Mangrove carbon stock assessment: Lacking proper methodology

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***Abstract*- The present work observed a greater variation in estimating the carbon stocks in mangrove vegetation of *Avicennia marina*, by using different allometric equations. This work calls for finding out an reliable method for mangrove carbon estimations, which assumes importance in the present context of carbon trading practices**.

***Index Terms*- Mangrove, *Avicennia,* vegetation, carbon, estimation.**

I. INTRODUCTION

Mangroves are of global significance especially for its rich carbon storage potential. Mangrove vegetation biomass is determined by non-destructive method of using allometric equations; from which, carbon is estimated (Chave *et al.,* 2005; Komiyama *et al*., 2008; Kauffman and Donato, 2012; Kathiresan et al., 2013, 2014, 2021). Several equations are used by different researchers to determine biomass and carbon. This makes the comparison of such carbon data from different mangrove areas difficult. The present work attempted toassess the carbon storage in biomass of *Avicennia marina* as influenced by allometric equations for a specific mangrove area with larger sampling.

II. MATERIALS AND METHODS

Study site: Muthupet has the largest mangrove wetland and the second largest lagoon in Tamil Nadu state in southeast coast of India, covering about 61% of the state mangrove cover. The mangrove area is influenced by 6 distributaries of Cauvery River namely Nasuviniar, Pattuvanachiar, Paminiyar, Koraiyar, Kilaithangiar, and Marakkakoraiyar. It is located. It has a total area of 11,885.91 ha predominant with the mangrove species, *Avicennia marina* (95%) followed by *Excoecaria agallocha, Aegicera scorniculatum*, *Lumnitzera racemosa* and *Acanthus ilicifolius*.

Experimental design: The study was carried out in 12 stations across the mangrove area of Muthupet (Fig. 1) during 2022. Five sampling plots, each with the size of 10 m × 10 m, were fixed for each of the stations. A total of 60 sampling plots were established for non-destructive determination of biomass and vegetation carbon stock. Within the sampling plots, all the individuals of the trees for a total of 238 trees were measured for dbh.

Vegetation biomass determination: The following allometric equations were used to determine the vegetation biomass in mangrove habitats. The above-ground biomass (AGB) and below-ground biomass (BGB) and total tree biomass were estimated in kg.tree^{-1} based on dbh values, using the following two types of allometric equations, which are specific to *Avicennia marina* (e.g. Kathiresan *et al.* 2021).

Above-Ground Biomass = $0.3404 \times (Dbh)^{2.0273}$ (Vikrantetal.,2014)

Below-Ground Biomass = $0.3335 \times (Dbh)^{1.7294}$

Tree Biomass = $0.6616 \times (Dbh)^{1.9274}$

Above-ground biomass = $0.1848 \times (Dbh)^{2.3524}$ (Dharmawan & Siregar, 2008)

The following general allometric equations were used to determine the vegetation biomass as suggested commonly for all mangrove species based on diameter and wood density as predictive variables (Komiyama et al. 2005, 2008 and Chave *et al*., 2005):

Above-ground biomass = $0.168 \times \rho \times (Dbh)^{2.47}$

Above-ground biomass = $0.251 \times r \times (Dbh)^{2.46}$

Above ground biomass = $0.0509 \times r \times (Dbh)^{2} \times$ tree height

Below ground biomass = $0.199 \times r^{0.899} \times (Dbh)^{2.22}$

Where Dbh is diameter in cm at the breast height of 1.3 m; and 'r' is wood density of 0.48g.cm^{-3} for *Avicennia* species.

Biomass values were summed for the trees from each experimental plot and averaged to get the mean value sink g.tree^{-1} and then converted to mega-gram per hectare (Mg.ha^{-1}) by multiplying with the number of trees present in one hectare area for AGB, BGB and tree biomass.

Carbon stock determination:

Carbon content in the pools of above-ground and below-ground was calculated by multiplying biomass by a factor of 0.48 for above ground biomass and 0.39 for below ground biomass (Kauffman & Donato 2012). Estimated total vegetation carbon stock was converted into CO_2 equivalents by multiplying with the factor 3.67. The factor was derived as the ratio of molecular weight between carbon and carbon dioxide (Kauffman & Donato 2012). The data were analyzed for one way ANOVA.

III. RESULTS

The carbon stockings were found significantly different between allometric equations used. The above-ground biomass carbon varied from 11.58 to 67.28 Mg/ha, the below-ground biomass from 17.67 to 20.54 Mg/ha, and the total biomass carbon ranged from 32.12 to 84.94 Mg/ha. The carbon values in above-ground biomass and total biomass were found to be the maximum with the equation of Dharmawan & Siregar (2008), which is proposed for *Avicennia marina,* and those were the minimum with the equation of Chave *et al*., (2005). However, the below-ground biomass carbon stock did not exhibit a greater variation between the equations used.

Researchers use different allometric equations to determine vegetation biomass and carbon content in mangroves. This makes the comparison of such carbon data from different mangrove areas difficult. In this work, a wide variation of carbon content with above-ground biomass was observed with the equations used. However, below-ground biomass did not vary drastically between the equations. It is worthwhile to note that the carbon content of the mangroves was found greater in above-ground than that in below-ground biomass. The equations have been derived after analyzing the real time data of biomass by destructive method, but under different tropical and subtropical regions of the world. Hence, these equations are not fully acceptable for Indian conditions. Only one Indian equation used in the present study was of Vikrant et al. (2014) and the carbon values estimated fell intermediate among the varied data obtained.

The present study calls for an attempt to derive reliable allometric equations for determining carbon stocking, exclusively for the mangroves of India. A hybrid approach of allometry and GIS is proposed for estimating the carbon stock of areas that are inaccessible. This approach has estimated carbon content of 34 Mega grams in one hectare for *Avicennia marina* stand of an arid and dry mangrove area (Vikrant *et al.*, 2014), as against 67.52 Mg/ha for the present study area (Table 1). The satellite remote sensing technology is proven to be effective in monitoring mangrove restoration results, preventing the release of significant emissions of CO_2 into the atmosphere. The digital technology in combination with ground truth surveys helps the policy makers in monitoring the mangrove carbon projects**.**

Figures and Tables

Table 1: Biomass carbon of *Avicennia marina* in Muthupet mangrove forest as influenced by different allometric equations

Allometric equation	Above-ground biomass carbon (Mg/ha)	Below-ground biomass carbon (Mg/ha)	Total biomass carbon (Mg/ha)	CO_2 equivalent of total biomass carbon (Mg/ha)	Total CO_2 equivalent of total biomass carbon (Mg)for 11,885.91 ha of Muthupet
Vikrant et al.(2014)	49.86	17.67	67.52	247.81	2,945,447
(Dharmawan & Siregar,2008)	67.28	17.67	84.94	311.74	3,705,314
Chave *et al.*, (2005); Komiyama *et al*., (2008)	40.22	20.54	60.75	222.97	2,650,201
Komiyama *et al* ., (2005)	58.38	20.54	78.92	289.65	3,442,754
Chave *et al*., (2005)	11.58	20.54	32.12	117.88	1,401,111

Values of average of 238 individual trees in 60 sampling plots of 10 m x 10 m area for 12 stations

All the values are statistically significant at 1% level between allometric equations

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