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Short-Communication

The Estimation of Biomass in *Rhizophora apiculata* and *Rhizophora mucronata* in Tuamese Village, North Central Timor Regency, East Nusa Tenggara Province

Ludgardis Ledheng[1,*], Yolanda Getrudis Naisumu[2], Remigius Binsasi[2]

[1] Study Program of Biology Education, Faculty of Education Sciences, Universitas Timor. Jl. El Tari Km. 9, Kefamenanu, 85613, Nusa Tenggara Timur, Indonesia
[2] Study Program of Biology, Faculty of Agriculture, Universitas Timor. Jl. El Tari Km. 9, Kefamenanu, 85613, Nusa Tenggara Timur, Indonesia
* Corresponding Author. E-mail address: ludgardisledheng12@gmail.com

ABSTRACT

Mangrove forest in North Central Timor Regency is dominated by *Rhizophora* sp. The highest number was found in Tuamese Village, namely *Rhizophora apiculata* and *Rhizophora mucronata*. The biomass productivity in mangrove forests varies according to age, dominant species, and locality. It shows differences in carbon uptake and storage at the level, type, and place of growth. This study aimed to analyze the carbon content and carbon uptake of *R. apiculata* and *R. mucronata* at the stake level to the tree level in two plots with the size of 2,000 m^2 each. The method used was allometric equations, while the power discrimination test used an independent sample t-test. The result showed that *R. apiculata* and *R. mucronata* had the same potential in producing biomass and necromass as well as in storing and absorbing carbon. The total biomass was 77.21 Mg/ha, which can absorb and store carbon, respectively, 141.68 Mg/ha and 36.61 Mg/ha. This research data provides an overview of the potential of biomass in meeting carbon trading standards as an effort to succeed in mangrove conservation in Tuamese Village.

1. Introduction

The total mangrove forests in North Central Timor Regency, East Nusa Tenggara Province, is 298.26 ha (Ledheng et al. 2012). *Rhizophora* sp. dominated this forest stands at the sapling and seedling strata with the important value index (IVI) of 106.93% and 50.02%. In comparison, *Bruguiera* sp. dominated the tree and the pole level with the IVI of 79.49% and 99.88%, respectively (Ledheng et al. 2012). The intense pressure on the tree strata every year has caused the growth and the development of *Bruguiera* sp. to be threatened (Ledheng et al. 2012). A study by Ledheng et al. (2020) in North Central Timor Regency found four mangrove species, namely *Rhizophora apiculata*, *Rhizophora mucronata*, *Sonneratia alba,* and *Avicennia marina*. The results indicated that there had been a change in the dominance and the extinction of *Bruguiera* sp. The damage and the disruption to the growth strata are the obstacles to the tree regeneration process where young trees will replace the mature trees (Heriyanto and Subiandono 2012). Ledheng et al. (2020) found *R. apiculata* and *R. mucronata* at the sapling to tree strata in Tuamese village, North Central Timor Regency. These species were the dominant *Rhizophora's* genus in

the mangrove forest area because they have the characteristics of the hypocotyl that has germinated while still in the trees. Therefore, these species are relatively easier to breed for revegetation in the coastal areas (Irawan et al. 2013).

Concerning the mitigation of global warming, the mangrove forest in Tuamese Village has a role in reducing the release of carbon into the air. Therefore, it is vital to suppress the release of carbon as low as possible and optimize the amount of carbon uptake by the forest, where the carbon absorbed could be stored in the stems, leaves, roots, and the most significant carbon store is in the stems (Nurruhwati et al. 2018). However, the productivity of mangrove forest biomass varies according to age, dominant species, and location (Qiu et al. 2011). In other words, the stand carbon potential is different at the growth level, species, and the place of growth. For example, *R. mucronata* generally grows in the group on tidal river embankments and in the estuary so that it grows more towards the sea. Meanwhile, *R. apiculata* lives side by side with *R. mucronata* but grows more towards the mainland (Jumiati 2008). Therefore, this study aimed to determine the carbon content and the CO_2 uptake of *R. apiculata* and *R. mucronata* stands in Tuamese Village.

2. Materials and Methods

2.1. Research Location

The research was carried out from October 2020 – January 2021 in the mangrove forest of Tuamese Village, Biboki Anleu District, North Central Timor Regency, East Nusa Tenggara Province. The research samples were taken at two location points (**Fig. 1**). The first location is dominated by *R. apiculata* (9°3'45.62" S; 124°42'38.05" E), while the second location is dominated by *R. Mucronata* (9°3'34.38" S; 124°42'58.66" E).
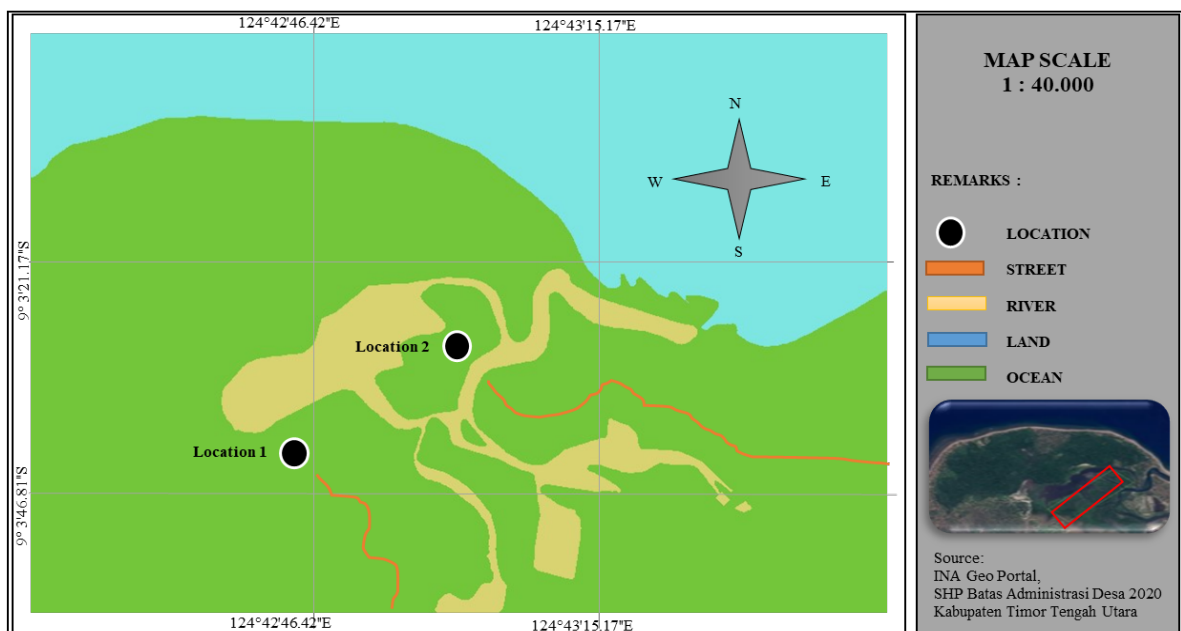

Fig 1. Research location.

2.2. Materials

The tools and materials used were roll meters (50 m), plastic ropes, the stake of diameter at breast height (1.3 m), machetes, observation forms, and the 30 observation specimens for each tree species.

2.3. Data Collection

Two large plots of 2,000 m² consisting of one sub-plot measuring 200 m² were developed (**Fig. 2**). The observation of biomass and necromass was carried out on the trees with diameters > 5 cm to 30 cm. In addition, the trunk diameter was measured at a breast height of 1.3 m (**Fig. 3**).
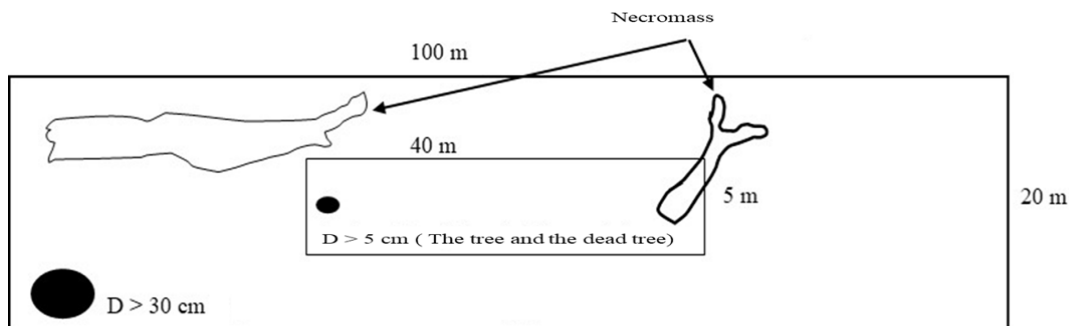

Fig. 2. Plot shape and size for each diameter group.
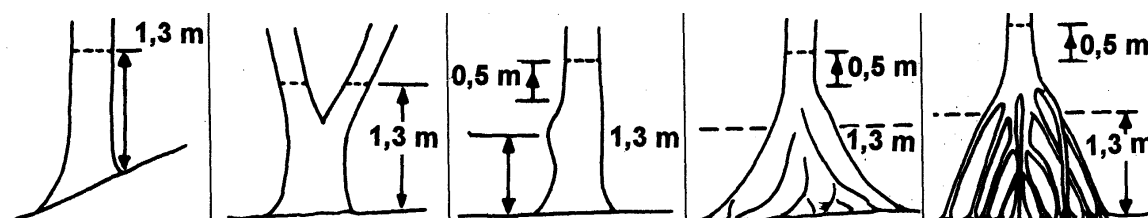

Fig. 3. The position of diameter measurement (Weyerhaeuser and Tennigkeit 2000).

2.4. Data Analysis

2.4.1. Biomass

The biomass calculation in *R. apiculata* used equation 1 (Amira 2008), while in *R. mucronata* used equation 2 (Dharmawan 2010).

$$B = 0.043 \times D^{2.63} \tag{1}$$

$$B = 0.1466 \times D^{23136} \tag{2}$$

where *B* is biomass (Mg/ha) and *D* is diameter at breast height (cm).

2.4.2. Necromass

The calculation of necromass used the allometric formula developed by Hairiah and Rahayu (2007).

$$N = \pi \times \rho \times \left(\frac{dbh}{40}\right)^2 \times t \times f \tag{3}$$

where *N* is necromass (kg), *t* is tree height (cm), *f* is the constant value (0.6).

2.4.3. Carbon content

The carbon content is calculated based on the biomass data. The carbon content was calculated using equation 4 (Dharmawan 2010).

$$C = B \times 0.5 \tag{4}$$

where C is the carbon content (Mg/ha), B is biomass (Mg/ha), and 0.5 is the conversion factor value.

2.4.4. Carbon dioxide uptake

The carbon dioxide (CO_2) uptake (Mg/ha) was calculated using the formula of Dharmawan (2010).

$$CO_2 \ Uptake = 3.7 \ \times C \tag{5}$$

where 3.7 is a constant and C is the carbon content (Mg/ha).

After acquiring the data of biomass, carbon content, and CO_2 uptake, the t-test was conducted to determine the differences between *R. apiculata* and *R. mucronata*.

3. Results and Discussion

3.1. Biomass, Carbon Content, and CO_2 Uptake

Table 1 shows that the biomass of *R. apiculata* was 39.42 Mg/ha and could store and absorb the carbon of 19.71 Mg/ha and 72.33 Mg/ha, respectively. The value of CO_2 uptake of *R. apiculata* was equal to 482.2 kg/tree, which is higher than the CO_2 uptake of *R. apiculata* in Gampong Jawa and Lambaro Banda Aceh of 4.03 kg/tree (Dewiyanti et al. 2019). The higher CO_2 uptake of *R. apiculata* in Tuamese Village was due to higher tree diameter than in Gampong Jawa and Lambaro Banda Aceh. The biomass content of *R. mucronata* was 37.79 Mg/ha, which could store and absorb carbon of 18.90 Mg/ha and 69.35 Mg/ha, respectively (**Table 1**). The CO_2 uptake of *R. mucronata* in Tuamese Village was higher than in Oebelo, Kupang Regency of 48.75 Mg/ha (Manafe et al. 2016), and in Ciasem Purwakarta of 0.14 Mg/ha (Dharmawan 2010).

Table 1. Biomass, carbon content, and CO_2 uptake

Species	Biomass (Mg/ha)	Carbon content (Mg/ha)	CO_2 uptake (Mg/ha)
R. apiculata	39.42 a	19.71 a	72.33 a
R. mucronata	37.79 a	18.90 a	69.35 a
Total	38.61	19.30	70.84

Note: Numbers followed by the same notation showed no significant difference according to the t-test at the significant level $\alpha = 0.05$.

Rahim et al. (2018) reported that the CO_2 uptake of *R. mucronata* reached 31.97 Mg/ha, higher than the CO_2 uptake of *Ceriops tagal* at 0.48 Mg/ha in the two tree samples. On the other hand, the CO_2 uptake of *C. tagal* was lower than that of *A. marina,* which amounted to one tree. Therefore, the number of individual plants does not always have a high CO_2 uptake but is also affected by tree diameter. Heriyanto and Subiandono (2012) stated that the absorbed carbon is converted into energy for photosynthesis and enters the plant structure into cellulose which makes up the stem organs. Plants then use the tree growth through photosynthesis to grow horizontally and vertically. Therefore, the larger the diameter, the bigger the biomass storage resulting from CO_2 conversion and the increase in CO_2 absorbed by plants. However, the results of the t-test on biomass, carbon content, and CO_2 uptake did not show differences (**Table 2**).

Table 2. T-test analysis between *R. apiculata* and *R. mucronata*

Parameter	Sig. (2-tailed).
Biomass	0.58
Carbon content	0.64
CO_2 uptake	0.59

The ability of the mangrove forest to absorb and store carbon is highly dependent on the soil and climatic conditions. According to Heriyanto and Subiandono (2012), biomass production in mangrove forests is strongly affected by soil fertility. Therefore, *R. apiculata* and *R. mucronata* growth are influenced by the condition of the base substrate as a nutrient provider for plants. These species are generally found in slightly sandy loamy sediments. The environmental conditions of *R. apiculata* and *R. mucronata* in Tuamese Village is presented in **Table 3**.

Table 3. Environmental parameters

Parameters	Station	
	R. mucronata	*R. apiculata*
Temperature (C)	29.22	28.87
pH	7.60	7.50
Salinity (‰)	30	30
pH sediment	8.50	8.55
C-Organic (%)	3.39	4.04
N Total (%)	0.07	0.03
P Availability (ppm)	28.78	44.47
K Availability (ppm)	671.42	624.77
Texture: Sand	56.39	47.24
Dust	33.63	39.33
Clay	25.42	29.87
The Class of Sediment Texture	Sandy Clay	Sandy Clay

Source: Ledheng et al. (2012).

R. apiculata and *R. mucronata* in Tuamese Village generally have similar physical and chemical characteristics such as temperature, pH, salinity, sediment pH, and substrate characteristics to adapt well. Mustika et al. (2014) also stated that the adaptability and the tolerance to the environment greatly influenced the growth of *R. apiculata* in Muara Village, Teluk Naga District, Tangerang, Banten.

According to the Regional Government of North Central Timor (2016), the location of mangroves in Tuamese Village is a conservation area. Therefore, the planting pattern followed the development of conservation forests. Based on several factors, namely the sediment and the ecological suitability, the planting time and spacing in the conservation area also affect the growth of the two species. Dewiyanti et al. (2019) reported similar results, stating that CO_2 uptake of *R. apiculata* and *R. mucronata* in the Gampong Java and Lambaro mangrove areas in Banda Aceh was influenced by the planting time and spacing for each species. Plant spacing is essential in providing optimal growth space for mangrove growth because it affects light, nutrients, water, and CO_2.

The distribution of diameter sizes at the two observation locations is not much different. The average diameter of *R. apiculata* was 27.20 cm, while that of *R. mucronata* was 24.63 cm. The average diameter observed was higher than the observations of *R. apiculata* and *R. mucronata* in Tarjun Village, South Kalimantan (Ariani et al. 2016), which were 21 cm and 19 cm, respectively. The distribution of diameters is presented in **Fig. 4.**
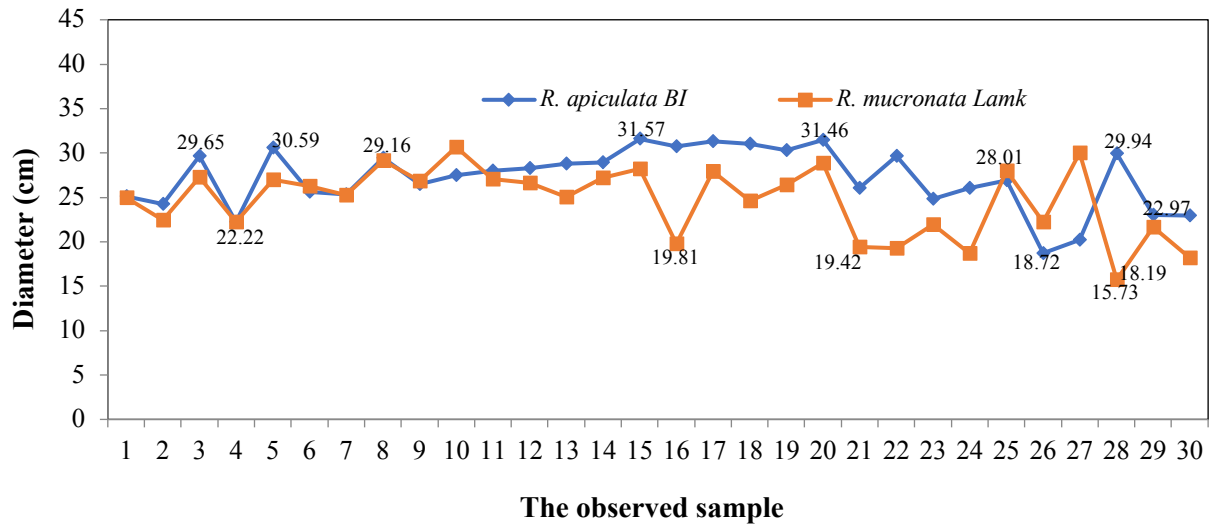
Fig. 4. The diameter size of *R. apiculata* and *R. mucronata*.

The result of the t-test did not show any difference in the diameter size between *R. apiculata* and *R. mucronata*. The similarity in diameter growth might be due to the similarity of the basic substrate in the observation area, which affects the supply of plant nutrients. It was reported that the increase in the average diameter of *R. apiculata* was strongly influenced by soil organic matter content (Herpinawati et al. 2010). The relationship between the number of individuals and the observed diameter class is presented in **Fig. 5** and **Fig. 6,** respectively.
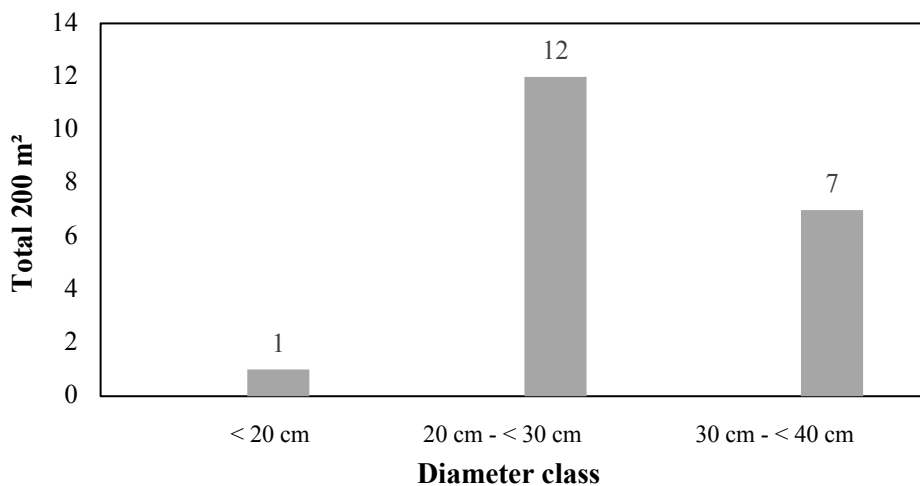
Fig. 5. The diameter class distribution of *R. apiculata*.

Based on the diameter class in **Fig. 5** and **Fig. 6**, the observation locations were included in a less normal regeneration condition because the number of individuals in the diameter class < 20 cm in *R. apiculata* and *R. mucronata* were fewer than those in the 20-30 cm diameter class. However, the diameter class of 20-30 cm to > 30 cm showed normal regeneration, characterized by fewer individuals as the diameter class increased. It might be due to the logging activities in the

classes, which were smaller than 20 cm in diameter for firewood purposes because, at the observation site, the mangrove logging activities were found to be used as firewood. It was reported that the demands of the coastal communities influenced the activities and the damage to mangrove forests in TTU Regency to fulfill their firewood needs (Ledheng et al. 2012).
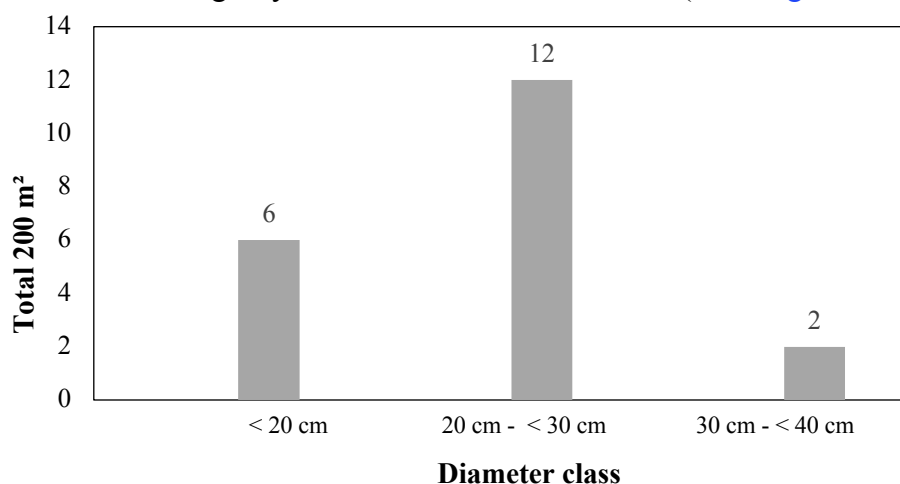
Fig. 6. The diameter class distribution of *R. mucronata*.

3.2. Necromass

The calculation of necromass began with measuring the diameter and height of dead trees. The result showed that the dead tree of *R. apiculata* with a height of 3.64 m and a diameter of 35.72 cm had a necromass of 3.06 kg and could store and absorb carbon as much as 1.53 kg and 5.62 kg, respectively. The result of this observation was greater than the necromass of the dead trees, with a height of 4.16 m and a diameter of 28.72 cm. It was found that a total of 2.26 kg could store and absorb carbon of 1.13 kg and 4.13 kg, respectively. This observation data showed that the difference in the height of dead trees did not affect the necromass content but was influenced by the diameter. The observation of the dead tree in *R. mucronata* with a height of 6.63 m and a diameter of 27.05 cm had a necromass of 3.20 kg and could store and absorb carbon of 1.60 kg and 5.87 kg, respectively. This necromass value was higher than the necromass in the dead trees with other heights and diameters. The necromass values are presented in **Table 4**.

Table 4. Necromass at the observation site

Location	Height (cm)	Dbh (cm)	Biomass (kg)	Carbon content (kg)	CO_2 uptake (kg)
1	3.64	35.72	3.06	1.53	5.62
	4.52	28.29	2.39	1.19	4.38
	4.16	28.72	2.26	1.13	4.15
Total			7.71a	3.85a	14.14a
2	6.63	27.05	3.20	1.60	5.87
	5.21	25.20	2.18	1.09	4.00
	4.50	23.45	1.63	0.82	2.99
Total			7.01a	3.51a	12.87a

Note: Numbers followed by the same notation do not differ according to the t-test at significant level $\alpha = 0.05$.

The dead trees of *R. apiculata* stored and absorbed carbon of 3.85 kg and 14.14 kg, respectively (**Table 4**). The dead tree of *R. mucronata* stored and absorbed carbon by 3.51 kg and 12.87 kg, respectively. It illustrates that the larger the diameter, the higher the necromass content in the dead trees. Therefore, the dead trees with large diameters store and absorb more carbon (Ariani et al. 2016). However, the result of the t-test did not show any difference in the necromass, carbon content, and CO_2 uptake. It is suspected that the dead tree samples found in the observation site generally had a similar shape, so the value of the form factor also influences. The necromass of the dead trees at each location was analyzed using a correction value of 0.60 (National Standardization Agency, 2011). The result of the t-test is presented in **Table 5**.

Table 5. The t-test result of dead tree carbon storage

Parameter	Sig. (2-tailed)
Necromass	0.68
Carbon content	0.69
CO_2 uptake	0.68

The carbon content and CO_2 uptake of the dead trees as a whole were 7.36 kg and 26.90 kg, which were lower than that observed in the mangrove area of Tarjun Village, South Kalimantan (Ariani et al. 2016), showing the carbon content and CO_2 uptake of 22.20 kg and 81.4 kg. Mughofar et al. (2018) reported the presence of *R. mucronata* in the coastline zone (the area directly facing the sea) and the presence of *R. apiculata* in the middle zone (an area located behind the coastline zone). Therefore, the presence of the dead trees from zoning is also influenced by the tidal movements of seawater. The number of different dead trees in this study is thought to be due to the influence of waves hitting the mangroves in the shoreline zone. It has caused the age of the mangroves in that zone to be younger than the zone behind the coastline resulting in the mangroves in that area cannot adapt to the extreme tidal conditions so that the dead stands were found in the coastline zone. **Table 4** shows that the diameter of trees killed by *R. mucronata* was smaller than that of *R. apiculata*. It has been demonstrated that *R. mucronata* stands were younger and had less wave resistance, making them easy to break and die. Meanwhile, the location of *R. apiculata* stands was close to the settlements, which caused the trees' stems and branches to be cut down more often for the home industry purposes. At the observation site, it was found to make the table salt by a group of people using wood fuel.

3.3. *Above-Ground Biomass*

The above-ground biomass (AGB) is the total observed biomass above the ground level. This study observed the tree trunk biomass and the dead tree necromass. The results of AGB are presented in **Table 6**.

Table 6. Above-ground biomass (Mg/ha)

Species	Biomass		Carbon content		CO_2 uptake	
	Tree	Necromass	Tree	Necromass	Tree	Necromass
R. apiculata	39.42	0.04	19.71	0.02	72.33	0.07
R. mucronata	37.79	0.03	18.90	0.02	69.35	0.06
Total	77.28		38.64		141.81	

The AGB value reached 77.21 Mg/ha and could store and absorb carbon of 38.61 Mg/ha and 141.68 Mg/ha, respectively. This observation result was greater than the AGB value of the wildlife reserve, Karang Gading, North Sumatra, which was 9.05 Mg/ha with a carbon content of 4.25 Mg/ha (Barus and Kuswanda 2016) in an area of 6,000 m^2. According to Golden Agri-Resources (2012), the forest with an estimated carbon of approximately 192 Mg/ha is categorized into the high-density forests; the medium density forests has an estimated carbon of 166 Mg/ha, while the low-density forest has an estimated carbon of less than or equal to 107 Mg/ha.

4. Conclusions

The results of the t-test on diameter, biomass, carbon content, and the CO_2 uptake of *R. apiculata* and *R. mucronata* in Tuamese Village were not significantly different. It shows that *R. apiculata* and *R. mucronata* in the sapling to tree growth strata have the same potential to store and absorb the carbon. The total biomass was 77.21 Mg/ha, which could store and absorb 36.61 Mg/ha and 141.68 Mg/ha, respectively. The result of this study has provided an overview of the biomass and carbon potential of the dominant species in the mangrove area in Tuamese village. Therefore, it can be used to measure the achievement of the economic value of environmental services in actualizing the success of the conservation.

References

Amira, S. 2008. *Pendugaan Biomassa Jenis Rhizophora apiculata Bl. di Hutan Mangrove Batu Ampar Kabupaten Kubu Raya, Kalimantan Barat*. Skripsi. Institut Pertanian Bogor. Bogor

Ariani, E., Ruslan, M., Kurnain, A., and Kissinger. 2016. Analisis Potensi Simpanan Karbon Karbon Hutan Mangrove di Area PT. Indocement Tunggal Prakasa, Tbk P12 Tarjun. *EnviroScienteae* 12(3): 312-329. DOI: 10.20527/es.v12i3.2456

Barus, S. P., and Kuswanda, W. 2016. Nilai ekonomi Jasa Lingkungan Hutan Mangrove di Suaka Margasatwa Karang Gading, Sumareta Utara. *Jurnal Penelitian Hutan dan Konservasi Alam* 13(1): 29-41. DOI: 10.20886/jphka.2016.13.1.29-41

Dewiyanti, I., Martunis, M., and Agustina, S. 2019. Estimation of Mangrove Biomass and Carbon Absorption of *Rhizophora apiculata* and *Rhizophora mucronata* in Banda Aceh, Aceh Province, Banda Aceh, Aceh Province, Indonesia. *IOP Conference Series: Earth and Environmental Science* 348: 012119. DOI: 10.1088/1755-1315/348/1/012119

Dharmawan, I. W. S. 2010. Pendugaan Biomasa Karbon di Atas Tanah pada Tegakan *Rhizophora mucronata* di Ciasem Purwakarta. *Jurnal Ilmu Pertanian Indonesia* 15(1): 50-56.

Golden Agri-Resources. 2012. *Hutan Berstok Karbon Tinggi*: *Laporan Penelitian*. Golden Agri-Resources. Jakarta, Indonesia.

Hairiah, K., and Rahayu, S. 2007. *Pengukuran 'Karbon Tersimpan' di Berbagai Macam Penggunaan Lahan*. World Agroforestry Centre - ICRAF. Bogor.

Heriyanto, N. M., and Subiandono, E. 2012. Komposisi dan Struktur Tegakan, Biomassa, dan Potensi Kandungan Karbon Hutan Mangrove di Taman Nasional Alas Purwo. *Jurnal Penelitian Hutan dan Konservasi Alam* 9(1): 23-32. DOI: 10.20886/jphka.2012.9.1.023-032

Herpinawati, Dahlan, Z., and Sarno. 2010. Tingkat Pertumbuhan dan Biomassa Bibi*t Rhizophora apiculata* Perairan Delta Upang Banyuasin Sumatera Selatan. *Maspari Journal* 1(1): 59-62. DOI: 10.36706/maspari.v1i1.1116

Irawan, B., Muadz, M., and Rosadi, A. 2013. *Karakterisasi dan Kekerabatan Tumbuhan*

Mangrove Rhizophoraceae Berdasarkan Morfologi, Anatomi dan Struktur Luar Serbuk Sari. Prosiding Seminar Nasional Sains dan Teknologi Nuklir PTNBR – BATAN. 289-297.

Jumiati, E. 2008. Pertumbuhan *Rhizophora mucronata* dan *R. apiculata* di Kawasan Berlantung. *Jurnal Manajemen Hutan Tropika* 14(3): 104-110.

Ledheng, L., Ardhana, I., and Sundra, I. K. 2012. Komposisi dan Struktur Vegetasi Mangrove di Pantai Tanjung Bastian Kabupaten Timor Tengah Utara Provinsi Nusa Tenggara Timur. *Ecotrophic: Jurnal Ilmu Lingkungan* 4(2): 80-85.

Ledheng, L., Naisumu, Y. G., and Binsasi, R. 2020. Kajian Biomassa dan Cadangan Carbon pada Hutan Mangrove Pantai Utara Kabupaten Timor Tengah Utara Provinsi Nusa Tenggara Timur. *Prosiding Seminar Nasional SMIPT* 3(1): 217-229.

Manafe, G., Kaho, M. R., and Risamasu, F. 2016. Estimasi Biomassa Permukaan dan Stok Karbon pada Tegakan Pohon *Avicennia marina* dan *Rhizophora mucronata* di Perairan Pesisir Oebelo Kabupaten Kupang. *Jurnal Bumi Lestari* 16(2): 163-173. DOI: 10.24843/blje.2016.v16.i02.p09

Mughofar, A., Masykuri, M., and Setyono, P. 2018. Zonasi dan Komposisi Vegetasi Hutan Mangrove Pantai Cengkrong Desa Karanggandu Kabupaten Trenggalek Provinsi Jawa Timur. *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan* 8(1): 77-85. DOI: 10.29244/jpsl.8.1.77-85

Mustika, D. I., Rusdiana, O., and Sukendro, A. 2014. Pertumbuhan Bakau Minyak (*Rhizophora apiculata*) di Persemaian Mangrove Desa Muara Teluk Naga, Tangerang, Banten. *Bonorowo Wetlands* 4(2): 108-116. DOI: 10.13057/bonorowo/w040204

National Standardization Agency. 2011. *Standard Nasional Indonesia SNI 7724*: Jakarta, Indonesia: Penulis

Nurruhwati, I., and Purwita, S. D. 2018. Blue Carbon Content of Mangrove Vegetation in Subang district. *Conference Series: Earth and Environmental Science* 137: 012065. DOI: 10.1088/1755-1315/137/1/012065

Qiu, Y. W., Yu, K. F., Zhang, G., and Wang, W. X. 2011. Accumulation and Partitioning of Seven Trace Metals in Mangroves and Sediment Cores from Three Estuarine Wetlands of Hainan Island, China. *Journal of Hazardous Materials* 190(1-3): 631-638. DOI: 10.1016/j.jhazmat.2011.03.091

Regional Government of North Central Timor. 2016. *Rencana Pembangunan Jangka Menengah Daerah Tahun 2016 - 2021*. Government of North Central Timor. Kefamenanu, Indonesia.

Rahim, S., Baderan, D. K., and Hamidun, M. S. 2018. Keanekaragaman Spesies Biomassa dan Stok Karbon pada Hutan Mangrove Torosiaje Kabupaten Pohuwato Provinsi Gorontalo. *Jurnal Pro-Life* 5(3): 650-665. DOI: 10.33541/jpvol6Iss2pp102

Weyerhaeuser, H., and Tennigkeit, T. 2000. Forest Inventory and Monitoring Manual. *HBS-ICRAF-CMU*: 1-30.