BIODIVERSITAS
Volume 25, Number 1, January 2024
Pages: 21-29

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d250103

Assessment of species diversity, biomass and carbon stock of mangrove forests on Belitung Island, Indonesia

HENRI[1,♥], ARTHUR MUHAMMAD FARHABY[2], OKTO SUPRATMAN[2], WAHYU ADI[2], SIGIT FEBRIANTO[3]

[1]Department of Biology, Faculty of Agriculture, Fisheries and Marine, Universitas Bangka Belitung. Jl. Kampus Terpadu UBB Balunijuk, Bangka 33172, Bangka Belitung, Indonesia. Tel./fax.: +62-717-4260046, ♥email: biology.henry@gmail.com

[2]Department of Aquatic Resource Management, Faculty of Agriculture, Fisheries and Marine, Universitas Bangka Belitung. Jl. Kampus Terpadu UBB Balunijuk, Bangka 33172, Bangka Belitung, Indonesia

[3]Department of Aquatic Resources, Faculty of Fisheries and Marine Sciences, Universitas Diponegoro. Jl. Prof. H. Soedarto, Semarang 50275, Central Java, Indonesia

Manuscript received: 15 November 2023. Revision accepted: 2 January 2024.

Abstract. *Henri, Farhaby AM, Supratman O, Adi W, Febrianto S. 2024. Assessment of species diversity, biomass and carbon stock of mangrove forests on Belitung Island, Indonesia. Biodiversitas 25: 21-29.* Mangroves are highly productive ecosystems that provide important ecosystem services for people and nature, including climate change mitigation. This study analyzed species diversity, biomass value, and estimated carbon stocks in mangrove forest ecosystems on Belitung Island, Indonesia. The data collection method is carried out by creating a linear plot consisting of several circular subplots. Data analysis was carried out to determine the frequency, density, important value index, biomass (above-ground and below-ground biomass), and carbon content. The results of research on mangrove ecosystems on Belitung Island obtained ten species of mangroves dominated by *Rhizophora apiculata* Blume found in all research sites. The density of mangroves in the four locations (>1,500 trees/ha) is very dense. In contrast, the location in Juru Seberang (1,349 trees/ha) is categorized as moderate because it is the location of previous reforestation. *Rhizophora apiculata* has an important value index at the tree (161.24%) and sapling (149.24%) levels. Mangroves on Belitung Island have a total biomass value (225.08 t ha^{-1}), estimated carbon content (112.54 t C ha^{-1}), and carbon dioxide (CO_2) absorption of 413.02 t CO_2 ha^{-1}. Sustainable coastal ecosystem management can significantly reduce carbon emissions from the land use sector and maintain ecosystem services in these coastal habitats, considering Belitung Island as one of the archipelago areas.

Keywords: Belitung Island, biomass, carbon stock, mangrove, species diversity

INTRODUCTION

Mangrove forests are one of the ecosystems with high biodiversity (Lee et al. 2014) whose ecological habitats are found in bays, estuaries, lagoons, and along tidal zones of coastal areas (Mukherjee et al. 2014; Thomas et al. 2017; Bunting et al. 2018). Mangroves have a role in coastal ecological protection, including mitigating storm damage, stabilizing sediments, maintaining water quality, filtering pollutants (Passos et al. 2022; Strain et al. 2022), and providing various ecosystem services (Choi et al. 2022). The mangrove habitat is currently declining at an alarming rate of 1-2% per year, with 20-35% of global mangrove area lost over the past 50 years due to deforestation and land exploitation, as well as sea level rise and erosion (Alongi 2015; Goldberg et al. 2020).

Although mangrove forests only occupy 0.5% of the world's coastal areas, they can contribute 10-15% of total carbon and play an important role in soil carbon flux (Alongi 2014; Ouyang and Lee 2020). Mangroves are highly productive and have significant carbon storage capacity, while the soil in them has the potential to store more than 90% of carbon (Hapsari et al. 2020). Mangroves, together with seagrass and salt marsh ecosystems, are currSently known as blue carbon ecosystems, which have recently been recognized for their carbon sequestration value as nature-based solutions to adapt and mitigate the impacts of climate change (Murphy et al. 2023). Blue carbon implies carbon storage in aquatic plants, soil, and sediments. In addition, biodiversity protection and climate change mitigation have been widely recognized (Lai et al. 2022).

Southeast Asia is a strategic area for mangrove ecosystems because of its natural conditions that support the development of mangrove ecosystems, making this area has the highest area and diversity of mangrove species in the world (Daru et al. 2013). Indonesia is one of the Southeast Asian countries that has recently actively enacted several blue carbon policies and has established a new body responsible for mangrove restoration, with an ambitious mangrove restoration target of 600,000 ha by 2024 (Sidik et al. 2023). Based on national mangrove mapping in 2021, the existing mangrove area in Indonesia is ±2,264,080 ha, and the potential area of mangrove habitat is ±756,183 ha.

Mangrove ecosystems exist in the category of sparse, medium, or dense. This can be observed from the vegetation structure, which is determined by species diversity, the relative density of constituent species, the overall density of stands, the base area representing the size of plant stems, and their height. The vegetation structure indicates its functional capacity, influencing global climate change due to its high carbon sequestration potential (Sahu and Kathiresan 2019). Several studies have analyzed mangrove distribution based on optimal zoning factors (Yuvaraj et al. 2017), and other studies have considered the optimal carbon content of land in existing mangrove areas (Byrd et al. 2018). This ecosystem stores high-value carbon in the soil, above-ground, and below-ground biomass (Cuc and Hien 2021). Carbon emissions and mangrove structure require horizontal and vertical heterogeneity measurements, ecosystem biomass calculations, and mangrove area and change measurements (Wong et al. 2020).

Several studies have inventoried and estimated mangrove biomass and carbon storage to improve understanding of ecosystem functions and services (Sitoe et al. 2014; Njana 2020; Rahman et al. 2021). Studies regarding mangroves on Belitung Island have been carried out, including regarding the diversity and distribution of mangroves in the small islands area of Manggar Sub-district, East Belitung District (Ridho et al. 2015), the condition of the mangrove ecosystem on Sebongkok Island (Akhrianti 2016), the composition and density of mangroves in the cluster Memporang Island (Aliviyanti et al. 2020) and diversity and zonation of mangrove flora in Belitung Island (Irawan et al. 2021). Besides that, there is also related research analysis of mangrove litter production and carbon stock in Sukamandi Village, East Belitung District (Farhaby et al. 2023). The existence of mangroves in Bangka Belitung is essential because as an archipelago area, effective conservation is needed to protect, restore, and preserve the remaining mangrove areas (Sari et al. 2023). This study assessed species diversity and above- and below-ground biomass and carbon stocks in the mangrove forests of Belitung Island. The topic is of large scientific and management interest, considering that Indonesia has the largest mangrove areas in the world (22.6%). Therefore, assessing the diversity of mangrove vegetation is undoubtedly important because it will impact estimating the value of mangrove biomass and carbon, especially mangroves on Belitung Island in a sustainable manner.

MATERIALS AND METHODS

Location and time of research

This research was conducted on Belitung Island, Bangka Belitung Islands Province, Indonesia, divided into five research location villages: Juru Seberang, Sukamandi, Sijuk, Terong, and Air Saga (Figure 1). The study was conducted for three months, from July to September 2023.

Procedures data collection

Vegetation structure

The research's sampling plot was linear (Figure 2), consisting of several circular subplots covering an area of 0.15 ha arranged perpendicular to the edge of the mangrove forest. Each plot carried out measurement activities for the diameter and height of trees and identification of the type of tree being measured. In this design, circular plots are established perpendicular to the marine-mangrove ecotone, with the first plot established 15 m inland from this ecotone. The circular plots are relatively easy to establish and efficient to measure. This circular plot is 14 meters in diameter (r = 7 m; A = 153.9 m^2) to inventory smaller trees and circles with a diameter of 2 meters to inventory saplings and poles. Wood debris is measured in four planar intersect transects per plot. Soil samples of depth, bulk density, and carbon concentration are collected at prescribed depths near the center of each plot. Suppose an abundance of very large trees is present (e.g., >50 cm diameter at breast height [dbh]). In that case, this size class can be further measured in a 40 × 125 m (0.5 ha) rectangular plot surrounding the sampler circular plots (see Figure 2) (Donato et al. 2011).

Tree biomass estimation

The tree species on each plot were recorded and measured at chest level diameter (1.3 m above ground level or 30 cm above the highest fulcrum for root-rooted species such as *Rhizophora* spp.). Since no specific allometric equations were published at the study site, the published allometric equations were used to calculate the above-ground and below-ground biomass of each tree using allometric equations, as shown in Table 1.

Table 1. Biomass allometric equations and wood density values used in the study

Mangrove species	Above-Ground Biomass (AGB) (kg)	Below-Ground Biomass (BGB) (kg)	References	Wood density (g/cm^{-3})
Avicennia marina (Forssk.) Vierh.	Biomass = $0.308*dbh^{2.11}$	Biomass = $1.28*dbh^{1.17}$	(Comley and McGuinness 2005)	0.74[a]
Bruguiera gymnorrhiza (L.) Lam.	Biomass = $0.186*dbh^{2.31}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Clough and Scott 1989; Komiyama et al. 2005)	0.85[b]
Ceriops decandra (Griff.) Ding Hou	Biomass = $0.251*\rho*dbh^{2.46}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Komiyama et al. 2005)	0.89[b]
Ceriops tagal (Perr.) C.B.Rob.	Biomass = $0.251*\rho*dbh^{2.46}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Komiyama et al. 2005)	0.89[b]
Lumnitzera littorea (Jack) Voigt	Biomass = $0.251*\rho*dbh^{2.46}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Komiyama et al. 2005)	0.88[a]
Rhizophora apiculate Blume	Biomass = $0.235*dbh^{2.42}$	Biomass = $0.00698*dbh^{2.61}$	(Ong et al. 2004)	0.98[b]
Rhizophora mucronata Lam.	Biomass = $0.235*dbh^{2.42}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Ong et al. 2004)	0.98[b]
Scyphiphora hydrophyllacea C.F.Gaertn.	Biomass = $0.251*\rho*dbh^{2.46}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Komiyama et al. 2005)	0.68[c]
Sonneratia alba Sm.	Biomass = $0.251*\rho* dbh^{2.46}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Komiyama et al. 2005)	0.83[b]
Xylocarpus granatum J.Koenig	Biomass = $0.251*\rho* dbh^{2.46}$	Biomass = $0.199*\rho^{0.899}*dbh^{2.22}$	(Komiyama et al. 2005)	0.66[b]

Note: a: Alongi (2015), b: Brown and Fischer (1920), c: Zanne et al. (2009)

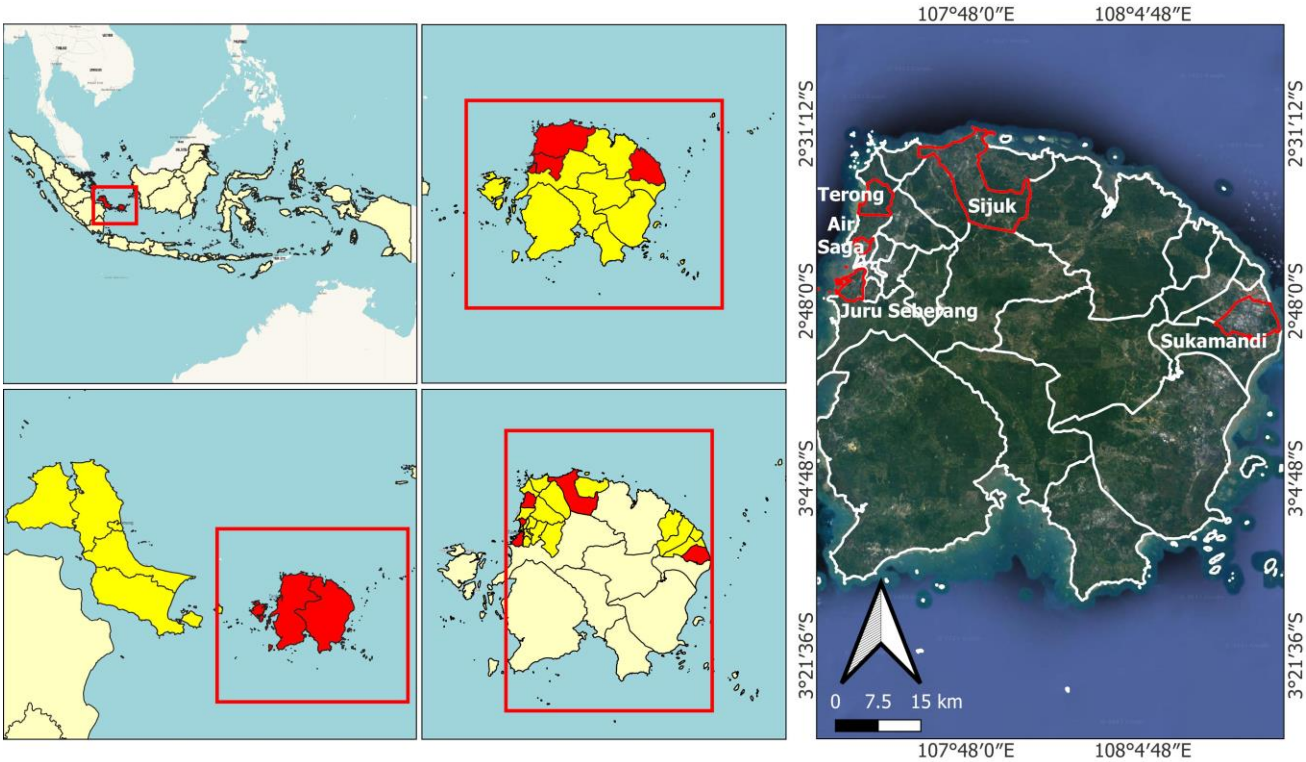

Figure 1. Mangrove research location on Belitung Island, Indonesia

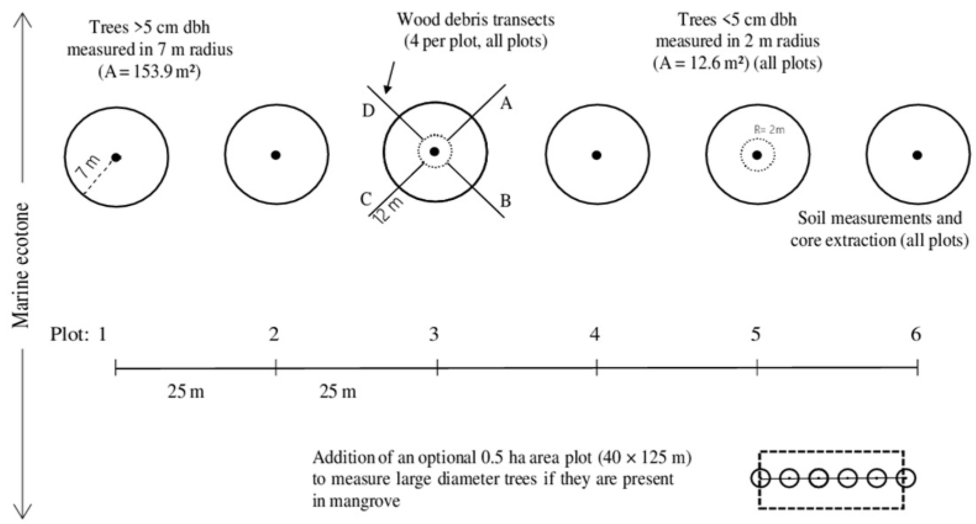

Figure 2. Plot chart of research samples on Belitung Island (Kauffman and Donato 2012)

Substrate sampling

Soil organic carbon using a color sampler tool and carried out by a composite method, mixing soil samples from five soil sample points at a depth of 30 cm to determine the C-organic content. Sampling was conducted in all four cardinal directions and the middle of the plot. Furthermore, composite substrate samples were taken as much as ±300 g of total weight for further carbon content analysis using the Loss of Ignition (LOI) method (Cortés-Esquivel et al. 2023).

Data analysis

Mangrove community structure analysis

Data analysis for vegetation analysis was perceived with the conditions of Density type (K), Relative Density (KR), type Frequency (F), Relative Frequency (FR), type Dominance (D), Relative Dominance (DR), and Important Value Index (IVI) of mangroves in the study site.

The IVI described the dominant tree species in the study area. The formula for calculating IVI is as follows:

IVI = FR + KR + DR

Where:
IVI : Importance Value Index (%)
FR : Relative Frequency (%)
KR : Relative Density (%)
DR : Relative Dominance (%)

Relative Density (KR) formula :

$$KR\ (\%) = \frac{\text{Density of a species}}{Total\ density\ of\ all\ species} x100\%$$

Relative Frequency (FR) formula :

$$FR\ (\%) = \frac{\text{Frequency of a species}}{Total\ frequency\ of\ all\ species} x100\%$$

Relative Dominance (DR) formula :

$$DR\ (\%) = \frac{\text{Dominance of a species}}{Total\ dominance\ of\ all\ species} x100\%$$

Calculation of biomass C stock

The above and below-ground biomass data were converted to stock C equivalent by multiplying the values by 48% and 39%, respectively as suggested by Kauffman and Donato (2012). The sum of above-ground and below-ground biomass tree C stocks, hereinafter referred to as tree C stocks, is calculated to determine the tree C stock per plot and averaged per location and land use to obtain the average tree C stock per land use. The value is converted to CO_2 equivalent by multiplying stock C by 3.67 (Pendleton et al. 2012). Then, the carbon content is calculated following research conducted by (Zulhalifah et al. 2021).

Carbon content = Biomass × 50%

Besides that, further calculation of carbon dioxide (CO_2) absorption is carried out using the formula:

CO_2 = Mr.CO/Ar. C x carbon content

Where:
CO_2 : Carbon dioxide uptake
Mr : Relative molecule
Ar : Relative atom

RESULTS AND DISCUSSION

Vegetation composition of mangrove species on Belitung Island

Mangroves found on Belitung Island based on the results of research, as many as 10 mangrove species consist of *Avicennia marina*, *Bruguiera gymnorrhiza*, *Ceriops decandra*, *Ceriops tagal*, *Lumnitzera littorea*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Scyphiphora hydrophyllacea*, *Sonneratia alba*, *Xylocarpus granatum* (Table 2). These results are different from previous research conducted by Irawan et al. (2021), stated that mangrove diversity on Belitung Island consists of 12 families, 16 genera, and 24 species. This is caused by differences in the methods used, Irawan et al. (2021) collected data on mangrove diversity using the roaming method in each mangrove forest, including the edge of the mangrove forest that borders the open sea, the middle part of the mangrove forest, and part of the border between the mangrove forest and the mainland forest. Meanwhile, this research uses a circular plot method arranged perpendicular to the edge of the mangrove forest. These results show that the diversity of mangrove species on Belitung Island is quite high in the category of true mangroves compared to the results of similar studies conducted in other Bangka Belitung regions such as in the Lepar Pongok Islands, namely four species of mangroves (Heriyanto and Silvaliandra 2019), in Mapur consisting as seven species of mangroves (Farhaby et al. 2020), on Takari beach as many as five species of mangroves (Farhaby and Anwar 2022). Baskara Bakti has five types of true mangroves (Henri et al. 2022). The diversity of species and changes in their existing distribution will certainly show how climate change impacts the landscape (Zhang et al. 2021).

Rhizophora apiculata is a dominating mangrove species from the Rhizophoraceae family, which has an extraordinary role in the growth and primary production of mangrove ecosystems. This is because *R. apiculata* colonizes relatively faster and grows faster and higher than other species (Tomlinson 2016). It is also influenced that the genus Rhizophora is a type of mangrove that tolerates various environmental conditions such as substrate, tides, salinity, and nutrient availability, allowing it to thrive in various locations (Usman et al. 2013). In this study, *Avicennia marina* is the least mangrove species found compared to other species. This is because the genus Avicennia is usually found on the borders of coastal areas and shows resistance to environmental stresses. *Avicennia* can thrive in sediments dominated by mud or a mixture of clay and sand with a low clay-to-sand ratio (Sari et al. 2019).

These five research locations have varied characteristics, namely at the BLMT 01 (Juru Seberang) location, which is a location for planting activities through reforestation on former tin mining land carried out by community groups. In comparison, the other four locations are natural mangrove forests. Mangroves are currently gaining global attention due to frequent environmental degradation, thus requiring various rehabilitation and restoration measures (López-Portillo et al. 2017), mostly through planting and reforestation (Primavera et al. 2019). Mangroves in rehabilitation and restoration sites need to be monitored for growth to determine the program's success rate and assess the health status of mangroves (Dale et al. 2014; Worthington and Spalding 2018). Mangroves that grow under diverse environmental conditions provide ecological niches for various microorganisms (Thatoi et al. 2012).

The density of mangrove vegetation in the five locations on Belitung Island was highest at the BLTM 03 (Sijuk) location of 3,932 trees/ha and the lowest at the BLTM 01 (Juru Seberang) location of 1,349 trees/ha. The vegetation density value is based on the Minister of Environment Number 201 Decree of 2004 concerning standard criteria and guidelines for determining mangrove damage. The requirements for mangroves are divided into three: density

>1,500 ind/ha including very dense criteria, density ≥1,000-<1,500 trees/ha including medium criteria, and mangroves with a density of <1,000 trees/ha including rare criteria. Based on this, the calculation of the average value of mangrove vegetation density on Belitung Island is included in the criteria of very dense density in the four locations (BLTM 02, BLTM 03, BLTM 04, and BLTM 05) while at the BLTM 01 location is included in the medium category. The number of trees also influences the density of mangrove trees in each location (see Figure 3), where the vegetation found has different variations even in location 1, dominated by small trees, while in other locations there are more large trees. In general, giant trees have more access to light, thus allowing them to grow taller (Stark et al. 2012), but smaller trees are more susceptible to competition (i.e., reduced accumulation of carbon as biomass) (McDowell et al. 2018).

Important Value Index of mangroves on Belitung Island

Based on the results of the Important Value Index (IVI) in the highest tree category, namely in *Rhizophora apiculata* at 161.24%, while the lowest in the species *Rhizophora mucronata* 2.73%. The highest IVI sapling category remains in *Rhizophora apiculata* (149.24%) and the lowest in *Lumnitzera littorea* (12.80%). Species not found in the tree category are *Ceriops tagal* and *Scyphiphora hydrophyllacea*, while in the sapling category are *Avicennia marina* and *Xylocarpus granatum*, as presented in Table 3.

Rhizophora apiculata is a species that has the highest IVI in both the tree and sapling categories. *Rhizophora apiculata* species belonging to the genus Rhizophoraceae genetically have a strong adaptive capacity to extreme environmental conditions, even at high salinity levels (Tomlinson 2016; Raganas and Magcale-Macandog 2020) and become the dominant species that utilize their environment optimally (Efriyeldi et al. 2023). *Rhizophora* is dominant in mangrove forest areas because it has hypocotyledonous characteristics, germinating while still in the tree. Therefore, this genus group species is relatively easier to breed for revegetation in coastal areas (Usman et al. 2022).

The Important Value Index (IVI) provides an overview of the influence or importance of a mangrove plant species in its community ecosystem (Serosero et al. 2020); the higher the IVI value of a species means, the more important its role in the community which illustrates that the species can compete in its environment and by other species (Pamoengkas et al. 2018; Matatula et al. 2021). IVI is also influenced by several other factors, such as the density of mangroves with a homogeneous distribution, which tends to cause a species to become dominant (Pamungkas et al. 2023). In addition, differences in stand age are also one of the leading factors of variations in the growth of mangrove species, which often occur due to competition between species in their habitat (Sadono et al. 2020).

Biomass, carbon stocks, and absorption of carbon dioxide (CO_2) in mangrove vegetation on Belitung Island

The results of the research analysis showed that the species *Rhizophora apiculata* in the mangrove ecosystem on Belitung Island had the highest above-ground biomass value (123.61 t ha^{-1}) and the lowest in the species *Avicennia marina* (0.62 t ha^{-1}) with a total value of 174.98 t ha^{-1}. The highest below-ground biomass value was in the species *Bruguiera gymnorrhiza* (15.52 t ha^{-1}), and the lowest value was in the species *Xylocarpus granatum* (1.79 t ha^{-1}) with a total of 50.10 t ha^{-1}. The above-ground and below-ground biomass results certainly affect biomass's total value, carbon content, and CO_2 absorption. *Rhizophora apiculata* mangrove species is the species that has the highest value in total biomass (126.77 t ha^{-1}), carbon content (63.39 t C ha^{-1}), and CO_2 absorption (232.62 t CO_2 ha^{-1}), as presented in Table 4.

The diversity and species composition of mangroves in each location on Belitung Island influence the biomass and carbon stocks in the mangrove forest. The results showed that above-ground biomass (174.98 t ha^{-1}) was higher than below-ground biomass (50.10 t ha^{-1}). Tree species diversity can affect above-ground biomass through several mechanisms, such as niche complementarity, sampling effects, and biomass ratio effects, resulting in more efficient resource use or higher productivity with greater diversity (Tilman et al. 2014). The biomass fraction varies by tree component, with the highest biomass fraction on the trunk, followed by branches and leaves (Rodrigues et al. 2015). Other factors affecting above-ground biomass include total tree volume, form factor, wood base density, and variables derived from the header, such as header volume, header diameter, tree architecture, and others (MacFarlane 2015).

Table 2. The composition and abundance of mangrove species on Belitung Island

Mangrove species	BLTM 01	BLTM 02	BLTM 03	BLTM 04	BLTM 05	∑ Individual mangrove
Avicennia marina	2	-	-	-	-	2
Bruguiera gymnorrhiza	-	24	14	10	30	78
Ceriops decandra	-	1	14	4	30	49
Ceriops tagal	-	20	-	-	-	20
Lumnitzera littorea	-	4	6	-	-	10
Rhizophora apiculata	60	98	190	74	104	526
Rhizophora mucronata	10	-	-	-	-	10
Scyphiphora hydrophyllacea	-	-	15	-	-	15
Sonneratia alba	12	7	-	13	-	32
Xylocarpus granatum	-	-	3	1	5	9

Note: BLTM 01: Juru Seberang; BLTM 02: Sukamandi; BLTM 03: Sijuk; BLTM 04: Terong; and BLTM 05: Air Saga

Table 3. Relative Frequency (FR), Relative Density (KR), Relative Dominance (DR), and Important Value Index (IVI) of tree and sapling category of mangrove species on Belitung Island

Mangrove species	Tree				Sapling			
	FR (%)	KR (%)	DR (%)	IVI (%)	FR (%)	KR (%)	DR (%)	IVI (%)
A. marina	2.08	0.51	0.18	2.77	-	-	-	-
B. gymnorrhiza	18.75	5.87	11.21	35.83	12.50	15.51	10.93	38.94
C. decandra	12.50	5.10	3.47	21.08	12.50	8.31	6.49	27.30
C. tagal	-	-	-	-	12.50	5.54	2.58	20.62
L. littorea	10.42	2.30	4.25	16.96	12.50	0.28	0.02	12.80
R. apiculata	31.25	76.02	53.97	161.24	12.50	63.16	73.58	149.24
R. mucronata	2.08	0.51	0.14	2.73	12.50	2.22	2.17	16.88
S. hydrophyllacea	-	-	-	-	12.50	4.16	2.73	19.39
S. alba	12.50	7.40	23.27	43.16	12.50	0.83	1.50	14.84
X. granatum	10.42	2.30	3.52	16.23	-	-	-	-

Table 4. Biomass, carbon stocks, and absorption of carbon dioxide (CO_2) in mangroves on Belitung Island (mean ± SE)

Species mangrove	Above-ground biomass (t ha^{-1})	Below-ground biomass (t ha^{-1})	Total forest biomass (t ha^{-1})	Carbon content (t C ha^{-1})	Absorption CO_2 (t CO_2 ha^{-1})
A. marina	0.62 ± 0.44	2.56 ± 1.81	3.18 ± 2.25	1.59 ± 0.71	5.84 ± 2.61
B. gymnorrhiza	14.51 ± 7.26	15.52 ± 7.76	30.03 ± 15.02	15.02 ± 6.71	55.11 ± 24.64
C. decandra	12.30 ± 6.15	9.75 ± 4.88	22.05 ± 11.03	11.03 ± 4.93	40.46 ± 18.10
C. tagal	5.02 ± 3.55	3.98 ± 2.81	9.00 ± 6.36	4.50 ± 2.01	16.52 ± 7.39
L. littorea	2.51 ± 1.77	1.99 ± 1.41	4.50 ± 3.18	2.25 ± 1.01	8.26 ± 3.69
R. apiculata	123.61 ± 55.28	3.16 ± 1.41	126.77 ± 56.69	63.39 ± 28.35	232.62 ± 104.03
R. mucronata	2.35 ± 1.66	1.99 ± 1.41	4.34 ± 3.07	2.17 ± 0.97	7.96 ± 3.56
S. hydrophyllacea	3.77 ± 2.67	2.99 ± 2.11	6.76 ± 4.78	3.38 ± 1.51	12.40 ± 5.55
S. alba	8.03 ± 4.64	6.37 ± 3.68	14.40 ± 8.31	7.20 ± 3.22	26.42 ± 11.82
X. granatum	2.26 ± 1.30	1.79 ± 1.03	4.05 ± 2.34	2.02 ± 0.91	7.43 ± 3.32
Total	174.98	50.10	225.08	112.54	413.02

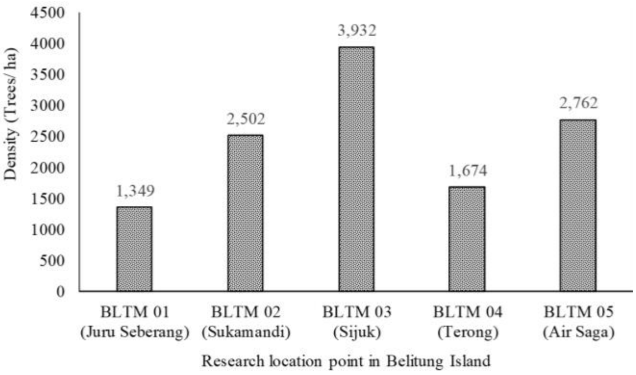

Figure 3. The density of mangrove vegetation at each location on Belitung Island

Below-ground biomass in mangrove forests on Belitung Island is relatively small (50.10 t ha^{-1}) because the mangrove plants are ecologically still alive, and there are no degraded conditions or logging carried out massively. This result is also influenced by the sampling technique that is carried out on the difficult parts, being near the root system, so root samples collected affect the estimation of root biomass. As described above, most of the root biomass (>80%) is concentrated in the first meter of soil, with >50% of the total root biomass being in the first 45 cm (Tamooh et al. 2008). Variations in this below-ground fraction of biomass are also affected by differences in resource gradient conditions (i.e., nutrients) and regulatory gradients such as salinity, stand age, and species-specific growth patterns (Ray et al. 2011; Adame et al. 2017; Chatting et al. 2020).

The research on Belitung Island showed total biomass (225.08 t ha^{-1}), estimated carbon content (112.54 t C ha^{-1}) and carbon dioxide (CO_2) absorption of 413.02 t CO_2 ha^{-1}, higher than the mangrove forest in Gunung Anyar, Surabaya which produces biomass value (101.98 t ha^{-1}), estimation of carbon stocks (47.93 t C ha^{-1}) and CO_2 absorbing ability in mangrove stands (175.90 t CO_2 ha^{-1}) (Permana et al. 2022). However, mangroves on Belitung Island have a lower value when compared with Bahowo mangrove forest in Bunaken which produced total biomass (433.69 t ha^{-1}), estimated carbon content (203.83 t C ha^{-1}), and CO_2 absorption (748.07 t CO_2 ha^{-1}) (Bachmid et al. 2018) and the Mangunharjo mangrove forest, which produces biomass value (341.02 t ha^{-1}), estimated carbon stock (156.87 t C ha^{-1}), and CO_2 absorbing ability in mangrove stands (575.71 t CO_2 ha^{-1}) (Apriliana et al. 2021).

The ability of carbon absorption in each type of mangrove can be influenced by the age of the mangrove species, leaf cross-sectional area, water physicochemical factors, and the morphology of mangrove strata (Hilyana and Rahman 2022). Well-maintained mangroves will sequester carbon from ecosystems, reducing atmospheric CO_2 concentrations and mitigating global climate change (Gnanamoorthy et al. 2020). Although mangrove forests cover only a small part (0.5%) of the global coastal ocean, they are among the most productive ecosystems with high carbon sequestration rates (Sanders et al. 2016).

In conclusion, mangroves on Belitung Island are important as the main buffer for coastal areas against environmental changes, and existing mangrove forests contribute to carbon sequestration. This study identified 10 species of mangroves spread across Belitung Island, including *Avicennia marina*, *Bruguiera gymnorrhiza*, *Ceriops decandra*, *Ceriops tagal*, *Lumnitzera littorea*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Scyphiphora hydrophyllacea*, *Sonneratia alba*, and *Xylocarpus granatum*. The density of mangrove vegetation is also relatively dense (>1,500 trees/ha), with *Rhizophora apiculata* dominating the tree and sapling levels. Mangroves on Belitung Island also have a high biomass value and estimated carbon stocks. Hence, the potential absorption of carbon dioxide (CO_2) is also better. All stakeholders must play their roles efficiently to reduce CO_2 emissions and aid in the fight against climate change.

ACKNOWLEDGEMENTS

The author would like to thank the Directorate General of Higher Education, Research, and Technology, Ministry of Education, Culture, Research, and Technology for funding through the Domestic Collaboration Research scheme in 2023 based on contract number 116/E5/PG.02.00.PL/2023 for supporting funding sources for this research. In addition, thanks were also conveyed to the Aquatic Resources Management Laboratory, Universitas Bangka Belitung, for supporting facilities and infrastructure in the research conducted.

REFERENCES

Adame MF, Cherian S, Reef R, Stewart-Koster B. 2017. Mangrove root biomass and the uncertainty of below-ground carbon estimations. For Ecol Manag 403: 52-60. DOI: 10.1016/j.foreco.2017.08.016.

Akhrianti I. 2016. Mangrove ecosystems in Sebongkok Island, District of Selat Nasik, Belitung Timur Regency. J Aquatropica Asia 3 (1): 13-21.

Aliviyanti D, Isdianto A, Asadi MA, Saputra DK, Kristanti FD, Haykal MF. 2020. Composition and density of mangroves in the Momparang Island Cluster Water Tourism Park Conservation Area. Indones J Conserv 9 (2): 63-67. DOI: 10.15294/ijc.v9i2.26547. [Indonesian]

Alongi DM. 2014. Carbon cycling and storage in mangrove forests. Ann Rev Mar Sci 6: 195-219. DOI: 10.1146/annurev-marine-010213-135020.

Alongi DM. 2015. The impact of climate change on mangrove forests. Curr Clim Chang Rep 1: 30-39. DOI: 10.1007/s40641-015-0002-x.

Apriliana WI, Purwanti F, Latifah N. 2021. Estimated biomass bontent and carbon ctorage of mangrove forests, Mangunharjo, Semarang. Life Sci 10 (2): 162-172. DOI: 10.15294/lifesci.v10i2.54447. [Indonesian]

Bachmid F, Sondak CFA, Kusen JD. 2018. Estimation of carbon absorption at Bawoho Mangrove Forest, Tongkaina Urban Village, Bunaken Regency. Jurnal Pesisir dan Laut Tropis 1 (1): 8-13. DOI: 10.35800/jplt.6.1.2018.19463. [Indonesian]

Brown WH, Fischer A. 1920. Philippine mangrove swamps. In: Brown WH (eds). Minor Products of Philippine Forests. Bureau of Printing, Manila, Philippines.

Bunting P, Rosenqvist A, Lucas RM, Rebelo LM, Hilarides L, Thomas N, Hardy A, Itoh T, Shimada M, Finlayson CM. 2018. The global mangrove watch - A new 2010 global baseline of mangrove extent. Remote Sens 10: 1669. DOI: 10.3390/rs10101669.

Byrd KB, Ballanti L, Thomas N, Nguyen D, Holmquist JR, Simard M, Windham-Myers L. 2018. A remote sensing-based model of tidal marsh above-ground carbon stocks for the conterminous United States. ISPRS J Photogramm Remote Sens 139: 255-271. DOI: 10.1016/j.isprsjprs.2018.03.019.

Chatting M, LeVay L, Walton M, Skov MW, Kennedy H, Wilson S, Al-Maslamani I. 2020. Mangrove carbon stocks and biomass partitioning in an extreme environment. Estuar Coast Shelf Sci 244: 106940. DOI: 10.1016/j.ecss.2020.106940.

Choi C-Y, Xiao H, Jia M, Jackson MV, Lai Y-C, Murray NJ, Gibson L, Fuller RA. 2022. An emerging coastal wetland management dilemma between mangrove expansion and shorebird conservation. Conserv Biol 36 (5): e13905. DOI: 10.1111/cobi.13905.

Clough BF, Scott K. 1989. Allometric relationships for estimating above-ground biomass in six mangrove species. For Ecol Manag 27 (2): 117-127. DOI: 10.1016/0378-1127(89)90034-0.

Comley BWT, McGuinness KA. 2005. Above- and below-ground biomass, and allometry, of four common northern Australian mangroves. Aust J Bot 53 (5): 431-436. DOI: 10.1071/bt04162.

Cortés-Esquivel JL, Herrera-Silveira J, Quintana-Owen P. 2023. Organic matter content in mangrove soils from a karstic environment: Comparison between thermogravimetric and loss-on-ignition analytical techniques. Forests 14 (7): 1469. DOI: 10.3390/f14071469.

Cuc NTK, Hien HT. 2021. Stand structure and above ground biomass of *Kandelia obovata* Sheue, H.Y. Liu & J. Yong mangrove plantations in Northern, Viet Nam. For Ecol Manag 483: 118720. DOI: 10.1016/j.foreco.2020.118720.

Dale PER, Knight JM, Dwyer PG. 2014. Mangrove rehabilitation: A review focusing on ecological and institutional issues. Wetl Ecol Manag 22 (6): 587-604. DOI: 10.1007/s11273-014-9383-1.

Daru BH, Yessoufou K, Mankga LT, Davies TJ. 2013. A global trend towards the loss of evolutionarily unique species in mangrove ecosystems. PLoS One 8 (6): e66686. DOI: 10.1371/journal.pone.0066686.

Donato DC, Kauffman JB, Murdiyarso D, Kurnianto S, Stidham M, Kanninen M. 2011. Mangroves among the most carbon-rich forests in the tropics. Nat Geosci 4 (5): 293-297. DOI: 10.1038/ngeo1123.

Efriyeldi E, Syahrial S, Effendi I, Almanar IP, Syakti AD. 2023. The mangrove ecosystem in a harbor-impacted city in Dumai, Indonesia: A conservation status. Reg Stud Mar Sci 65: 103092. DOI: 10.1016/j.rsma.2023.103092.

Farhaby AM, Anwar MS. 2022. Analysis of the health condition of the mangrove ecosystem in Takari Beach, Bangka Regency. Bioma 24 (2): 147-154. DOI: 10.14710/bioma.24.2.147-154 [Indonesian]

Farhaby AM, Safitri Y, Wilanda M. 2020. Preliminary study of the health conditions of mangrove forests in Mapur Village, Bangka Regency. Samakia: Jurnal Ilmu Perikanan 11 (2): 108-117. DOI: 10.35316/jsapi.v11i2.789. [Indonesian]

Farhaby AM, Sapriyadi, Henri, Arizona MO. 2023. Analysis of mangrove litter production and carbon stock in Sukamandi Village, Belitung Timur Regency. IOP Conf Ser: Earth Environ Sci 1267: 012061. DOI: 10.1088/1755-1315/1267/1/012061.

Gnanamoorthy P, Selvam V, Deb-Burman PK, Chakraborty S, Karipot A, Nagarajan R, Ramasubramanian R, Song Q, Zhang Y, Grace J. 2020. Seasonal variations of net ecosystem (CO_2) exchange in the Indian tropical mangrove forest of Pichavaram. Estuar Coast Shelf Sci 243: 106828. DOI: 10.1016/j.ecss.2020.106828.

Goldberg L, Lagomasino D, Thomas N, Fatoyinbo T. 2020. Global declines in human-driven mangrove loss. Glob Chang Biol 26 (10): 5844-5855. DOI: 10.1111/gcb.15275.

Hapsari KA, Jennerjahn TC, Lukas MC, Karius V, Behling H. 2020. Intertwined effects of climate and land use change on environmental dynamics and carbon accumulation in a mangrove-fringed coastal lagoon in Java, Indonesia. Glob Chang Biol 26 (3): 1414-1431. DOI: 10.1111/gcb.14926.

Henri, Syafa'ati R, Randiansyah. 2022. Species composition and vegetation structure of mangrove forest in Baskara Bakti Village, Central Bangka Regency, Bangka Belitung. IOP Conf Ser Earth Environ Sci 1108: 012004. DOI: 10.1088/1755-1315/1108/1/012004.

Heriyanto NM, Silvaliandra V. 2019. Mangrove diversity and carbon stock in Lepar Pongok Islands, South Bangka. Bul Plasma Nutfah 25 (2): 123-132. DOI: 10.21082/blpn.v25n2.2019.p47-58. [Indonesian]

Hilyana S, Rahman FA. 2022. Variabilities of the carbon storage of mangroves in Gili Meno Lake, North Lombok District, Indonesia. Biodiversitas 23 (11): 5862-5868. DOI: 10.13057/biodiv/d231140.

Irawan A, Chikmawati T, Sulistijorini. 2021. Diversity and zonation of mangrove flora in Belitung Island, Indonesia. Biodiversitas 22 (5): 2981-2992. DOI: 10.13057/biodiv/d220563.

Kauffman JB, Donato DC. 2012. Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. CIFOR, Bogor, Indonesia.

Komiyama A, Poungparn S, Kato S. 2005. Common allometric equations for estimating the tree weight of mangroves. J Trop Ecol 21 (4): 471-477. DOI: 10.1017/S0266467405002476.

Lai Q, Ma J, He F, Zhang A, Pei D, Wei G, Zhu X. 2022. Research development, current hotspots, and future directions of blue carbon: A bibliometric analysis. Water 14 (8): 1193. DOI: 10.3390/w14081193.

Lee SY, Primavera JH, Dahdouh-Guebas F, Mckee K, Bosire JO, Cannicci S, Diele K, Fromard F, Koedam N, Marchand C, Mendelssohn I, Mukherjee N, Record S. 2014. Ecological role and services of tropical mangrove ecosystems: A reassessment. Glob Ecol Biogeogr 23 (7): 726-743. DOI: 10.1111/geb.12155.

López-Portillo J, Lewis RR, Saenger P, Rovai A, Koedam N, Dahdouh-Guebas F, Agraz-Hernández C, Rivera-Monroy VH. 2017. Mangrove forest restoration and rehabilitation. In mangrove ecosystems: A global biogeographic perspective: Structure, function, and services. Springer International Publishing, New York.

MacFarlane DW. 2015. A generalized tree component biomass model derived from principles of variable allometry. For Ecol Manag 354: 43-55. DOI: 10.1016/j.foreco.2015.06.038.

Matatula J, Afandi AY, Wirabuana PYAP. 2021. Short communication: A comparison of stand structure, species diversity and above-ground biomass between natural and planted mangroves in Sikka, East Nusa Tenggara, Indonesia. Biodiversitas 22 (3): 1098-1103. DOI: 10.13057/biodiv/d220303.

McDowell N, Allen CD, Anderson-Teixeira K et al. 2018. Drivers and mechanisms of tree mortality in moist tropical forests. New Phytol 219 (3): 851-869. DOI: 10.1111/nph.15027.

Mukherjee N, Sutherland WJ, Dicks L, Hugé J, Koedam N, Dahdouh-Guebas F. 2014. Ecosystem service valuations of mangrove ecosystems to inform decision making and future valuation exercises. PLoS One 9 (9): e107706. DOI: 10.1371/journal.pone.0107706.

Murphy AE, Sherren K, Frank B, Saunders S. 2023. "Whose carbon is it?" Understanding municipalities role in blue carbon ecosystems management in Canada. Nat-Based Solut 4: 100089. DOI: 10.1016/j.nbsj.2023.100089.

Njana MA. 2020. Structure, growth, and sustainability of mangrove forests of mainland Tanzania. Glob Ecol Conserv 24: e01394. DOI: 10.1016/j.gecco.2020.e01394.

Ong JE, Gong WK, Wong CH. 2004. Allometry and partitioning of the mangrove, *Rhizophora apiculata*. For Ecol Manag 188 (1-3): 395-408. DOI: 10.1016/j.foreco.2003.08.002.

Ouyang X, Lee SY. 2020. Improved estimates on global carbon stock and carbon pools in tidal wetlands. Nat Commun 11 (1): 317. DOI: 10.1038/s41467-019-14120-2.

Pamoengkas P, Siregar IZ, Dwisutono AN. 2018. Stand structure and species composition of merbau in logged-over forest in Papua, Indonesia. Biodiversitas 19 (1): 163-171. DOI: 10.13057/biodiv/d190123.

Pamungkas GT, Soenardjo N, Subagiyo. 2023. Mangrove canopy structure and cover in Genuk District, Semarang, Central Java. J Mar Res 12 (1): 116-123. DOI: 10.14710/jmr.v12i1.34372. [Indonesian]

Passos T, Penny D, Barcellos R, Nandan SB, Babu DSS, Santos IR, Sanders CJ. 2022. Increasing carbon, nutrient and trace metal accumulation driven by development in a mangrove estuary in south Asia. Sci Total Environ 832: 154900. DOI: 10.1016/j.scitotenv.2022.154900.

Pendleton L, Donato DC, Murray BC, Crooks S, Jenkins WA, Sifleet S, Craft C, Fourqurean JW, Kauffman JB, Marbà N, Megonigal P, Pidgeon E, Herr D, Gordon D, Baldera A. 2012. Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. PLoS One 7 (9): e43542. DOI: 10.1371/journal.pone.0043542.

Permana DA, Wijaya NI, Mahmiah. 2022. Estimation of carbon stocks and carbon dioxide uptake of biomass mangrove stands on Mount Anyar, Surabaya. J Trop Mar Res 4 (2): 97-110. DOI: 10.30649/jrkt.v4i2.56. [Indonesian]

Primavera JH, Friess DA, Van Lavieren H, Lee SY. 2019. The Mangrove Ecosystem. In: Sheppard C (eds). World Seas: An Environmental Evaluation Volume III: Ecological Issues and Environmental Impacts. Elsevier Ltd, Netherlands. DOI: 10.1016/B978-0-12-805052-1.00001-2.

Raganas AFM, Magcale-Macandog DB. 2020. Physicochemical factors influencing zonation patterns, niche width and tolerances of dominant mangroves in southern Oriental Mindoro, Philippines. Ocean Life 4 (2): 51-62. DOI: 10.13057/oceanlife/o040201.

Rahman MS, Donoghue DNM, Bracken LJ. 2021. Is soil organic carbon underestimated in the largest mangrove forest ecosystems? Evidence from the Bangladesh Sundarbans. Catena 200: 105159. DOI: 10.1016/j.catena.2021.105159.

Ray R, Ganguly D, Chowdhury C, Dey M, Das S, Dutta MK, Mandal SK, Majumder N, De TK, Mukhopadhyay SK, Jana TK. 2011. Carbon sequestration and annual increase of carbon stock in a mangrove forest. Atmos Environ 45 (28): 5016-5024. DOI: 10.1016/j.atmosenv.2011.04.074.

Ridho MS, Yustiati A, Indah R. 2015. Diversity and distribution of Mangrove in small islands area, Sub-District of Manggar, East Belitung District. Jurnal Perikanan dan Kelautan 3: 1-10. [Indonesian]

Rodrigues DP, Hamacher C, Estrada GCD, Soares MLG. 2015. Variability of carbon content in mangrove species: Effect of species, compartments and tidal frequency. Aquat Bot 120: 346-351. DOI: 10.1016/j.aquabot.2014.10.004.

Sadono R, Soeprijadi D, Susanti A, Matatula J, Pujiono E, Idris F, Wirabuana PYAP. 2020. Local indigenous strategy to rehabilitate and conserve mangrove ecosystem in the southeastern gulf of Kupang, East Nusa Tenggara, Indonesia. Biodiversitas 21 (3): 1250-1257. DOI: 10.13057/biodiv/d210353.

Sahu SK, Kathiresan K. 2019. The age and species composition of mangrove forest directly influence the net primary productivity and carbon sequestration potential. Biocatal Agric Biotechnol 20: 101235. DOI: 10.1016/j.bcab.2019.101235.

Sanders CJ, Santos IR, Maher DT, Breithaupt JL, Smoak JM, Ketterer M, Call M, Sanders L, Eyre BD. 2016. Examining $^{239+240}$Pu, ^{210}Pb and historical events to determine carbon, nitrogen and phosphorus burial in mangrove sediments of Moreton Bay, Australia. J Environ Radioact 151: 623-629. DOI: 10.1016/j.jenvrad.2015.04.018.

Sari N, Patria MP, Soesilo TEB, Tejakusuma IG. 2019. The structure of mangrove communities in response to water quality in Jakarta Bay, Indonesia. Biodiversitas 20 (7): 1873-1879. DOI: 10.13057/biodiv/d200712.

Sari SP, Koedam N, Pamungkas A, Muftiadi MR, Van Coillie F. 2023. Unveiling the diversity of Bangka Island's mangroves: A baseline for effective conservation and restoration. Forests 14 (8): 1666. DOI: 10.3390/f14081666.

Serosero RH, Abubakar S, Hasan S. 2020. Distribution and community structure of mangrove in Donrotu, Guratu and Manomadehe Islands, West Halmahera District, North Maluku. Jurnal Ilmu dan Teknologi Kelautan Tropis 12 (1): 151-166. DOI: 10.29244/jitkt.v12i1.26929.

Sidik F, Lawrence A, Wagey T, Zamzani F, Lovelock CE. 2023. Blue carbon: A new paradigm of mangrove conservation and management in Indonesia. Mar Policy 147: 105388. DOI: 10.1016/j.marpol.2022.105388.

Sitoe AA, Mandlate LJC, Guedes BS. 2014. Biomass and carbon stocks of Sofala Bay mangrove forests. Forests 5 (8): 1967-1981. DOI: 10.3390/f5081967.

Stark SC, Leitold V, Wu JL, Hunter MO, de Castilho CV, Costa FRC, Mcmahon SM, Parker GG, Shimabukuro MT, Lefsky MA, Keller M, Alves LF, Schietti J, Shimabukuro YE, Brandão DO, Woodcock TK, Higuchi N, de Camargo PB, de Oliveira RC, Saleska SR, Chave J. 2012. Amazon forest carbon dynamics predicted by profiles of canopy leaf area and light environment. Ecol Lett 15 (12): 1406-1414. DOI: 10.1111/j.1461-0248.2012.01864.x.

Strain EMA, Kompas T, Boxshall A, Kelvin J, Swearer S, Morris RL. 2022. Assessing the coastal protection services of natural mangrove forests and artificial rock revetments. Ecosyst Serv 55: 101429. DOI: 10.1016/j.ecoser.2022.101429.

Tamooh F, Huxham M, Karachi M, Mencuccini M, Kairo JG, Kirui B. 2008. Below-ground root yield and distribution in natural and replanted mangrove forests at Gazi bay, Kenya. For Ecol Manag 256 (6): 1290-1297. DOI: 10.1016/j.foreco.2008.06.026.

Thatoi H, Behera BC, Mishra RR, Dutta SK. 2012. Biodiversity and biotechnological potential of microorganisms from mangrove ecosystems: A review. Ann Microbiol 63 (1): 1-19. DOI: 10.1007/s13213-012-0442-7.

Thomas N, Lucas R, Bunting P, Hardy A, Rosenqvist A, Simard M. 2017. Distribution and drivers of global mangrove forest change, 1996-2010. PLoS One 12 (6): e0179302. DOI: 10.1371/journal.pone.0179302.

Tilman D, Isbell F, Cowles JM. 2014. Biodiversity and ecosystem functioning. Ann Rev Ecol Evol Syst 45: 471-493. DOI: 10.1146/annurev-ecolsys-120213-091917.

Tomlinson PB. 2016. The Botany of Mangroves. Cambridge University Press, United Kingdom.

Usman AHA, Hartoyo APP, Kusmana C. 2022. The growth performance of *Rhizophora apiculata* using the cut-propagule method for mangrove rehabilitation in Indonesia. Biodiversitas 23 (12): 6366-6378. DOI: 10.13057/biodiv/d231234.

Usman L, Syamsuddin, Hamzah SN. 2013. Analysis of mangrove vegetation on Dudepo Island, Anggrek District, North Gorontalo Regency. Jurnal Ilmiah Perikanan dan Kelautan 1 (1): 11-17. DOI: 10.37905/.v1i1.1211. [Indonesian]

Wong CJ, James D, Besar NA, Kamlun KU, Tangah J, Tsuyuki S, Phua M-H. 2020. Estimating mangrove above-ground biomass loss due to deforestation in Malaysian Northern Borneo between 2000 and 2015 using SRTM and landsat images. Forests 11 (9): 1018. DOI: 10.3390/f11091018.

Worthington T, Spalding M. 2018. Mangrove Restoration Potential: A global map highlighting a critical opportunity. Apollo - University of Cambridge Repository, United Kingdom. DOI: 10.17863/CAM.39153.

Yuvaraj E, Dharanirajan KD, Jayakumar S, Saravanan, Balasubramaniam J. 2017. Distribution and zonation pattern of mangrove forest in Shoal Bay Creek, Andaman Islands, India. Indian J Geo-Mar Sci 46 (03): 597-604.

Zanne AE, Lopez-Gonzalez G, Coomes DA, Ilic J, Jansen S, Lewis SL, Miller RB, Swenson NG, Wiemann MC, Chave J. 2009. Data from: Towards a worldwide wood economics spectrum, global wood density database. Dryad. DOI: 10.5061/dryad.234.

Zhang Y, Meng X, Xia P, Li Z. 2021. Response of mangrove development to air temperature variation Over the Past 3000 years in Qinzhou Bay, Tropical China. Front Earth Sci 9: 678189. DOI: 10.3389/feart.2021.678189.

Zulhalifah, Syukur A, Santoso D, Karnan. 2021. Species diversity and composition, and above-ground carbon of mangrove vegetation in Jor Bay, East Lombok, Indonesia. Biodiversitas 22 (4): 2066-2071. DOI: 10.13057/biodiv/d220455.