On the Use of Global Ecosystem Dynamics Investigation (GEDI) in the Mangrove Ecosystem. Estimation of Canopy Aboveground Biomass Density in Lian Batangas, Philippines

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Abstract: Aboveground biomass density is one important parameter to assess the mangrove forest productivity. Understanding the dynamics of mangrove forests is beneficial because of their high capability of sequestering carbon dioxide, which can be used to mitigate the effects of climate change. This study utilizes data from GEDI (Global Ecosystem Dynamics Investigation) to estimate aboveground biomass density (AGBD) of mangrove forests in different coastal areas in Lian, Batangas, Philippines. GEDI provides high-quality laser ranging observations that measure and understand forest biodiversity. Analysis shows that mangrove aboveground biomass density varies from 10 Mg/ha to 30 Mg/ha. Differences in aboveground biomass density (AGBD) estimation were observed because of uneven planting of mangroves in different time periods. The findings contribute valuable insights into the assessment of mangrove carbon stocks and ecosystem health, facilitating informed conservation strategies and sustainable management practices in coastal regions in the Philippines.

1. Introduction

Mangrove ecosystems are very important for coastal communities, as they provide various opportunities such as food sources and protection against coastal hazards [1]. Recent studies show that without mangroves, flooding and damage to people and important infrastructure in the Philippines would increase by approximately 25% annually [2]. Mangrove ecosystems also play an important role in mitigating climate change, as they significantly store carbon and sequester carbon dioxide [3-5]. Given its long coastline, the Philippines is capable of utilizing the natural uses of mangrove.

Measurement and estimation of aboveground biomass (AGB) in forest and terrestrial ecosystems is critical, as it quantifies carbon stocks in the ecosystem [6]. Allometric equations are used to estimate aboveground biomass (AGB), wherein variables such as height (DBH), tree height (H), tree age (t), and tree density are common variable inputs for the equation [7]. Remote Sensing techniques utilize these variables to estimate aboveground biomass (AGB) with a large spatial coverage [8-9]

The Global Ecosystem Dynamics Investigation (GEDI) produces high-resolution laser ranging observations of the 3D structure of the Earth. It provides measurements of forest canopy height and vertical structure that greatly contribute to characterizing terrestrial ecosystems such as mangrove forests.

The study compared the estimated aboveground biomass density (AGBD) derived data from GEDI to allometric equations from published studies.

2. Materials and Methods

The study utilizes LIDAR data from the Global Ecosystem Dynamics Investigation (GEDI). The instrument is a light detection and ranging (lidar) laser system comprised of 3 lasers that produce 8 parallel tracks of observations. Each laser fires 242 times per second and illuminates a 25 m spot (a footprint) on the surface over which the 3D structure is measured [10-11].

Lidar signals measure the vertical distribution of vegetation through reflected laser from different plant materials such as stems, branches, and leaves. From GEDI waveforms, four types of structure information can be extracted: surface topography, canopy height metrics, canopy cover metrics, and vertical structure metrics [12].

The mangrove forest was in Lian, Batangas. Different mangrove species are planted in the province of Batangas; the predominant species in the site is *Rhizophora apiculata.* Google Earth Engine was used for analysis and visualization of the GEDI data. The "LARSE/GEDI/GEDI04_A_002_MONTHLY" dataset that ranges from January 1, 2019, to December 31, 2023, was being observed.

Figure: Site Location in Lian, Batangas

Table 1: Mangrove Forest Characteristics [13-14]

Stand Age	Planted Species	Average Diameter at Breast Height (DBH) (cm)
5-yr-old		6.65
9- yr-old	*Rhizophora Apiculata*	7.77
21-yr old		13.08

Studies were conducted by Ong et al. [14] to quantify aboveground biomass using an allometric equation for Rhizophora *apiculata.*

Allometric Equation

$$AGB = 0.235DBH^{2.420} \quad (1)$$

The study uses Root Mean Square Error to compare the data from GEDI and Allometric equations for aboveground biomass density (AGBD) [11]

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{\left(\hat{y}_i - y_i\right)^2}{n}} \quad (2)$$

Where $\hat{y}_i$ are the predicted values, y_i are the observed values, and n are the number of observations in the study.

3. Observation

In this study, allometric equations of *Rhizophora apiculata* and Global Ecosystem Dynamics Investigation (GEDI) Level 4A (L4A) Version 2 for aboveground biomass density (AGBD) of mangrove forest were used. Analysis and visualization from the Global Ecosystem Dynamics Investigation (GEDI) Level 4A shows that mangrove aboveground biomass density varies from 10 Mg/ha (tons per hectare) to 30 Mg/ha (tons per hectare). Limited data points were provided by the GEDI sensor for the given time and location.

Using the allometric equation (1) from Ong et al., the estimated aboveground biomass for 9-year-old and 21-year-old mangrove forest are 30 kg to 130 kg per mangrove plant, respectively. Considering the uncertainty on the age of the mangrove forests, the estimated RMSE value ranges from 13.57 to 98.37.

4. References

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