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Allometry and Biomass Studies for Planted Mangroves of Kantiyajal, Gujarat, India

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ABSTRACT

Allometric equation for the planted mangroves of Kantiyajal village, Gulf of Khambhat, Gujarat, India was derived by studying morphometric characters. Studied plantation was carried out in three phases from the year of 2010 - 11, 2011-12 and 2012 - 13. The objective of the present study was to understand the height-biomass relationship to establish allometric equation for young (maximum four years old) planted mangroves. The plantation is a single species formation of Avicenna Marina which is the predominant species in the natural mangrove formation in this coastal stretch. In total 24 plants were tried to completely uproot, out of which five plants were excluded from study due to difficulties in removing complete root system and 19 specimens were used to derive equation. To the best of our knowledge, the allometric models developed in the present study is the first attempt so far made for commercially planted mangroves in Gujarat. Thus it may be significant for future estimation of biomass growth of planted mangroves in Gujarat as a whole in view of the uniformity of geographic and environmental factors.

Keywords : Planted Mangrove, Allometric Relationship, A. Marina; An Approach To Monitor Growth Of Planted Mangroves

I. INTRODUCTION

Mangrove forests are important components of shallow, tropical coastal areas, which have experienced significant decline, largely due to logging and other human-derived transformations, over the last 50 years (Aksornkoae 1993; Arrhenins 1992; Go´mez 1988). Despite of its very important ecosystem services to coastline communities like supporting high floral and faunal biodiversity and sequester significant amounts of CO_2 effective conservation of this natural resource is still elusive. Mangroves have significant high above and below-ground carbon (C) pools, including soil. Factoring in soil, mangroves have been found to be amongst the most carbon-dense forests in the tropics, with similar or greater above- and exceptionally larger below-ground carbon stock compared to the terrestrial systems reported in several studies (Kauffman and Donato 2012).

Despite their tremendous importance as a carbon sink and as an ecosystem service provider, within last 50 years, global mangrove loss has been rapid and widespread, with estimates of 30%–50% since 1960 (Polidoro et al 2010), 25%–35% from 1980–2000 (Valiela et al 2001) and 36% since 1990 (FAO 2007).

Annual loss is estimated at around 1%–2%, exceeding the deforestation rates of inland tropical forests (Alongi DM 2002; Duke NC 2007; Spalding M 2010) which need urgent attention to restore such a significant ecosystem.

As a part of mangroves restoration activities under several projects such as REMAG – 4101 ha (Restoration of mangroves in Gujarat supported by Indian Canada Environment Facility), PPP – 4675 ha (Public private partnership) Model, GoG – 3015 ha (Govt. of Gujarat), GoI – 300 ha (Govt. of India) and ICZM – 3250 ha (Integrated coastal zone management supported by World Bank) have planted 15,341 ha of mangroves in different coastline of Gujarat from 2001 to 2011 (GEC 2012). However, for the measurement of success only survival rate of plantation was considered and no attention was given on biomass growth. It may be due to its tedious nature and non availability of area specific allometric equation for the estimation of plant biomass.

Therefore, it is very essential to develop a simple but accurate tool to measure restoration success in addition to calculate only survival rate per hectare. Scaling relations are fundamental in ecological studies from the level of the individual organism to the examination of patch structure across landscapes (Horn 1971; Niklas 1994). In forest ecology these relations have been used to examine how an individual tree's crown architecture changes during growth from seedling to sapling to adult stature (Aiba and Kohyama 1997). Allometric relations "characterize harmonious growth with changing proportions" usually with a logarithmic association (Lieth and Whittaker 1975). They are developed by establishing relations between some easily measurable individual plant parameter(s) and some variable that is much harder to measure. For trees, the diameter at breast height (DBH) of the trunk is commonly used, allowing for non-destructive assessment of biomass and growth rates. Once developed, the equation can be used to calculate an estimate of the biomass for both living and dead plants of specific geographic region. With a calculated biomass figure it is possible to determine a change in biomass from one time to another based on change in DBH. Scaling relations have been used to estimate forest biomass and productivity in temperate regions since long (Rochow 1974; Whittaker and Marks 1975) and tropical regions (Day et al. 1987; Clough and Scott 1989).

Several researchers have developed relations to predict aboveground biomass using DBH for mangroves from a variety of areas (Woodroffe 1985; Putz and Chan 1986; Clough and Scott 1989; Silva et al. 1991; Fromard et al. 1998). However, no allometric equations have been developed for mangroves in west coast of India; an area at the western limit of their distribution which is 21° 28' N 72° 39' E latitude. The present investigation is an attempt to bridge this gap by deriving allometric relationship as a tool to estimate the biomass of young mangroves on coast of Kantiyajal, Gujarat, India.

II. MATERIALS AND METHODS

Study area: South Gujarat coast is a unique ecosystem with copious fresh water supply through precipitation of around 2000 (mm) and also via perennial rivers like Kim, Narmada and Tapi. Intertidal belt near Kantiyajal village is comparatively narrow (Fig. 1). However, estuarine system of Kim river supports luxuriant growth of mangroves. The study area is at the head of Gulf of Khambhat which is unique in its position due to its proximity to the Tropic of Cancer. The depth of Gulf ranges from 18 to 27 m and is less than 20 m over most of its length. However, the depth at the head is as low as 5 m and in the channel on the eastern side it increases. Because of funnel shape and the semi enclosed nature at head, the tidal height increases tremendously towards upstream. The mean tidal elevation is 4.7 m. Temperature in Gulf is extreme; the lowest being 8.4°C during January and highest of 43.7°C during May. Coastal area is highly fragmented and majority of the area is non-forest land. Coastal milieu with copious rainfall and other favorable condition support excellent growth of mangroves. The 1000 ha of plantation was divided into four plots based on different phase of plantation for ease of sampling. Minimum six plants were uprooted from individual plot and used to derive allometric equation.

Survival Rate of Planted Mangroves: Assessment of mangrove survival rate was calculated using transects and quadrate method in four plots.

Sample collections: In accordance to maintain conservation strategy for planted mangroves, an attempt was made to uproot 24 plants Out of which 19 plants were successfully uprooted (Fig. 2). Plants were uprooted manually using augers and well cleaned spade. Care was taken while uprooting the plant to retrieve the plant without losing any part of the plant. Diameter at Breast Height (DBH) was measured using standard Aerospace Dial Vernier Caliper (size: 0-200 mm x 0.02 mm). Height was measured from the sediment surface to the highest point of canopy using a graduated centimetre tape. Wet weight of the plant was measured immediately on site using digital balance from Mettler Toledo model no. XS32001L. DBH (cm), height (m) and weight (kg) was measured in sequence for individual plant one by one.

Allometric Relationship: Equations of logarithmic regression were used to develop allometric models for predicting above-ground biomass and total biomass. The Best fit regression equation was determined by having the highest R^2 value.

III. RESULT AND DISCUSSION

Assessment of mangrove survival rate was calculated using transects and quadrate method in four plots. Estimated survival was 64.26 % as out of 2500 sapling per hectare 1606 plants per hectare were calculated. Uprooted plants were measured for height, DBH and whole plant weight which were explained in Table 1.
The coefficient of determination (R^2) describes the general fittings of the regression equation for linear relationship between above ground biomass and total biomass of the plant.

Considering parameters of estimation, the best allometric model for above ground biomass (Graph 3) is as follows: y = 3.2918x - 0.9664 (R^2 = 0.9272) (1) where 'y' is the above ground biomass and 'x' is the DBH.
In case of total biomass (Graph 4) the equation is as follows: y = 2.9777x - 0.6885 (R^2 = 0.8569) (2) where 'y' is the total biomass and 'x' is the DBH.
As the R^2 value is >0.92 for equation 1 and >0.85 for equation 2, the quality of the estimation was found to be reliable.

The allometric relations differ by species and region and do not necessarily follow latitudinal or general area trends. The biomass values generated for *A. Marina* at coastline of Kantiyajal, Bharuch, Gujarat with allometric equations should be considered with caution when used to extrapolate outside of the size range sampled or from areas with inherently different environmental parameters *viz.* for example, salinity, nutrients, hydrological exchange, stem density, net primary productivity, and herbivory (Smith and Kevin, 2005). However, the present allometric equation could be useful for measuring growth of biomass for natural younger age groups and planted mangroves of west coast of India.

TABLE 1. GROWTH PARAMETERS OF PLANT

Sr. No.	Height (m)	DBH (cm)	Whole plant weight (gm)
1	0.907 ± 0.057	1.09 ± 0.061	195.86 ± 45.59

Results were expressed in Mean ± SEM; n = 20

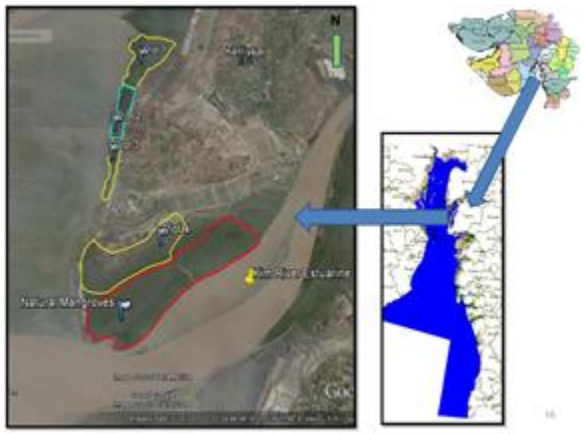
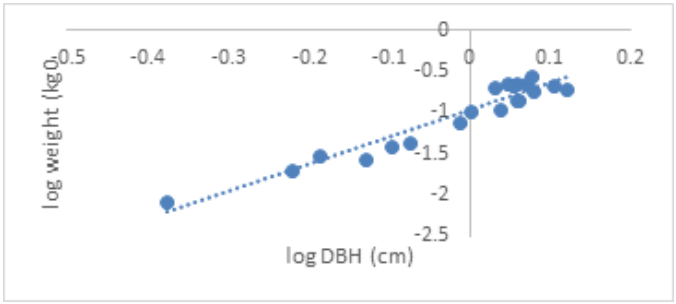
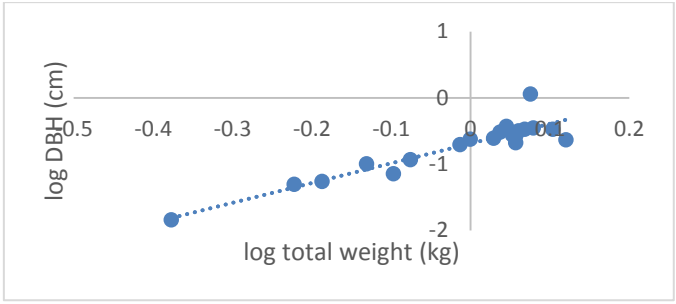


Figure 1. Mangroves plantation area near Kantiyajal village, Gulf of Khambhat, Gujarat, India

Figure 2. Uprooting mangroves for allometric equation near Kantiyajal village, Gulf of Khambhat, Gujarat, India



Graph 3. Above ground biomass as a function of DBH for the mangrove species.



Graph 4. Total biomass as a function of DBH for the mangrove species.

IV. CONCLUSION

Field based assessment of above ground biomass and total biomass will be more accurate and gives reliable information. Since the R^2 value is >0.92 and >0.85, the quality of the estimation is also very accurate. The equation number 1 and 2 will be used for the estimation of mangroves biomass near Khambat Coast.

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