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Regression Correlation Analysis between GBH and Carbon Stock of Major Tree Species in Dharoi Range, Gandhinagar Forest Division, India

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ABSTRACT: Aim of this study is to analyse the regression correlation between GBH and Carbon stock in the major tree species of Dharoi Range, Gandhinagar Forest Division. Major ten dominant tree species in Dharoi range were selected for study. Total biomass and carbon sequestered in the major tree species have been estimated using non-destructive method. Based on this analysis and interpretation the allometric model is prepared which will be helpful to estimate carbon stock of major tree species by Girth at Breast Height (GBH). Species like *Anogeissus pendula* Edgew, *Acacia tortilis* (Forsk) Hyne and *Wrightia tinctoria* R Br were dominant while *Bauhinia racemosa* Lam, *Butea monosperma* (Lam) Taub less in number. The maximum carbon stock estimated in *Acacia tortilis* (Forsk) Hyne, *Anogeissus pendula* Edgew, and *Wrightia tinctoria* R Br whereas *Bauhinia racemosa* Lam, *Butea monosperma* (Lam) Taub showed least carbon stock. On the basis of analysis the regression correlation between GBH and Carbon Stock is linear in Dharoi range for major tree species. On the basis of study following species showed a deviation from the correlation viz, *Butea monosperma* (Lam) Taub having very small ratio while *Azadirachta indica* A Juss having a very large ratio in the range. This shows that the species which having small ratio are poorly adapted to that particular ranges while the species shows large ratio are very well adapted to this range. The results are discussed in the context of their adaptive significance and use in determining suitability of the tree species for afforestation, forest regeneration and establishment of shelter belts to arrest deforestation.

KEYWORDS: Regression Correlation, Girth at Breast Height, Carbon Sequestration, Allometric Model,

I. INTRODUCTION

With the growing danger of environmental pollution, energy crisis, loss of biological diversity and mismanagement of natural resources due to economic development needs of human civilization, the role of natural as well as planted forests is being increasingly felt for diverse intangible ecosystems services than the tangible economic goods. Consequently the dimensions of forest-based trades and international politics are shifting from timber-oriented focus toward the regional and global services like conservation of biological diversity, watershed values, ecotourism and mitigating climate changes [1].

Carbon sequestration is the process of removing excess carbon dioxide (CO_2) from the atmosphere. Plants store carbon for as long as they live, in terms of live biomass. Carbon sequestration is one of the most important environmental issue of this century and is an extensively researched topic in the recent past. A large number of studies have been carried out in various countries on the biomass factors or equations. Biomass studies have increased in recent years [2]. Trees perform important ecological function in sequestering carbon and reducing automobile pollution. The net save in carbon emissions that can be achieved by planting trees. Tree canopies provide a cooling effect on microclimate directly by shading the ground surface and indirectly through transpiration [3]. Carbon sequestration is the long term storage of carbon in oceans, soils, vegetation (especially forests), and geological formations. Global warming is undoubtedly one of the major environmental issues of this century. This phenomenon is global climate by increasing

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earth's temperature and is caused primarily by the increase in atmospheric concentrations of GHGs the most common of which is CO_2 [4].

The main objective of the study is (i) to calculate biomass of tree species by non-destructive method, (ii) to examine correlation between GBH and carbon stock of tree species and (iii) to determine the significance of these relationship on adaptation of major tree species in Dharoi Range, Gandhinagar Forest Division.

II. MATERIALS AND METHODOLOY

A) Study Area

This study was carried out in Dharoi range, comes under Gandhinagar forest Division, India. According to the revised classification of forest type by Champion and Seth (1968), part of this forest falls under group 5-A Tropical Dry Deciduous Forests [5]. Dharoi range has 14 villages. Total number of species present in the range is 91. Total area of this range is 6,300.60 hectare, which covers about 55.95% of total Division. As far as the geographical distribution is concerned Dharoi range is situated at 24° 01' N latitude and 72° 47' E Longitude. 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.

B) Methods

For the estimation of carbon stock of major tree species, non-destructive method was used. The biomass of trees was estimated on the basis of GBH (Girth at Breast Height) and tree height.

1. Above Ground Biomass (AGB):

The AGB of trees includes the whole plant parts outside the soil. The random sampling method was used for sampling the above ground biomass. The GBHs of trees having diameter greater than 10 cm were measured directly by measuring tape and height of the trees were measured by using Haga's altimeter [6]. Allometric equations for biomass usually include information on trunk Diameter at breast height *DBH* (in m), total tree height *H* (in m), and wood density (in Kg/m^3). The unit of the AGB estimated from the allometric equation is the kilogram (Kg). AGB is calculated using the following formula:

$$\text{AGB (kg/tree)} = \text{Volume of tree (m}^3\text{) x Wood density (kg/m}^3\text{)}$$
$$= \pi r^2 \text{H (m}^3\text{) x Wood density (kg/m}^3\text{)}$$
$$= \frac{(GBH)^2}{4\pi} \text{ x H x Wood density (kg/m}^3\text{)}$$

Where, r = radius of the tree (in m) = $\frac{GBH}{2\pi}$

H = Height of the tree (in m)

Radius of the tree is calculated from GBH of tree. The wood densities were obtained from the website – www.worldagroforestrycentre.org/sea/products/AFDbases/WD [6]. Wherever the wood density of tree species was unavailable, the standard average value 0.6 gm/cm^3 were taken [7].

2. Below Ground Biomass (BGB):

The Below Ground Biomass (BGB) includes all biomass of live roots excluding fine roots having < 2 mm diameter. The BGB has been calculated by multiplying AGB by 0.26 factors as the root: shoot ratio. BGB is calculated by given following formula BGB (Kg/tree) or (ton/tree) = AGB (Kg/tree) or (ton/tree) x 0.26 [8].

3. Total Biomass:

Total biomass of trees was calculated by sum of AGB and BGB of trees. The Total Biomass of trees was calculated by following method [8]. Total Biomass (Kg/tree) or (ton/tree) = AGB + BGB

4. Regression analysis

To assess the closeness of the apparent relationships and test their significance at population level, a regression analysis was performed with the help of Graph pad Prism 6. To achieve this, the product moment correlation coefficient, r, was obtained by regression analysis in Graph pad Prism 6.

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III. RESULTS AND DISCUSSIONS

Table-1: Girth Class-wise total number of major tree species in Dharoi Range

Sr. No.	Scientific Name	GBH (in cm)						Total
		0-30	31-60	61-90	91-120	121-150	> 150	
1.	*Anogeissus pendula* Edgew	650890	24160	5490	1360	310	80	682290
2.	*Acacia tortilis* (Forsk) hyne	244460	54410	13620	1990	510	90	315080
3.	*Wrightia tinctoria* R Br	208000	18710	2880	640	90	-	230320
4.	*Acacia senegal* Willd	116230	22580	3210	210	10	-	142240
5.	*Diospyros montana* Roxb	66740	5200	670	130	20	-	72760
6.	*Acacia leucophloea* (Roxb) Willd	25220	11640	2020	320	20	-	39220
7.	*Holoptelia integrifolia* (Roxb) P	29790	4770	1590	440	330	60	36980
8.	*Azadirachta indica* A Juss	27900	4200	1200	320	100	10	33730
9.	*Butea monosperma* (Lam) Taub	11660	6440	3410	860	520	60	22950
10.	*Bauhinia racemosa* Lam	14730	3120	700	160	40	10	18760
	Total	**1395620**	**155230**	**34790**	**6430**	**1950**	**310**	**1594330**

GBH = Girth at Breast Height, cm = centimetre, > = above

Range is dominated by *Anogeissus pendula* Edgew, *Acacia tortilis* (Forsk) Hyne, *Wrightia tinctoria* R Br, while in higher girth class (above 150 cm) are *Acacia tortilis* (Forsk) Hyne and *Anogeissus pendula* Edgew are the leading species. Species like *Azadirachta indica* A Juss, *Butea monosperma* (Lam) Taub and *Bauhinia racemosa* Lam are minimum in number (Table-1).

Table-2: Species wise total carbon stock of major trees in different girth classes in Dharoi Range

Sr. No.	Scientific Name	GBH (in cm)						Total CS (in ton)
		0-30	31-60	61-90	91-120	121-150	> 150	
1.	*Anogeissus pendula* Edgew	5412.65	1166.97	927.62	524.10	230.22	96.49	8358.05
2.	*Acacia tortilis* (Forsk) Hyne	2550.15	3540.69	3447.37	1002.32	488.48	164.23	11193.24
3.	*Wrightia tinctoria* R Br	2432.10	1468.96	786.53	451.08	124.87	-	5263.54
4.	*Acacia senegal* Willd	1214.40	999.51	492.69	65.86	5.25	-	2777.71
5.	*Diospyros montana* Roxb	1445.73	363.31	142.51	63.84	19.83	-	2035.22
6.	*Acacia leucophloea* (Roxb) Willd	296.85	763.83	417.19	144.22	17.53	-	1639.62
7.	*Holoptelia integrifolia* (Roxb) P	1522.57	801.21	577.21	349.82	262.36	86.21	3599.38
8.	*Azadirachta indica* A Juss	379.55	300.57	268.18	159.13	110.70	20.67	1238.8
9.	*Butea monosperma* (Lam) Taub	45.46	151.71	272.75	157.17	173.52	32.02	832.63
10.	*Bauhinia racemosa* Lam	74.26	110.38	86.20	49.48	24.05	8.49	352.86
	Total	**15373.72**	**9667.14**	**7418.25**	**2967.02**	**1456.81**	**408.11**	**37291.05**

GBH = Girth at Breast Height, cm = centimetre, > = above, CS = Carbon Stock

Table-2 shows that the total carbon stock of the major trees species in Dharoi range is 37,291.05 ton. *Acacia tortilis* (Forsk) hyne, *Anogeissus pendula*, *Wrightia tinctoria* R Br and *Holoptelia integrifolia (Roxb) P* are the leading total carbon stock major tree species while *Azadirachta indica A Juss*, *Butea monosperma* (Lam) Taub and *Bauhinia racemosa* Lam are the lesser carbon stock containing among the major tree species in Dharoi range. The maximum of carbon stock present in girth class 0-30 cm which is followed by girth class 31-60 cm and girth class 61-90 cm, while girth class above 150 cm and girth class 121-150 cm shows least carbon stock in this range.

Table-3: Regression analysis for GBH Vs. carbon stock of major tree species in Dharoi Range

Sr. No.	Scientific Name	R^2	b	A	Y = bx + A
1.	*Anogeissus pendula* Edgew	0.9030	728.71	257.99	728.71x + 257.99
2.	*Acacia tortilis* (Forsk) Hyne	0.8761	1023.80	375.34	1023.80x + 375.34
3.	*Wrightia tinctoria* R Br	0.8613	1053.30	348.94	1053.30x + 348.94
4.	*Acacia senegal* Willd	0.9249	396.19	108.59	396.19x + 108.59
5.	*Diospyros montana* Roxb	0.8637	682.23	200.60	682.23x + 200.60
6.	*Acacia leucophloea* (Roxb) Willd	0.8905	614.29	177.96	614.29x + 177.96
7.	*Holoptelia integrifolia* (Roxb) P	0.9080	943.33	485.30	943.33x + 485.30
8.	*Azadirachta indica* A Juss	0.8369	1112.10	429.62	1112.10x + 429.62
9.	*Butea monosperma* (Lam) Taub	0.9045	321.69	111.21	321.69x + 111.21
10.	*Bauhinia racemosa* Lam	0.8472	456.85	143.21	456.85x +143.21

GBH = Girth at Breast Height, R= Product moment/correlation coefficient, b = regression coefficient/slope, A = intercept, Y= regression line

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The analysis shows exponential regression model along with R^2 values developed for Girth at Breast Height (GBH) and carbon stock relationship. Regression slopes indicate that *Butea monosperma* (Lam) Taub and *Acacia senegal* Willd showed a nonconformity from this pattern and having very small ratio while *Azadirachta indica* A Juss, *Wrightia tinctoria* R Br and *Acacia tortilis* (Forsk) Hyne having a very large ratio in the range. The developing model for the Dharoi Range to determine standing woody biomass from Girth at Breast Height (GBH) is found for major tree species (Table-3).

The relationship between GBH and carbon stock is likewise linear in all major tree species. In other words, wide GBH trees have maximum carbon stock. The regression models developed for the prediction of Biomass for regional basis to avoid the necessity of repeated destructive sampling. In this range most of the tree species have linear relationship with respect to Girth at Breast Height (GBH) and carbon stock. As a tree increase in girth, its metabolic and growth requirements would also increase. As data for these increase requirements, its likely that trees have evolved wide girth so as maximize light interception and thus increase their photosynthetic rate.

IV. CONCLUSION

Based on this analysis and interpretation the GBH-Carbon Stock relationship showed relatively higher R^2 values. Therefore, GBH alone can safely be used to estimate carbon stock of major tree species in Dharoi Range. Some species like *Azadirachta indica* A Juss, *Wrightia tinctoria* R Br, *Acacia tortilis* (Forsk) Hyne and *Anogeissus pendula* Edgew having a very large regression coefficient which showed that they are well adapted to the range. The forest managers can use these evidences for planning to fill the blanks inside the forest by target species mentioned above so that the tree productivity would be maintained. This will also help in maintaining the tree composition of the forest during stand development. On the basis of this study we can develop an allometric model for each tree species which can be used as tool for carbon stock estimation from GBH by non-destructive methods.

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