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The Mangroves Of Bongabong, Oriental Mindoro, Philippines: Study On The Vegetation And Biomass Level

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ABSTRACT

Mangroves are group of salt-tolerant trees, shrubs, and plants that thrive in the brackish to saline tidal waters of tropical and subtropical coastlines. They provide essential environmental services and critical ecological functions that impact both land and sea resources. Despite their immense value, mangrove ecosystems are globally under threat . To ensure the preservation of these vital ecosystems, it is imperative to enhance the understanding of mangrove biology and ecology. Comprehensive assessments are needed to identify species composition, evaluate biomass production, and implement conservation measures to safeguard these invaluable habitats. This study aims to provide baseline data regarding the ecology, distribution, and carbon sink potentials of the abovementioned tree species. Allometric and vegetation analysis were used to collect baseline data regarding the status of mangroves in the Municipality of Bongabong, Oriental Mindor, Philippines. The mangrove sites in Bongabong boast high diversity, hosting around 17 species of mangroves from 8 families that are classified as true mangrove species. Based on the data, *Sonneratia alba* was notable as the most dominant species, boasting an impressive Importance Value Index (IVI) of 96.81%. Followed by *Avicennia marina*, with a respectable IVI of 52.67%, while *Rhizophora mucronata* and *Rhizophora apiculata* hold their IVIs of 30.31% and 28.96% respectively. Meanwhile, the total aboveground biomass of Bongabong mangroves is 95.4 tons/ha, and a specific area stands out for its high biomass production is the Sukol River with 45.6 tons/ha. There should be a substantial baseline data collection to create a better strategy in conserving and protecting the mangroves.

Keywords: Bongabong, biomass, mangroves, Oriental Mindoro, Philippines, vegetation

INTRODUCTION

Mangroves are a crucial group of salt-tolerant trees, shrubs, and plants that thrive in the brackish to saline tidal waters of tropical and subtropical coastlines. These unique species have evolved special adaptations such as stilt roots and pneumatophores to survive the saline environment. They play a key role in coastal ecosystems by providing essential environmental services and critical ecological functions that impact both land and sea resources. One of the primary benefits of mangroves are their ability to protect coastlines from storms and tsunamis, acting as a natural barrier against extreme weather events. They also help regulate water quality, provide breeding and rearing habitats for various fish and shellfish species, offer important forest products for local communities, and support biodiversity by housing rare and endangered species. Additionally, mangroves serve as a source of nutrients and energy for neighbouring habitats like seagrass beds and coral reefs, while also attracting visitors for ecotourism activities (Agustriani, 2023).

The significance of mangroves extend beyond their ecological functions. These ecosystems are essential for the livelihoods of indigenous peoples who have relied on them for centuries for resources like wood, thatch, medicines, and food. Moreover, mangrove forests are significant carbon sinks, playing a vital role in sequestering carbon and mitigating climate change (Bimrah, 2022).

Despite their immense value, mangrove ecosystems are under threat. Rapid deforestation and degradation have led to a significant decline in mangrove areas, such as in the Philippines where a substantial reduction has occurred over the past century. To ensure the preservation of these vital ecosystems, it is imperative to enhance the understanding of mangrove biology and ecology. Comprehensive assessments are needed to identify species composition, evaluate biomass production, and implement conservation measures to safeguard these invaluable habitats.

By conducting thorough research and implementing targeted conservation strategies, policymakers and decision-makers can protect and restore mangrove ecosystems for a sustainable future, benefiting both nature and society. Relative to the above discussions regarding mangrove ecosystem services, and the necessity to gather substantial data for utilization in conservation strategies; this study aims to provide baseline data regarding the ecology, distribution and carbon sink potentials of the abovementioned tree species.

MATERIAL AND METHODS

Location of the Study

The study was carried out in the mangrove stations of the five barangays of Bongabong, Oriental Mindoro, namely: Masaguisi (12º41'35"N, 121º32'14"E), Labasan (12.765ºN, 121.477ºE), Ipil (Sukol River) (12º44'39"N, 121º29'22"E), Cawayan (12.649ºN, 121.547ºE), and Anilao (12.728ºN, 121.517ºE). Mangrove structures were evaluated based on their species composition, and biomass production. The mangrove site was brackish water, riverine and inter-tidal in characteristics.

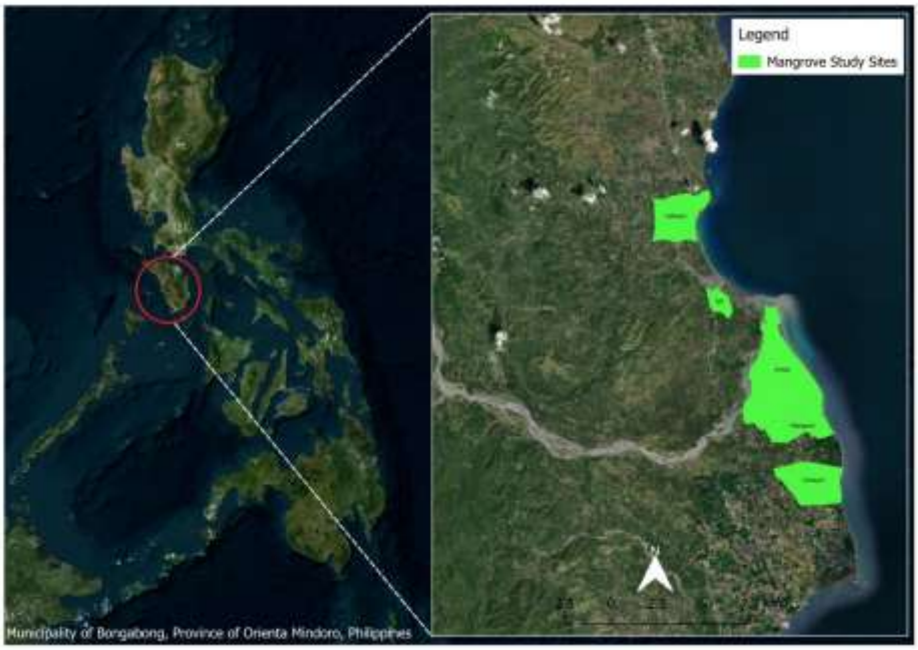

Figure 1. The location map of the study sites, Municipality of Bongabong, Oriental Mindoro, Philippines

Data Gathering Procedure and Data Processing

Plot Sampling, Species Identification and Girth Determination

Using a tape measure, the tree's girth was measured at breast height, around 1.3 meters above the ground. When dealing with large stems, they were seen as separate trees, each requiring individual measurement. In the case of Rhizophora species, measurements were specifically taken above the most prominent prop root. Previous studies utilized DBH (Diameter at Breast Height) and TH (Total Height) as key factors in mathematical equations to calculate the above-ground biomass of mangrove species. The approach followed in this study, inspired by Hossain et al. (2015), focused on allometric models using DBH as the sole independent variable, rather than total tree height. This method proved effective in the field, prompting the recommendation of DBH as the primary variable for allometric models in similar investigations.

Below is the allometric equations used to estimate above-ground biomass using DBH and TH:

$$\sqrt{Biomass} = 0.48DBH - 0.13$$

Vegetation Analysis

In estimating the mangrove vegetation, frequency denotes the extent of dispersion of individual species within a particular area and is commonly represented as a percentage of occurrence. Based on this condition, the study employed the formulae of Curtis (1933) which utilized by Raunkiaer (1934) to estimate the frequency and relative frequency of mangroves species in a given area of the study sites. This method enables the researcher to probe into the distribution and abundance of various species present in the ecosystem, providing valuable insights into the intricate dynamics of these coastal habitats.

Below are the frequency and relative frequency formulae use to assess mangrove vegetation:

$$\text{Frequency} = \frac{No. of\ occurences\ of\ species}{Total\ no. of\ site\ samples\ taken} \text{ x 100}$$

$$\text{Relative Frequency} = \frac{No. of\ occurences\ of\ particular\ species}{Total\ no. of\ occurences\ of\ all\ the\ species} \text{ x 100}$$

In studying species resilience in the environment, researcher often assess their density and abundance to gain insights regarding their populations. Density refers to the number of individuals found within a specific sampling unit, while abundance indicates the quantity of individuals present per sampling unit. To further evaluate the significance of mangroves, the study uses the Important Value Index (IVI), which combines the relative frequency, relative abundance, and relative density of each species to provide a comprehensive understanding of their dominance and ecological impact (Nabi & Brahmaji Rao in 2012).
Below are the formulae for computing Mangroves Abundance, Density and Important Value Index:

$$\text{Abundance (A)} = \frac{Total\ number\ of\ inviduals}{Number\ of\ Sampling\ units\ of\ occurence} \text{ x 100}$$

$$\text{Relative Abundance} = \frac{Abundance\ of\ a\ particular\ species}{Sum\ of\ the\ abundance\ of\ all\ species} \text{ x 100}$$

$$\text{Density} = \frac{Total\ no. of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ no. of\ quadrats\ sampled} \text{ x 100}$$

$$\text{Relative Density} = \frac{Density\ of\ a\ particular\ species}{Sum\ of\ the\ densities\ of\ all\ species} \text{ x 100}$$

$$\text{IVI} = Relative\ frequency + Relative\ abundance + Relative\ density$$

RESULT AND DISCUSSION

Vegetation

Generally, the mangrove sites in Bongabong boast high diversity, hosting around 17 species of mangroves from 8 families that are classified as true mangrove species (see Table 1). Tomilinson (1986) distinguishes true mangrove species by their unique characteristics such as their exclusive adaptation to the mangrove environment, ability to form pure stands, significant community role, morphological adaptations for environmental adaptability, saltwater excretion capability, and taxonomic isolation from terrestrial mangroves. According to Primavera (2000), there are 70 species of mangroves worldwide, with at least 47 species found in the Philippines. This indicates that the mangroves in Bongabong represent nearly 24% of global mangrove species and 36% of Philippines' mangrove species.
While the mangrove diversity in Bongabong is considered rich, it falls slightly behind other sites in the Philippines. For instance, a study in Abatan River, Maribojoc, Bohol identified approximately 31 mangrove species. Other areas with high species diversity include the mangrove regions of Aurora Province with 30 species, Makato River, Aklan with 22 species, and Puerto Princesa Bay, Palawan with 28 mangrove species (Middeljans, 2015).

Table 1. List of Mangrove species in the study sites

Scientific Name	Family Name	Local Name
Sonneratia alba	Sonneratiaceae	Pagatpat
Avicennia marina	Avicenniaceae	Bungalon
Rhizophora mucronata	Rhizophoraceae	Bakhawang Lalaki
Rhizophora apiculata	Rhizophoraceae	Bakhawang Babae
Bruguiera sexangula	Rhizophoraceae	Pototan
Scyphiphora hydrophyllaceae	Rubiaceae	Nilad
Avicennia officinalis	Avicenniaceae	Api-api
Ceriops decandra	Rhizophoraceae	Baras-baras
Bruguiera cylindrica	Rhizophoraceae	Pototan
Avicennia rumphiana	Avicenniaceae	Api-api
Heritiera littoralis	Malvaceae	Dungon
Lumnitzera racemosa	Combretaceae	Kulasi
Bruguiera parviflora	Rhizophoraceae	Pototan

Aegiceras corniculatum	Myrsinaceae	Saging-saging
Avicennia alba	Avicenniaceae	Api-api
Bruguiera gymnorrhiza	Rhizophoraceae	Busain
Excoecaria agallocha	Euphorbiaceae	Pipisik

Based on Table 2, Vegetation analysis on the mangroves of Bongabong, in this study of coastal vegetation analysis, certain species emerge as key players to provide ecological importance. Based on the data, *Sonneratia alba* was notable as the most dominant species, boasting an impressive Importance Value Index (IVI) of 96.81%. Followed by *Avicennia marina*, with a respectable IVI of 52.67%, while *Rhizophora mucronata* and *Rhizophora apiculata* hold their IVIs of 30.31% and 28.96% respectively. It is noteworthy that among these species, two belong to the family Rhizophoraceae, one to *Sonneratiaceae*, and one to *Avicceniaceae*, each contributing uniquely to the coastal landscape. Conversely, species like *Excoecaria agallocha*, *Bruguiera gymnorrhiza*, and *Avicennia alba* exhibit lower importance value indices, indicating a lesser impact on the overall vegetation dynamics. *Avicennia marina* emerges as the most frequently occurring species, representing 21% of the vegetation, while *Sonneratia alba* lead in density at 26.36%. These statistics shed light on the distribution and abundance of key species within coastal habitats, offering insights into the intricate balance of the environment. Previous research findings point towards the dominance of *Sonneratia* species in coastal communities across the Philippines, highlighting their significant role in shaping local ecosystems. On the other hand, *Avicennia marina* emerges as a prevalent species in Aurora Province and Bohol Island, showcasing the regional variations in vegetation composition and distribution. By understanding the unique attributes of each species and their ecological significance, experts gain a deeper appreciation for the intricate features of coastal vegetation and the vital role it plays in sustaining biodiversity and ecosystem health.

Table 2. Vegetation analysis on the Mangroves of Bongabong

Mangrove Species	**Tree density**	**F**	**Basal area (m^2/ha)**	**RD**	**RF**	**RDom**	**IVI**	**Rank**
Sonneratia alba	271	16	4.07	26.36	19.75	50.7	96.81	1
Avicennia marina	172	17	1.2	16.73	21	14.94	52.67	2
Rhizophora mucronata	137	8	0.57	13.33	9.88	7.1	30.31	3
Rhizophora apiculata	90	8	0.83	8.75	9.88	10.33	28.96	4
Bruguiera sexangula	85	3	0.44	8.27	3.7	5.5	17.47	5
Scyphiphora hydrophyllaceae	103	3	0.25	10.02	3.7	3.11	16.83	6
Avicennia officinalis	33	4	0.157	3.21`	4.94	1.95	10.1	7
Ceriops decandra	44	4	0.065	4.28	4.94	0.81	10.03	8
Bruguiera cylindrica	12	4	0.138	1.17	4.94	1.72	7.83	9
Avicennia rumphiana	14	3	0.053	1.36	3.7	0.66	5.72	10
Heritiera littoralis	3	2	0.173	0.3	2.47	2.15	4.92	11
Lumnitzera racemosa	21	1	0.077	2.04	1.23	0.96	4.23	12
Bruguiera parviflora	11	2	0.041	1.07	2.47	0.51	4.05	13
Aegiceras corniculatum	12	2	0.025	1.17	2.47	0.31	3.95	14
Avicennia alba	6	2	0.01	0.58	2.47	0.12	3.17	15
Bruguiera gymnorrhiza	6	1	0.051	0.58	1.23	0.63	2.44	16
Excoecaria agallocha	8	1	0.022	0.78	1.23	0.27	2.28	17
Total	1,028							

Mangrove Biomass

Based on Table 3, Total and Mean Aboveground Biomass of the mangroves of Bongabong, through the use of allometric models, the study has estimated the total aboveground biomass of Bongabong mangroves is 95.4 tons/ha. This calculation provides information into the immense carbon storage capacity of the mangrove ecosystems. One specific area that stands out for its high biomass production is the Sukol River in the community of Ipil, where the total biomass reaches 45.6 tons/ha. The dominance of large-girthed species like *Sonneratia alba* and *Rhizophora mucronata* in this area contributes significantly to its biomass production. The proximity of this area to the river further enhances its potential for carbon sequestration, making it a key player in mitigating climate change effects. When looking at species-level estimations, *Sonneratia alba* emerges as the top biomass producer among the mangrove species present in Bongabong. This highlights the importance of understanding the role of different species in overall biomass production, and carbon storage within mangrove ecosystems. Beyond their role in carbon sequestration, the mangroves of Bongabong offer a diverse ecosystem with unique interactions between flora and fauna. This diversity not only contributes to the environmental landscape of the region but also supports various species that rely on mangroves for habitat and resources.

Table 3. Total and Mean Aboveground Biomass of the Mangroves of Bongabong

Mangrove Sites	**Mean Aboveground Biomass(tons/ha)**
Masaguisi	31.9
Labasan	8.3
Ipil	45.6
Anilao	2.6
Cawayan	7.0
Total Estimated Biomass	**95.4**
Mean Aboveground Biomass	**19.08**

Implication

Mangroves have crucial part in gaseous exchange, biomass production, carbon sequestration, and oxygen release, contributing to the overall balance of the environment (Pillai & Harilal, 2018). Mangrove habitats play a significant role in maintaining homeostasis within the ecosystem, impacting biogeochemical cycles and offering a plethora of ecological benefits. They provide goods to coastal communities, support diverse flora and fauna, act as buffers against natural disasters, and offer essential services like water filtration and storm protection. Furthermore, mangroves support other marine ecosystems like sea grass and coral reefs by providing nutrients and shelter to various wildlife species, including a significant portion of tropical commercial fish (Jones et al., 2014).
Despite their ecological importance, mangrove populations worldwide have been on a decline ranging from 0.16% to 0.39% annually over the past two decades due to various human-induced activities such as extraction, degradation, and failed succession (Hamilton & Casey, 2016). These crucial ecosystems face threats from timber extraction, aquaculture, residential development, and industrial activities that disrupt their delicate balance. Natural phenomena like extreme weather events and sea level rise further endanger mangrove habitats, impacting their biodiversity and overall health (Soares, 2009).

Industrialization has significantly altered the abiotic factors affecting mangrove development, with industrial contamination posing a severe threat to their survival. The discharge of pollutants into water bodies, where mangroves thrive, introduces heavy metals and other harmful substances into their environment, affecting their ecological functions and nutrient processes (Parvaresh, 2011; Richards & Friess, 2016). As a result, mangrove ecosystems face challenges in maintaining their role as natural filters for pollutants.

The depletion of mangrove ecosystems, as seen in the drastic reduction of mangrove cover in the Philippines from 1920 to 1994, highlights the urgent need for conservation and proper management practices (Garcia et al., 2014). To address this decline, restoration initiatives must focus on understanding the growth patterns, nutrient cycling, and energy flow within mangrove ecosystems. Evaluating mangrove ecosystems for bioremediation, economic valuation, and biomass production are essential for their long-term sustainability (Lee et al., 2014). The conservation of mangrove ecosystems is vital to preserving their biological diversity and ecological functions. By understanding the species composition, biomass production, and overall community structure of mangroves, policymakers can develop efficient management strategies to ensure their continued existence.

CONCLUSIONS

Information on the species composition of the mangroves in Bongabong sheds light on the intricate structure of the study sites. The dominant mangrove species in the area hail from the families *Rhizophoraceae, Avicenniaceae, and Sonneratiaceae*. Additionally, the mangrove ecosystem along the Sukol River in Bongabong, Oriental Mindoro displays remarkable biomass production, particularly evident through the presence of sizable mangrove species indicating high productivity.

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