiana*, and *Rhus glutinosa*. Hence, it is generally agreed that site- and species-specific allometric models are ideal to estimate both biomass and carbon stocks of forests [12].

The species specific allometric models for quantifying biomass of major tree species having significant correlation between diameter at breast height (DBH) and carbon stock in Mansa range, should significantly improve capacity to accurately estimate biomass, fuel loads, and carbon dioxide sequestration in forest ecosystem. The present work considered the issue of what allometric models might be appropriate to apply in a particular estate. Whilst research has suggested there is considerable commonality of models across different species in different parts of the world, di8erences do exist so that there may be some bias introduced into the estate-sequestered carbon estimates if an allometric model developed for one species in one part of the world is applied to another species elsewhere in the world. The important issue then is whether or not the degree of bias is sufficiently large that it renders an estimate inappropriate. The more precisely, hence the narrower the confidence interval, the owner wants the estimate, the more heed will have to be given to the degree of bias inherent in the allometric model being used.

5. CONCLUSIONS

The newly constructed equations for major tree species were used to compare estimates with the destructive samples. The study gives insights about tree species like *Vachelia nilotica* (L.) P. J. H. Hurter & Mabb., *V. leucophloea* (Roxb) Maslin, Seigler & Ebinger, *V. tortilis* (Forssk.) Galasso & Banfi, *Prosopis cineraria* (Linn.) Druce and *Salvadora persica* L., which shows maximum average total biomass and carbon stock that, sequester more carbon dioxide sequestration which could be included in the afforestation program and carbon trading schemes.

To rescue the world from global warming and climate change, the sustainable management of forest with the objectives of carbon sequestration is mandatory. Before of organic carbon in the different strata of forest is necessary and to quantify organic carbon sequestration potential of forest accurate, easy and fast scientific method is required. The present study will unbolt a new arena in this aspect of carbon management for this range and other regions with similar environment.

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