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Allometric Model, Aboveground Biomass and Carbon Sequestration of Natural Regeneration of *Avicennia lanata* (Ridley). at in-active Pond of Muna Regency, Southeast Sulawesi

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ABSTRACT

This study aimed to establish an allometric model for estimation of aboveground biomass, and carbon sequestration in *A. lanata* mangrove forest growing in Muna Regency, Southeast Sulawesi. Research methods were done by transect and 5 quadrats with size of 100 m^2 each. A total of thirteen individual trees with different sizes were harvested. While DBH and D_{30} were measured. The samples were separated into stems, branches, and leaves and then weighted. The sample from each fresh organs were taken and brought to the Laboratory and then oven dried at 80°C for 7 days. The allometric equations were established by using independent variables (DBH and D_{30}), and dependent variables (Ws, Wb, Wl). The partial and overall aboveground biomasses were calculated from allometric model, while carbon stock and CO_2 sequestration were estimated. The results showed that the independent variable of DBH was more applicable for estimation of Ws, Wb, Wl, and total biomasses (Mg ha^{-1}) of *A. lanata* forest, which were estimated as 28.28±3.48, 6.40±0.79, 5.00±0.66, and 40.08±4.97 respectively. The carbon stock in stems (13.24±1.63 Mg ha^{-1}) was higher than in branches (3.01±0.37 Mg C ha^{-1}) as well as in leaves (2.35±0.31 Mg C ha^{-1}). The total of carbon stock were estimated at about 18.83±2.33 Mg C ha^{-1}. Meanwhile, the total of CO_2 absorption by *A. lanata* mangrove was 43.95±5.45 Mg CO_2 ha^{-1}. Therefore a regenerated *A. lanata* mangrove in this in-active pond area had potentiality on carbon stock and sequestrations, although these vegetation condition was still in the growth stage.

1. Introduction

Mangrove ecosystem was a productive ecosystem (Cameron *et al.* 2019; Simard *et al.* 2019) and has an ecological role to absorb and to accumulate heavy metal pollution in the water (Analuddin *et al.* 2017). Moreover, this ecosystem is to mitigate and reduce the impact of global climate change (Adame *et al.* 2017; Phan *et al.* 2019; Sharma *et al.* 2020; Indrayani *et al.* 2021). It is because mangrove plays an important role to supply O_2, to absorb and to sequestrate CO_2 (Analuddin *et al.* 2020).

According to (Alongi and Mukhopadhyay 2015; Adame *et al.* 2017; Kauffman *et al.* 2020), mangrove ecosystem has ability to store a large amount of carbon. Some research found that mangrove ecosystem plays an important role to absorb blue carbon. (Analuddin *et al.* 2016a, 2020) found that mangrove species of *R. apiculata*, *R. mucronata*, *R. stylosa*, *C. tagal*, and *L. racemosa* in Southeast Sulawesi have potential as carbon stock. Meanwhile, Sasmito *et al.* (2020) has studied the potency of mangrove sedimen as carbon stock in West Papua.

The ability of mangrove ecosystem to sequestrate carbon could be known by above ground biomass estimation of some trees by an allometric model (Sutaryo 2009; Wijeyaratne and Liyanage 2020). Some recent research has been establishing allometric models of several mangrove species i.e *Sonneratia* spp. (Kusmana *et al.* 2018), *A. rotundifolia* (Siddique *et al.* 2012), *A. schaueriana* (Estrada *et al.*

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2014), *A. marina* (Clough *et al.* 1997; Comley and McGuinness 2005). In fact, there has been no data of allometric model to estimate aboveground biomass and carbon stock for *A. lanata* species. Meanwhile, this species is one of species which well thrives and regenerates naturally at derelicted pond in Southeast Sulawesi which is one of regions that is undergoing mangrove degradation because of land conversion.

Establishment of allometric model of *A. lanata* species for estimation of biomass and carbon stock is important to support conservation and mangrove ecosystem management. Moreover, this area could become carbon source for the region and a new habitat for several mangrove-associated organisms which have economic value.

2. Materials and Methods

2.1. Description of Site

This research was conducted in mangrove ecosystem at in-active pond of Muna Regency, Southeast Sulawesi (Figure 1). This pond has been left for over a decade. The natural regeneration of *A. lanata* occurs in these in-active pond. The vegetation of *A. lanata* was dominated by young category, and it was rare to find pole and tree at the location. The average of three height of *A. lanata* was <10m.

2.2. Procedures for Tree Cencuss and Allometric Model

The mangrove tree cencuss was conducted by transect and 5 quadrats with sized of 100 m^2 each. All individual trees in the quadratics were measured their DBH. The mangrove species was identified by guide book for Indonesia's mangroves (Noor 2006). The data collection for allometric model was according to Analuddin *et al.* (2016b, 2018, 2020) and Sutaryo (2009). A total of 13 individuals of *A. lanata* with various DBH sizes was collected. While DBH and D_{30} were measured. The samples were separated into stems, branches, and leaves and then weighted. The sample from each fresh organs were taken and brought to the Laboratory and then oven dried at 80°C for 7 days. The weight ratio of fresh and dry sample was used to estimate the dry weight samples.

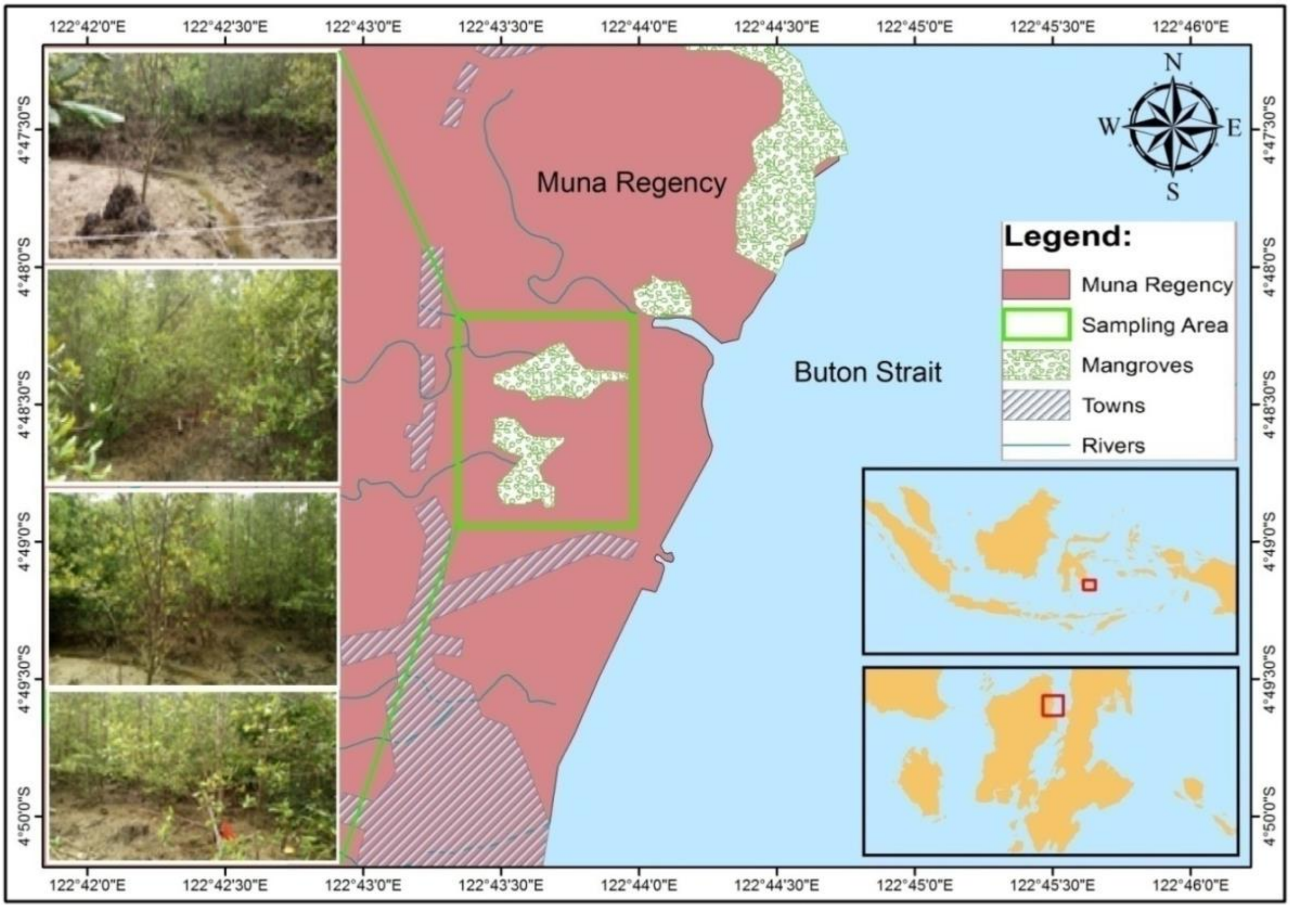

Figure 1. Map mangrove ecosystem of Muna Regency, Southeast Sulawesi. Green rectangular: study site

2.3. Data Analysis

2.3.1. Allometric Equation and Biomass Estimation

The allometric equation to estimate the biomass of each organ and total biomass of *A. lanata* was referred to Analuddin *et al.* (2016b, 2018, 2020) by DBH and D_{30}, variables. The biomass estimation of stems (Ws), branches (Wb), leaves (W*l*), and the total of biomass (W) were:

$$Ws = \sum_{i=1}^{n} Ws1 + Ws2 + Ws3 + \cdots . + Wsn \qquad \text{Eq.1}$$

$$Wb = \sum_{i=1}^{n} Wb1 + Wb2 + Wb3 + \cdots . + Wbn \qquad \text{Eq.2}$$

$$Wl = \sum_{i=1}^{n} Wl1 + Wl2 + Wl3 + \cdots . + Wln \qquad \text{Eq.3}$$

$$W = \sum_{i=1}^{n} Ws + Wb + Wl \qquad \text{Eq.4}$$

The stem biomass of each individual was symbolized by Ws1, Ws2, Ws3 till Wsn. The branches biomass of each individual was symbolized by Wb1, Wb2, Wb3 till Wbn. Meanwhile, the leaves biomass of each individu was symbolized by Wl1, Wl2 till Wln. The allometric model of all organs as well as each organ were written by $Y = g X^h$ or it could also be transformed into the following logarithmic form: $\log Y = \log g + (h \log X)$.

2.3.2.Carbon Stock Analysis and CO_2 Absorption

The carbon stock estimation of each organ of *A. lanata* mangrove was calculated by IPCC method (IPCC 2006) as follow:

$$\text{Carbon stock} = \text{Biomass} \times 0.47 \qquad \text{Eq.5}$$

The value of 0.47 was an carbon constanta in organic matter. The absorption of Carbon dioxide was calculated by an equation from Zulhalifah *et al.* (2021):

$$CO_2 \text{ Absorbtion} = Mr.CO / Ar.C \times \text{Carbon stock} \qquad \text{Eq.6}$$

3. Results

3.1. Allometric Equation for Estimation of Aboveground Biomass

Table 1. Allometric model to each organs of *Avicennia lanata*

Independent variable	Dependent variable	Coefficient values		R^2 values
		g	h	
D_{30}	Ws	0.0535	2.4851	0.9699
DBH		0.1143	2.3429	0.9870
D_{30}	Wb	0.0148	2.3869	0.8760
DBH		0.0304	2.2563	0.8960
D_{30}	W*l*	0.0201	2.1127	0.9380
DBH		0.0394	1.9734	0.9370
D_{30}	W	0.0862	2.4243	0.9743
DBH		0.1814	2.2825	0.9888

The allometric model of *A. lanata* showed various results in each organ both DBH and D_{30} variabel (Table 1). According to these data, the DBH variabel was suitable to estimate stem biomas (Ws) of *A. lanata.* It was caused by the acquired allometric model on stem organ (Ws) to DBH variable performed better results (coefficient *g*: 0.1143, coefficient *h*: 2.3429, R^2: 0,9870), if compared to D_{30} variable (coefficient *g*: 0.0535, coefficient *h*: 2.4851, R^2: 0.9699). The same results were also obtained to branch biomass estimation (Wb). The DBH variable (coefficient *g*: 0.0304, coefficient *h*: 2.2563, R^2: 0.8960) was more suitable compared to D_{30} variable (coefficient *g*: 0.0148, coefficient *h*: 2.3869, R^2: 0.8760). Meanwhile, the D_{30} variable was more suitable to estimate leaf biomass (Wl) of *A. lanata.*

It was caused by the allometric model which was obtained from leaf (W*l*) to this variable revealed better results (coefficient *g*: 0.0201, coefficient *h*: 2.1127, R^2: 0.9380), compared to the DBH variable (coefficient *g*: 0.0394, coefficient *h*: 1.9734, R^2: 0.9370).

For model of the total allometric (W), the DBH variable (coefficient *g*: 0.1814, coefficient *h*: 2.2825, R^2: 0.9888) was more suitable compared to the D_{30} variable (coefficient *g*: 0.0862, coefficient *h*: 2.4243, R^2: 0.9743) to estimate the total biomass of *A. lanata.* It is clerly shown in Table 1 as well as Figure 2.

3.2. Aboveground Biomass of Mangrove *A. lanata*

The aboveground biomass (AGB) of *A. lanata* is shown in Table 2.

According to the AGB data (Table 2), different result were obtained in each organ. The highest AGB total was in stem (28.18±3.48 Mg ha^{-1}). It was followed by branch (6.40±0.79 Mg ha^{-1}), and leaf (5.00±0.66 Mg ha^{-1}). The AGB total of all organs was 40.08±4.97 Mg ha^{-1}. It was because mangrove plants allocated higher percentage of biomass to their stems, compared to the branches and leaves (Figure 3).

The percentage of biomass allocation in each mangrove organ presents various results (Figure 3). Commonly, the percentage of biomass allocation was more allocated to stems (70.33±0.44%) than branches (15.93±0.04%) and leaves (12.46±0.39%).

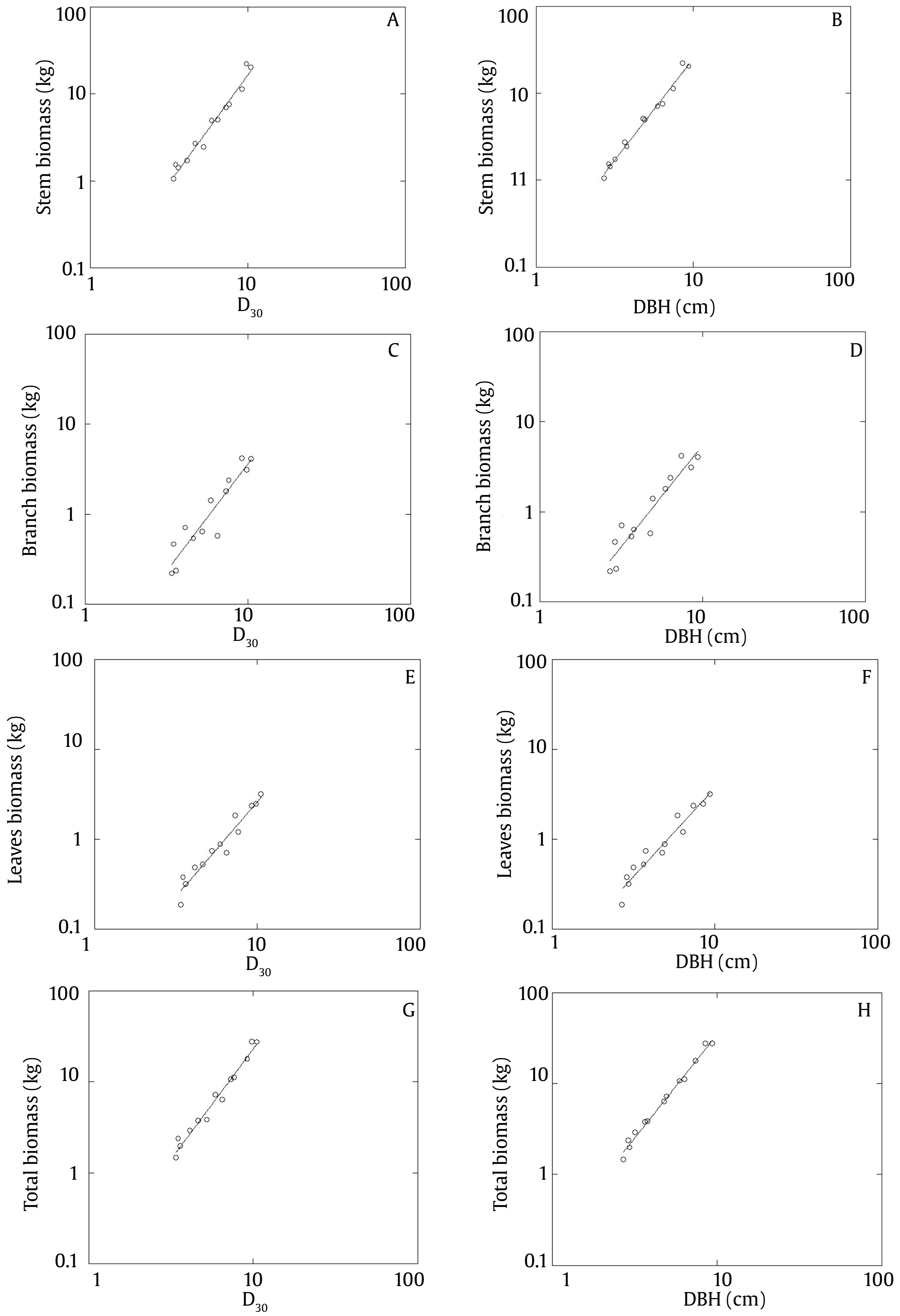

Figure 2. The relationship between stem diameter and biomass of each organ of *A. lanata* (A) D_{30} and stem biomass, (B) DBH and stem biomass, (C) D_{30} and branch biomass, (D) DBH and branch biomass, (E) D_{30} and leaves biomass, (F) DBH and leaves biomass, (G) D_{30} and total biomass, (H) DBH and total biomass

3.3. Carbon Stock and CO_2 Absorption by *A. lanata*

Carbon stock of *A. lanata* shows differences between stem, branch, and leaf. Besides, the absorption ability varies in mangrove stands which is shown in the following table (Table 3).

The highest total of carbon stock (Table 3) was in stem (13.24±1.63 Mg C ha^{-1}) if compared to branches (3.01±0.37 Mg C ha^{-1}), as well as leaves (2.35±0.31 Mg C ha^{-1}). The total of carbon stock for all organs was 18.83±2.33 Mg C ha^{-1}. The carbon stock on each organ (Table 3) was linear with the AGB (Table 2). In this reseach, the AGB value will be followed by a high carbon stock value.

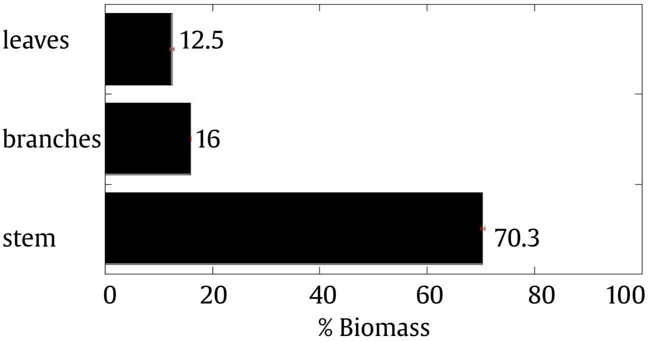

Figure 3. Percentage of biomass allocation of *A. lanata*

4. Discussion

4.1. Allometric Equation for Estimation of AGB of *Avicennia lanata*

Based on the Table 1 and Figure 2, the better allometric model for biomass estimation of *A. lanata* was allometric total (W) with DBH variable ($0.1814 \times DBH^{2.2825}$, $R^2 = 0.9888$, $n = 13$). It was because the R^2 value that used DBH variable had high value. This allometric model was aplicable for biomass and carbon stock estimation of mangrove vegetation for the same species and DBH range. Smith and Whelan (2006) also found the DBH was a better variable to estimate the biomass than stem height.

In Indonesia, the allometric model was established by Analuddin *et al.* (2018, 2020) who utilized DBH variable for *R. apiculata, R. mucronata, C. tagal, R. stylosa,* and *L. racemosa* at the conservation area of TNRAW, Southeast Sulawesi. Kusmana *et al.* (2018) also established the allometric model by using DBH, tree heigh, and wood density variables for *Sonneratia* spp. at mangrove ecosystem of Cilacap, Central Java.

Some recent studies already develops allometric model for various mangrove species. The comparsion of allometric model for several mangrove species can be seen in Table 4.

Table 2. Trend of aboveground biomass of mangrove *A. lanata*

	DBH (cm)	Total density (ind/ha^{-1})	Steam biomass (Mg ha^{-1})	Branches biomass (Mg ha^{-1})	Leaves biomass (Mg ha^{-1})	Aboveground biomass (Mg ha^{-1})
Max	9.3949		32.82	7.41	5.68	46.46
Min	2.7070		24.10	5.52	4.00	33.97
Average±stdev	5.12±2.24	5080	28.18±3.48	6.40±0.79	5.00±0.66	40.08±4.97

Table 3. Carbon stock and CO_2 absorption by *A. lanata*

	Steam C (Mg CO_2 ha^{-1})	Branch C (Mg CO_2 ha^{-1})	Leaves C (Mg CO_2 ha^{-1})	Total C (Mg CO_2 ha^{-1})	Absorption of CO_2 (Mg CO_2 ha^{-1})
Max	15.42	3.48	2.67	21.83	50.95
Min	11.33	2.54	1.88	15.96	37.25
Average±stdev	13.24±1.63	3.01±0.37	2.35±0.31	18.83±2.33	43.95±5.45

Table 4. Several allometric models for mangroves based on DBH

Mangroves species	Location	Allometric equation	References
A. lanata	Muna Island, Southeast Sulawesi, Indonesia	$W_{top} = 0.1814\ DBH^{2.2825}$ $R^2 = 0.98$, n = 13	This study
R. mocronata	Gazi bay, Kenya	$y = -0.8069\ DBH^{2.5154}$ $R^2 = 0.98$, n = 15	Kirui *et al.* (2006)
R. mangle	Sao Fransisco river, Brazil	$W_{top} = 5.534\ DBH^{2.404}$ $R^2 = 0.99$, n = 74	Santos *et al.* (2017)
R. apiculata	Southern Vietnam	$W_{total} = 0.383\ DBH^{2.234}$ $R^2 = 0.97$, n = 36	Vinh *et al.* (2019)
R. stylosa	Southeast Sulawesi, Indonesia	$W_{top} = 0.1579DBH\ 2.593$ $R^2 = 0.98$, n = 8	Analuddin *et al.* (2020)
B. gymnorrhiza	Hinchinbrook Island	$W_{top} = 0.186\ DBH^{2.31}$ $R^2 = 0.99$, n = 17	Clough and Scott (1989)
C. decandra	Sundarbans, Banglades	$y = 4.70x^{2.41}$ $R^2 = 0.97$	Hossain *et al.* (2012)
Sonneratia spp.	Cilacap, Indonesia	$W = 0.258\ DBH^{2.287}$ $R^2 = 0.91$, n = 30	Kusmana *et al.* (2018)
A. marina	Northern Australia	$W_{top} = 0.308\ DBH^{2.113}$ $R^2 = 0.97$, n = 22	Comley and McGuinness (2005)
A. marina	North-western Australia	$W_{top} = -0.750\ DBH^{2.299}$ $R^2 = 0.96$, n = 23	Clough *et al.* (1997)
A. schaueriana	Brazil	$AGB = 123.8716^{*}\ DBH^{2.5282}$, $R^2 = 0.99$, n = 53	Estrada et al. (2014)

The allometric model which was established in this research was allometric model by DBH for *A. lanata*. This mangrove species grew and developed to be a pure formation/monospecific on the research location for more than 10 years. The vegetation structure was dominated by weaning mangrove (DBH <10 cm). Therefore, this allometric model was aplicable to estimate the biomass of the same mangrove species as well as the same DBH range.

4.2. Aboveground Biomass of Mangrove *A. lanata*

To understand the role of mangrove on mitigating the global climate change, it is necessary to estimate the AGB of mangrove (Suwa *et al.* 2020). Several previous studies have conducted research on the estimation of AGB for several mangrove species. Cuc and Thi Hien (2020) found that the AGB total of *K. obovata* was 111.94±15.74 Mg ha^{-1} in the mangrove plantation area, Northern Vietnam. It was higher than this study. It was due to the age of these mangrove plantation which was about 20 years. Another part of Southeast Sulawesi's mangrove, Hasidu *et al.* (2021) found highest AGB (77.73 Mg ha^{-1}–226.76 Mg ha^{-1}) with 5 mangrove species, and various DBH size. Beside that, Analuddin *et al.* (2015; 2018; 2020) also found a high result than this study. The AGB total for mangrove species of *R. apiculata, R. mucronata, R. stylosa, C. tagal*, and *L. racemosa* were 651.60 Mg ha^{-1}, 232.11 Mg ha^{-1}, 365.57 Mg ha^{-1}, 162.61 Mg ha^{-1}, and 109.77 Mg ha^{-1} respectively. The high value of AGB total obtained is due to the fact that these study site is in the conservation area of Rawa Aopa Watumohai National Park as assumed that mangrove conditioan was still maintained and had not been degraded. Asadi and Pambudi (2020) were also found the highest biomass (533.1±566.7 Mg ha^{-1}) in the conservation area of Baluran National Park.

Meanwhile, Nam *et al.* (2016) found AGB which has not significant different between mangrove plantation area of CGMBR (130.55±15.5 Mg ha^{-1}), and natural regeneration area of KPVF (146.7±20.2 Mg ha^{-1}), Mekong Delta, Vietnam. The highest carbon stock both mangrove area because these two mangrove area was restored and natural regenerated for more than 35 years.

In general, the each-organ AGB as well as the AGB total gained in this study was lower than several recent study (Table 5). It was the research location was an in-active pond area. It is supported by Hasidu *et al.* (2020), who stated that some mangrove area in Southeast Sulawesi has been degraded for various purposes. Moreover, the vegetation condition in this site was still classified into natural regeneration for just ±10 years. Therefore, its vegetation structure was composed by young stand (DBH <10cm). There was not mangrove pole and tree. The difference of AGB was also probably because of a different environmental condition, species composition, vegetation characteristic, habitat, geographical position, climate (Komiyama *et al.* 2008), seasonality that affect the presence of reproductive parts of mangrove (Soares and Schaeffer-Novelli 2005), structure and age of mangrove, and nutrient (Analuddin *et al.* 2016b).

Some recent studies of aboveground biomass for various mangrove species (Table 5). The comparsion of aboveground biomass for several mangrove species can be seen in Table 5.

The percentage of biomass allocation in each mangrove organ presents various results (Figure 3). Commonly, the percentage of biomass allocation was more allocated to stems than branches and leaves. The same result was obtained by (Chandra *et al.* 2011) for *R. apiculata* in which the highest percentage of biomass was more to stems (57.30%) than branches (35.09%) and leaves (7.61%). It was similar to Analuddin *et al.* (2016b). The highest percentage of biomass allocation of *L. racemosa* was in the stem, than other organs. Meanwhile, Analuddin *et al.* (2018) found different biomass allocation between *R. apiculata, R. mucronata,* and *C. tagal* mangrove species, both protected and unprotected mangrove area. But generaly, the highest biomass allocation of those 3 mangrove species was in the stem, than branch as well as leaf.

4.3. Carbon Stock and CO$_2$ Absorption by *A. lanata*

The total of carbon stock which obtained in this research tends to be smaller than another research. Indrayani *et al.* (2021) found that carbon stock of several mangrove species in Demta Bay, Papua, was much higher. These species was *R. apiculata* (100.81 Mg C ha^{-1}), *R. mucronata* (61.25 Mg C ha^{-1}), and *B. gymorrhiza* (47.14 Mg C ha^{-1}). Nam *et al.* (2016) also found that aboveground carbon stock on *R. apiculata* was 71.8±4.8 Mg C ha^{-1}. The high value of carbon stock is because *R. apiculata* has biger DBH structure (mean

Table 5. Compartion of aboveground biomass in several mangrove species

Location	Species	Steam biomass (Mg ha^{-1})	Branches biomass (Mg ha^{-1})	Leaves biomass (Mg ha^{-1})	AGB (Mg ha^{-1})	References
Southeast sulawesi, Indonesia	*A. lanata*	28.18±3.48	6.40±0.79	5.00±0.66	40.08±4.97	This study
RAW National Park, Indonesia	*R. apiculata*	502.08	131.57	17.95	651.60	Analuddin *et al.* (2018)
	R. mucronata	132.56	92.51	15.02	232.11	
	C. tagal	106.59	41.06	10.24	162.61	
	R. stylosa	227.24	65.88	22.45	365.57*	Analuddin *et al.* (2020)
	L. racemosa	76.16	25.24	8.76	109.77	Analuddin *et al.* (2015)
Sarawak, Malaysia	*R. apiculata*	73.05	37.24	6.50	116.79	(Chandra *et al.* (2011)
Southeast coast of India	*A. marina*	2.38-25.93	1.21-8.65	0.52-11.31	29.76	Prasanna *et al.* (2014)
Northern Vietnam	*K. obovata*	98.19**		11.73***	111.94	Cuc and Hien (2020)
Mekong Delta	*R. apiculata* (99% dominated)				152.7±10.2	Nam *et al.* (2016)
Columbian Pacific (Quebrada, Valencia)	*Rhizophora* spp.				142.46	Peñaranda *et al.* (2019)
Cayo Culebra	*R. mangle* (96% dominated)				144.9 (SE: 23.5)	Adame *et al.* (2013)
Jor Bay, East Lombok, Indonesia	*S. alba*				907.52	Zulhalifah *et al.* (2021)
	S. caseolaris				127.26	
Kerala, Southwest coast of India	*S. alba*				0.61	Harishma *et al.* (2020)
	A. marina				162.18	
Ajuruteua Peninsula, Brazilian Amazon coast	*A. germinans*				66.14±2.98	Virgulino-Júnior *et al.* (2020)
Delta Kelantan, Peninsular, Malaysia	*A.marina*				112.19	Rozainah *et al.* (2018)

*without prop root, **stem and branch, ***leaf and propagule, SE: standar error

DBH = 14.6 cm (min 5.1 cm–max 19.9 cm)) compared with the object of this research (DBH <10 cm, Table 3). Moreover, the AGB total value (152.7±10.2 Mg ha^{-1}) was also higher than AGB total of this research which was 40.08±4.973 Mg ha^{-1} (Table 4). Meanwhile, Harishma *et al.* (2020) revealed that carbon stock of vegetation was 58.56 Mg C ha, with the higher DBH size was around 15.61±0.28 cm–30.34±1.66 cm in mangrove area of Kerala, Southwest India. Asadi and Pambudi (2020) were also found the highest carbon stock (239.8±256.9 Mg C ha^{-1}) in the conservation area of Baluran National Park, Indonesia. This is due to the fact that these study site is in the conservation area of BN Park as assumed that mangrove conditioan was still maintained and had not been degraded. In this research, the DBH size and AGB value will affect the total of carbon stock. The carbon stock will increase if the DBH size and the total of AGB also increase.

The CO_2 absorption by *A. lanata* was 43.9549±5.4551 Mg CO_2 ha^{-1} (Table 3). This result figured out that this ecosystem has sufficient ability in absorbing CO_2 emission from the air, and sequestrating it into biomass form. The absorption of CO_2 by *A. lanata* in this research was much higher than the CO_2 absorption of *L. racemosa* which was found by Zulhalifah *et al.* (2021) which was 29.35 Mg CO_2 ha^{-1}. It is because this species was not dominating in the ecosystem, so that the biomass value of *L. racemosa* was not too high (15.99 Mg ha^{-1}). Meanwhile, the *S. alba* has more ability to absorb CO_2 emission. it was 1665.30 Mg CO_2 ha^{-1}. These highest value of CO_2 absorption was linear with the number of individuals invented (232 individual), volume (66.49 m^3 ha), as well as AGB (907.52 Mg ha^{-1}) (Zulhalifah *et al.* 2021). The same result has been found by Indrayani *et al.* (2021) who revealed that the average CO_2 emission from the atmospheric at mangrove ecosystem of Demta Bay was 319.37±124.92 Mg CO_2 ha^{-1}. Harishma *et al.* (2020) also found the similar result in which the CO_2 absorption (513.13 Mg CO_2/ha) was much higher than this research. This high result was supported by vegetation structure as well as species composition that was more varied than this research. The vegetation composition in this research was only composed by 1 species (monospecific), with less than 10 cm DBH size.

Mangrove ecosystem in this research has undergone a land use change into pond. Thus it causing lossing of ecosystem services as carbon sequester (Bryan *et al.* 2020). However the last few years, these pond was in-active, thus it gives an opportunity for *A. lanata* mangrove to regenerated naturally. These vegetation was potential as absorber and sequester for biomass and carbon, although the vegetation was still on the early growing stage. Sasmito *et al.* (2019) states that to replace the lost of biomass and carbon stock due to land use and land cover change, it needs 15 until 40 years for regenerating. Thus, it needs conservation as well as management effort to support the ecosystem services (Analuddin *et al.* 2021). This was essential to prevent damage which cause CO_2 emission into the atmosphere. Carbon dioxide (CO_2) is one of the GHGs group, beside Methane (CH_4), Nitrit oxide (N_2O), and other primary GHGs which are causing global warming and global climate change (Farmer and Cook 2012). It is supported by Kauffman *et al.* (2020), Sidik and Lovelock (2013) who proved that the loss of mangrove area has contributed to GHGs emission and global climate change.

In conclusion, DBH variable was good for the allometric model. The allometric model which was used for total biomass estimation was $W_{top} = 0.1814\ DBH^{2.2825}$ $R^2 = 0.98$, n = 13. The AGB total was 40.0804±4.9743 Mg ha^{-1} and the highest biomass allocation was to stems then followed by branches and leaves. Moreover, the total of carbon stock of stems was higher than carbon stock of branches and leaves. The mangrove vegetation of *A. lanata* in this area has potency to be absorber and sequester of biomass and carbon eventhough the vegetation was still on the early growing stage. Accordingly, it needs conservation, management to support the ecosystem to become not only biomass sequester but also a habitat for various associated-mangrove organisms.

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