

ANALYSIS OF CARBON STOCK IN MANGROVE BIOMASS IN WORİ VILLAGE, NORTH SULAWESI, INDONESIA

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ABSTRACT

Mangrove ecosystems play a crucial role in maintaining coastal ecological balance by acting as shoreline protectors, providing habitat for various marine biota, and sequestering atmospheric carbon. Quantitative data on mangrove biomass and carbon stocks in Wori Village are still very limited. This study aims to estimate the potential of mangrove biomass and carbon stocks as a contribution to climate change mitigation. A non-destructive method was used by measuring Diameter at Breast Height (DBH) in the field. Biomass was calculated using the allometric equation of Komiyama et al. (2005) based on DBH and wood density from the Global Wood Density Database (Zanne et al., 2009 in Malabrigo et al., 2017). Carbon stock estimation was calculated by multiplying biomass by a conversion factor of 0.47 (IPCC, 2006). The study identified four mangrove species: *Avicennia marina*, *Rhizophora apiculata*, *Sonneratia alba*, and *Bruguiera gymnorhiza*. *Sonneratia alba* showed the highest biomass and carbon stock (1,307.45 kg/100m²) due to its large stem diameter, while *Rhizophora apiculata* had the lowest (247.48 kg/100m²). The total carbon stock from one observation plot was 3,077.43 kg/100m². The mangrove forest area in Wori Village covers 39.56 ha (satellite imagery via ArcMap 10.8), resulting in a total carbon stock of 12,174 tons or 307.74 tons C/ha. This value is higher than Sungaitohor Village (131.08 tons C/ha), Kawal Village (182.81 tons C/ha), and Bontang Mangrove Park (283.04 tons C/ha), indicating high ecological potential as a carbon sink that requires sustainable management.

Keywords: mangrove, biomass, carbon stock, climate change

INTRODUCTION

Mangrove forests are unique coastal ecosystems that thrive in brackish water with muddy substrates. These ecosystems are highly productive and provide significant ecological services, including coastal protection, habitat for various species, and carbon sequestration. Indonesia has the largest mangrove area in the world, approximately 3.36 million hectares, representing 22.6% of the global total (Giri et al., 2011; Murdiyarso et al., 2015).

The most important ecological function of mangrove ecosystems is their capacity to store large amounts of carbon. Mangroves are known as blue carbon ecosystems, sequestering up to four times more carbon than terrestrial forests (Donato et al., 2011). This capacity makes mangroves crucial in mitigating global climate change by reducing atmospheric carbon dioxide concentrations. Mangrove carbon storage occurs in several reservoirs: aboveground biomass (AGB), belowground biomass (BGB), dead wood, litter, and soil organic carbon (Komiya et al., 2005).

Wori Village, North Minahasa Regency, North Sulawesi Province, has a mangrove ecosystem along its coastline. However, quantitative data on biomass and carbon stocks are still very limited. Accurate carbon stock estimates are crucial for understanding the ecological value of mangroves and supporting sustainable conservation management policies and national and global climate change mitigation efforts. This study was conducted to estimate mangrove biomass carbon stocks in Wori Village using a non-destructive allometric approach.

METHODS

Study Site and Time

This research was conducted in the mangrove ecosystem of Wori Village, Wori District, North Minahasa Regency, North Sulawesi Province. Field surveys were conducted at low tide of 0.4 m on Saturday, December 6, 2025, between 9:23 and 11:37 WITA.

Research Design

A quantitative descriptive method with a non-destructive (allometric) approach was used. Biomass measurements were conducted without felling trees, but through DBH measurements and calculations using the allometric equation of Komiya et al. (2005). The quadrat transect method

was used with three 10 m × 10 m plots following the mangrove zonation from land to sea. Tree diameters were measured at a height of 1.3 m above ground level according to SNI (2011).

Data Analysis

Aboveground biomass (AGB) was calculated using the equation: $AGB = 0.251 \times \rho \times DBH^{2.46}$. Belowground biomass (BGB) was calculated using: $BGB = 0.199 \times \rho^{0.899} \times DBH^{2.22}$. Carbon stock estimation: $C = (AGB + BGB) \times 0.47$ (IPCC, 2006).

RESULTS AND DISCUSSION

Species Composition and Distribution

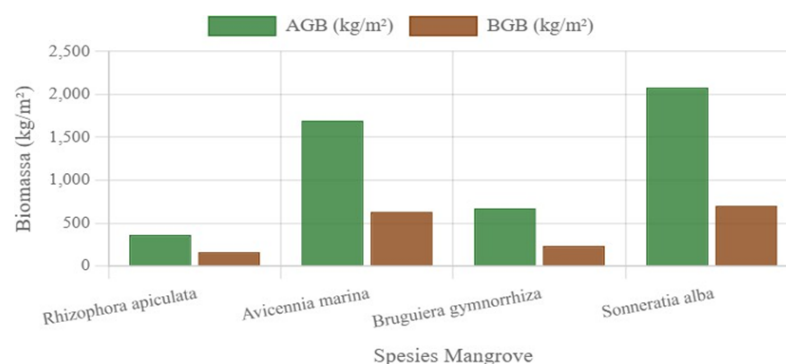
Four mangrove species were identified: *Avicennia marina*, *Rhizophora apiculata*, *Sonneratia alba*, and *Bruguiera gymnorrhiza*. Quadratic 1 (land zone) was dominated by *A. marina* (7 individuals) and *R. apiculata* (6 individuals) on a sandy mud substrate. Quadratic 2 (middle zone) was dominated by *R. apiculata* (7 individuals) on a muddy sand substrate. Quadratic 3 (marine zone) contained only *S. alba* (3 individuals) with the largest diameter, on a sandy substrate with coral debris.

Aboveground Biomass (AGB)

The aboveground biomass values of the four mangrove species found are presented in Table 1.

Table 1. Aboveground Biomass (AGB) Values

Jenis Mangrove	Rata-rata AGB/pohon (kg/pohon)	Total AGB/plot (kg/100m ²)
<i>Avicennia marina</i>	565,23	1.695,69
<i>Rhizophora apiculata</i>	83,90	363,56
<i>Sonneratia alba</i>	1.559,65	2.079,53
<i>Bruguiera gymnorrhiza</i>	1.011,93	674,62



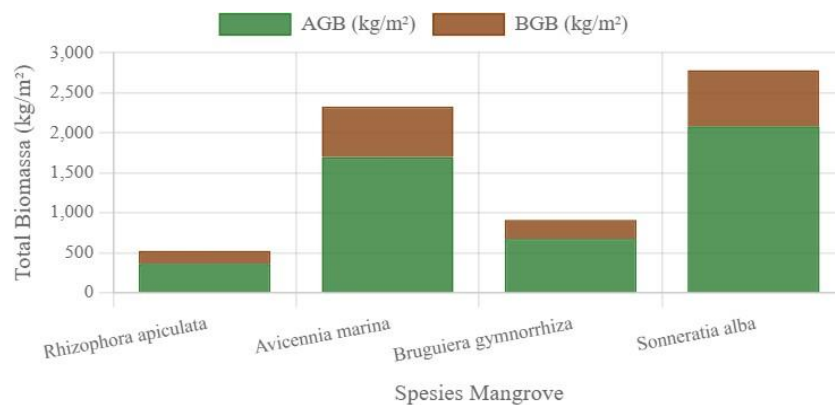
S. alba showed the highest AGB value (1,559.65 kg/tree) with a total of 2,079.53 kg/100m² due to its large trunk diameter (average DBH 47.70 cm). *A. marina* had an average AGB of 565.23 kg/tree (total 1,695.69 kg/100m²). Although its DBH was smaller (15.43 cm), the larger number of individuals (9 trees) contributed significantly. *R. apiculata* showed the lowest AGB value (83.90 kg/tree) due to its relatively small diameter (average DBH 11.96 cm).

Belowground Biomass (BGB)

The belowground biomass values based on root biomass are presented in Table 2.

Table 2. Belowground Biomass (BGB) Values

Jenis Mangrove	Rata-rataWR/pohon (kg/pohon)	Total WR/plot (kg/100m ²)
<i>Avicennia marina</i>	210,58	631,73
<i>Rhizophora apiculata</i>	37,62	163,00
<i>Sonneratia alba</i>	526,71	702,28
<i>Bruguiera gymnorrhiza</i>	355,97	237,31



Keterangan: *S. alba* = *Sonneratia alba*; *A. marina* = *Avicennia marina*; *B. gymnorrhiza* = *Bruguiera gymnorrhiza*; *R. apiculata* = *Rhizophora apiculata*

For BGB, *S. alba* also ranked highest (526.71 kg/tree; 702.28 kg/100m²), followed by *A. marina* (210.58 kg/tree; 631.73 kg/100m²). The BGB distribution pattern follows the AGB pattern, where species with larger diameters have higher root biomass.

Carbon Stock Estimation

Carbon stock estimation was derived from total biomass (AGB + BGB) calculations converted with a factor of 0.47 (Table 3).

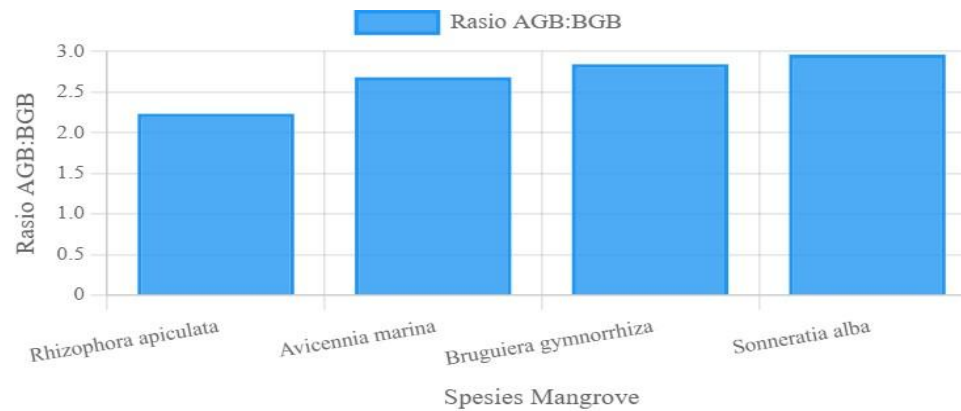
Table 3. Carbon Stock Values per Species

Jenis Mangrove	Total Stok Karbon/Plot (kg/100m ²)
<i>Avicennia marina</i>	1.093,89
<i>Rhizophora apiculata</i>	247,48
<i>Sonneratia alba</i>	1.307,45
<i>Bruguiera gymnorrhiza</i>	428,61
TOTAL	3.077,43

The total carbon stock from one observation plot (100 m²) was 3,077.43 kg. *S. alba* showed the highest value (1,307.45 kg) due to its large stem diameter (26.46-58.92 cm), although the number of individuals was smaller. *A. marina* (1,093.89 kg) contributed significantly due to its high number of individuals. With a mangrove forest area of 39.56 ha in Wori Village (satellite imagery via ArcMap 10.8), the total carbon stock was calculated in Table 4.

Table 4. Carbon Stock Value Conversion Results

Parameter	Nilai
Luas mangrove (ha)	39,56
Jumlah plot (100m ²)	3.956
Total C (kg/100m ²)	3.077,43
Total C (ton/ha)	307,74
Total C (ton)	12.174



Keterangan: Rasio menunjukkan perbandingan biomassa di atas tanah terhadap biomassa di bawah tanah

The total carbon stock for the 39.56-hectare area is 12,174 tons or 307.74 tons C/ha. This value is the highest compared to several locations in Indonesia: Sungaitohor Village (131.08 tons C/ha), Kawal Village (182.81 tons C/ha), and Bontang Mangrove Park (283.04 tons C/ha). This high value is due to the presence of large-diameter trees, especially *S. alba* with DBH ranging from 26.46-58.92 cm. The Wori Village mangrove ecosystem is an important asset for coastal carbon storage in North Sulawesi that requires sustainable maintenance and management.

CONCLUSION

The carbon stock of mangrove biomass in Wori Village was 3,077.43 kg/100m² (one plot measuring 10 m × 10 m) or 307.74 tons C/ha. The total estimated carbon stock for an area of 39.56 ha was 12,174 tons. Four species were found: *Avicennia marina*, *Rhizophora apiculata*, *Sonneratia alba*, and *Bruguiera gymnorhiza*. *S. alba* contributed the highest (1,307.45 kg/100m²) due to its largest diameter. The value of 307.74 tons C/ha indicates high potential as a carbon sink, confirming its important role in climate change mitigation.

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