Estimated Carbon Stock In The Mangrove Sylvo-Ecotourism Area, Tanjung Piayu Village, Sei Beduk District, Batam Island, Indonesia

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Abstract. The mangrove ecosystem acts as a carbon absorber in the atmosphere with more absorption capacity than other types of forest ecosystems. The mangrove sylvo-ecotourism area in Tanjungpiayu Village, Batam City, is part of the forest and land rehabilitation program carried out by BPDAS Sei Jang Duriangkang in the Riau Islands region. In an effort to provide data and information regarding the potential for carbon absorption in mangrove forest ecosystems resulting from the rehabilitation program, it is necessary to calculate the stored carbon stock as a reference for monitoring in subsequent years. The research was carried out from August to September 2023. The method used was the roaming method without harvesting using an allometric model. Data analysis was carried out by calculating the value of biomass, carbon stock and CO2 absorption. The analysis results show that the average total mangrove biomass at the top surface (ABG) and below the surface (BGB) is 420.50 tons/Ha with a biomass composition of AGB of 265.23 tons/Ha, and BGB of 155.27 tons/Ha. Ha. The average value of total carbon stock is 197.63 tonC/Ha with a carbon stock composition of AGB of 124.66 tonC/Ha and BGB of 72.97 tonC/Ha. Furthermore, the average value of total carbon uptake is 724.65 CO2 e ton /Ha with a carbon uptake composition of ABG of 457.07 CO2 e ton /Ha and BGB of 267.58 CO2 e ton /Ha.

1 Introduction

The Tanjungpiayu Mangrove Ecosystem of Batam City is a representation of small island mangrove forest ecosystems with different ecological characteristics from mangrove ecosystems found in maind land waters. The existence of the Tanjungpiayu mangrove forest ecosystem is very unique, because it has high connectivity with terrestrial forest ecosystems, in this case the Mangsang forest area. Another uniqueness of Tanjungpiayu mangrove forest is known as a green zamrut area located in the middle of a dense residential area of Batam City. The ecological function of mangrove ecosystems is very distinctive and its position is not replaced by other ecosystems [1]. In addition, mangrove ecosystems also have physical functions to maintain the coastline to remain stable, and protect the coast from abrasion, as well as biological functions as nurturing areas, foraging areas, and spawning areas of various marine life, and economic functions as sources of livelihoods including sources of fuel (wood), building materials (boards) as well as textile, medicine and food materials [2, 3]. As a forest area in the middle of the city center, Tanjungpiayu mangrove forest plays a role for the lungs of the city which provides oxygen and absorbs carbon dioxide which contributes to the reduction of greenhouse gases. This makes the mangrove forest ecosystem in this region play an important role in mitigating climate change for the long term.

The mangrove ecosystem has the ability to absorb CO_2, so that mangrove forests have a role in reducing the concentration of carbon dioxide in the air, and mangrove forests absorb much more carbon than terrestrial forests and tropical rain forests [4, 5]. Mangroves carry out a mechanism for absorbing and storing carbon from the atmosphere which is then stored in the form of biomass through the photosynthesis process [6], so that mangroves are able to play a role in mitigating global climate change which causes an increase in carbon dioxide gas as one of the largest contributors to global gas emissions. In the sequestration process, some of the carbon will be used to carry out physiological processes, some will be stored in the form of biomass and stored in carbon pools, including above-surface plant biomass (AGB), below-surface plant biomass (BGB), dead wood and also soil [10]. Mangroves have the optimal function of absorbing CO2 reaching 77.9%, this value is three times greater than mainland tropical forests. Mangrove forests in Indonesia are able to absorb 52.85 tonnes of CO2/ha/year, this value is twice as high as the global estimate of 26.42 CO2/ha/year [8]. The carbon content in mangroves describes how much mangroves are able to absorb carbon dioxide.

The estimated area of mangroves in Indonesia currently is around ± 3 million hectares [9]. Meanwhile, the area of mangroves in Batam City is 20,228.91 Ha [8]. However, the condition of mangroves in Batam is currently experiencing damage of up to 40% due to clearing activities, filling of mangrove forests and beach reclamation [7]. Batam City has a mangrove silvo-ecotourism area in Tanjung Piayu Village which is part of the forest and land rehabilitation program carried out by the Sei Jang Duriangkak BPDAS (River Watershed Management Center) Riau Islands. The ecosystem in the mangrove silvo-ecotourism area in Tanjung Piayu Village is very vulnerable to degradation because there is a lot of land conversion for settlements which causes mangroves to lose their forest function, one of which is as a carbon absorber. So, to support the rehabilitation program, it is necessary to estimate the existing carbon reserves in the mangrove silvo-ecotourism area in Tanjung Piayu Village. The novelty of this research was carried out in an area that has the potential for large land loss so that it can be used as monitoring in the following years.

This research was carried out using allometric equations to obtain above-ground plant biomass (AGB) and below-surface plant biomass (BGB) using non-destructive methods or without harvesting to eliminate the potential for destruction of mangrove forests. The aim of this research is to calculate above-surface plant biomass (AGB) and below-surface plant biomass (BGB), carbon stock values and carbon dioxide uptake values in mangrove ecosystems in the mangrove silvo-ecotourism area in Tanjung Piayu Village. The benefit of this research is to provide scientific information and serve as a reference for the government in managing mangrove forests.

2 Research Methods

2.1. Time and Location Research

This research was conducted in August – September 2023 in the mangrove silvo-ecotourism area of Tanjungpiayu Village, Batam City. There are 5 observation sampling points presented in Figure 1 below:

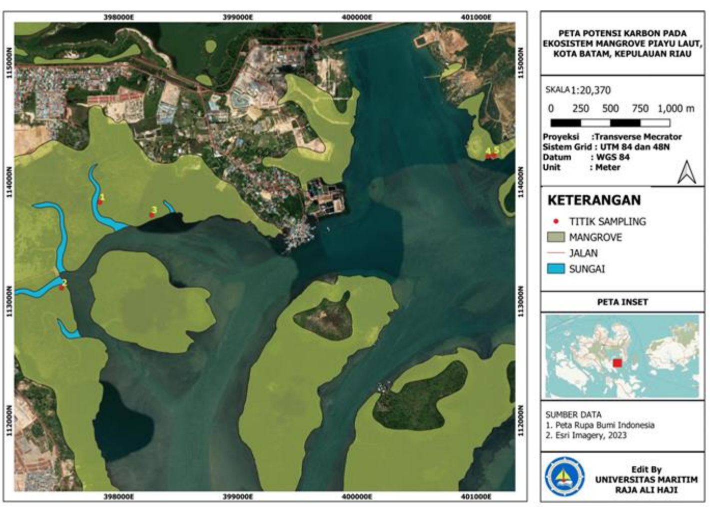

Fig. 1. Study Area

2.2. Tools and Materials

The tools and materials used during this study can be seen in Table 1 below:

Table 1. Tools and materials

Alat dan bahan	Keterangan
Raffia strap	Observation plot
Fabric meter	measuring the circumference of a rod
Caliper	measuring the diameter of the tillering rod

GPS	Determine the coordinates of the observation location
Camera	Field documentation
Sample mangrove	Identification of mangrove species

2.3. Research Procedure

The research was conducted using the exploration method which is a method of exploring paths that can represent mangrove ecosystems in the area studied directly because not all areas in this area are mangrove ecosystems. The research data collection plot used is in the form of a circle consisting of several subplots, the use of circle plots is suitable for use in areas with high species diversity in order to minimize sampling errors [9].

The procedure for measuring the diameter of the stand is carried out by identifying the type of tree referring to the identification book of the Guide to the Introduction of Mangroves in Indonesia by Wetlands International Indonesia then measuring the diameter as high as 1.3 m. Categorized trees if the diameter > 10 cm, the diameter between 2 - 10 cm is classified as a stake, while the diameter of < 2 cm is classified as seedlings [11]. The procedure for measuring the diameter of stands as high as 1.3 m is regulated in SNI 7724 of 2011, in the condition of trees found branches at a tree height of 1.3 m <, the diameter is measured according to the number of branches on the tree.

2.4. Data Analysis

Analysis of the biomass value of upper plant vegetation and lower plant biomass using allometric equations. Here are some allometric equation formulas to obtain the value of mangrove biomass above the surface presented in Table 2.

Table 2. Allometrik Equation for *Above Ground Biomass (AGB)*

Mangrove Species	**Allometrik Equation**	**Specific gravity (ρ)**
Rhizopora apiculata	$W= 0,43*D^{2,13}$	1,05
Rhizopora mucronata	$W= 0.1466*D^{2.3136}$	0,92
Bruguiera gymnorrhiza	$W= 0,0754*D^{2,505}*0.741$	0,741
Ceriops tagal	$W= 0.251*0.8859*D^{2.46}$	0,746
Ceriops decandra	$W = 0.251*0.725*D^{2.46}$	0,96
Xylocarpus granatum	$W = 0.1832*D^{2.21}$	0,7

Information : W = Biomass, D= Tree diameter
Source : [19]

3 Results and Discussion

The types of mangroves found at this research location are Rhizophora apculata, Rhizophora mucronata, Bruguiera gymnorizha, and Xylocarpus granatum. The dominant type is Rhizophora apiculata because it is found at every research station. The existence of this type is proven by research conducted by [12] that the types Rhizophora apculata, Rhizophora mucronata and Bruguiera gymnorizha are the most dominant types found in the coastal area of Kampung Bagan, Tanjung Piayu District, Batam City.

Biomass of mangrove stands is calculated using non-destructive sampling methods or without logging using allometric equations. In this research, the allometric equation in question is a mathematical equation that shows the relationship between certain parts of living things and other parts or certain functions of those living things by estimating certain parameters using other, easier parameters. Calculation of understory biomass values was carried out using a regression model and produced allometric equation values for root weight [12]. This is because measuring BGB biomass is quite difficult so calculations can be done using conversion factors or mathematical models from the results of previous research [17].

The results of the research show that the total average value of AGB in the mangrove vegetation of the Tanjungpiayu coastal area is 265.23 tons/ha, while the total average value of BGB is 155.27 and the total value of vegetation biomass (AGB and BGB) is 420.50 tons/ha. Ha (Figure 2). The AGB value is greater than BGB because the upper plant biomass value is influenced by the number of stands, stem diameter, and density [13]. The highest total biomass value was found at station 1 at 558.82 tons//Ha and the lowest value was found at station 5 at 323.35 tons/Ha. This is because the number of stands at station 1 was 42 stands, while at station 5 only 29 mangrove stands were found.

Biomass has a positive relationship with carbon reserves, because biomass content is capable of producing large conversions of carbon content. The total carbon stock value is obtained from the conversion of biomass value to the percentage value of carbon stored in a tree species, namely 47% of the total biomass. The total carbon stock value at the research location was 197.63 tonC/Ha with the average total value of each upper and lower plant being 124.66 tonC/Ha and 72.97 tonC/Ha (Figure 3). The carbon value obtained is relatively higher compared to research conducted by [14, 16] with carbon stock values of 127.85 tonC/Ha and 121.88 tonC/Ha respectively. The total carbon stock value at each station with the highest value found at station 1 and the lowest at station 5, this is directly proportional to the biomass value obtained.

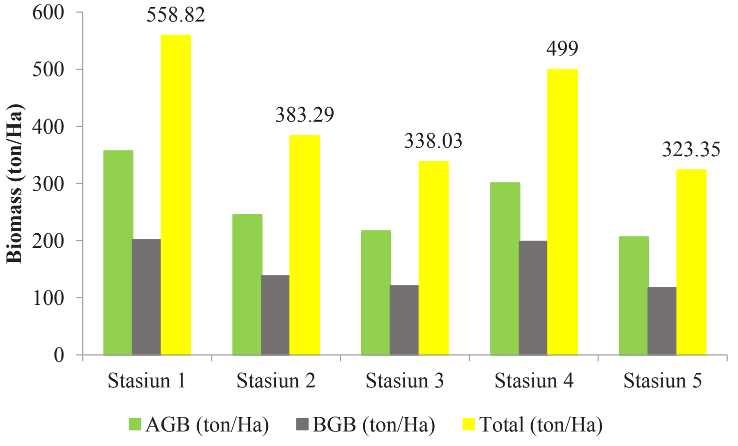

Fig. 2. Biomass Value

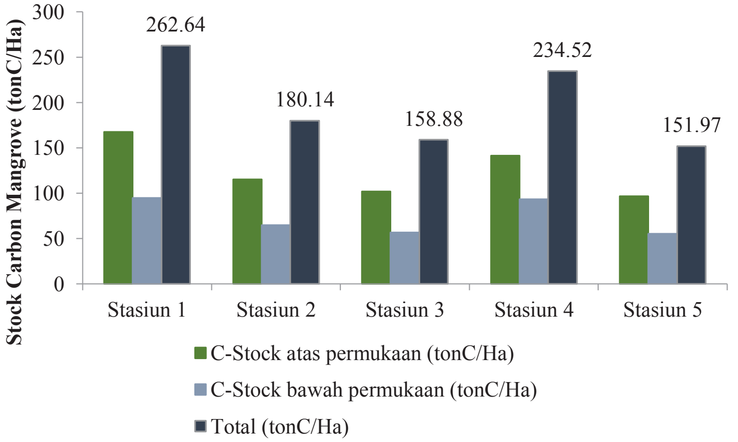

Fig. 3. Value Carbon Stock

Carbon sequestration or carbon uptake value is reflected in the process of removing carbon from the atmosphere and storing it in reservoirs or carbon storage places, known as carbon pockets. The average value of total carbon uptake at the research location was 724.65 tonC/Ha (Figure 4). The highest value was found at station 1 while the lowest value was found at station 5. Thus the amount of biomass is directly proportional to the value of mangrove carbon uptake. The carbon uptake value obtained is relatively smaller compared to research conducted by [18] on the mangrove ecosystem in the North Kayopng area, West Kalimantan which had a carbon uptake value of 1037.41 tonC/Ha. According to [18] the low level of carbon absorption is caused by poor mangrove management in the area.

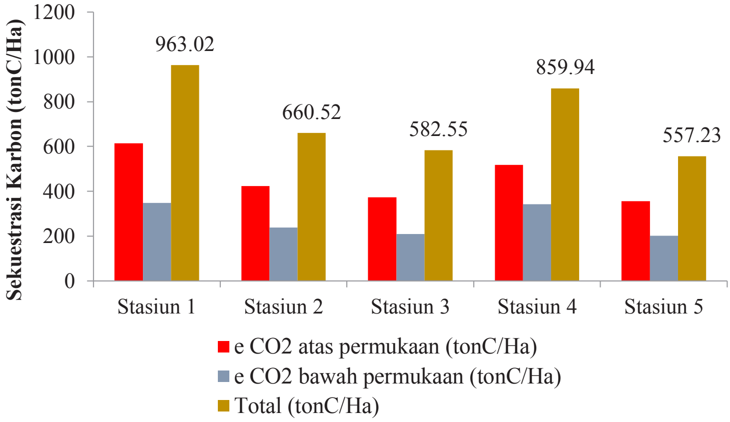

Fig. 4. Equivalence Carbon Uptake Value

Mangroves as an ecosystem that plays a role in absorbing and storing carbon have not yet optimized this function because many mangrove ecosystems have experienced degradation due to human activities. The change in function of mangrove forests that occurs can have an impact on reducing carbon absorption, literally mangroves as absorbers and stores actually become contributors to CO2 gas emissions due to lack of attention in managing mangrove forests. An alternative that can be developed to control carbon concentrations in the atmosphere is to increase absorbing vegetation. carbon through rehabilitation of mangrove ecosystems. The mangrove silvo-ecotourism area in Tanjung Piayu Village which is part of the forest and land rehabilitation program by BPDASHL Sei Jang Duriangkaang Riau Islands must be of concern to the government which is then expected to contribute to mitigating global climate change and minimizing mangrove forest degradation and deforestation activities in Batam City .

4 Conclusion

The mangrove ecosystem in the silvo-ecotourism area of Tanjung Piayu sub-district, Batam City has an average value of total biomass, carbon stock and carbon sequestration respectively of 420 tons / Ha, 197.63 tons C / Ha and 724.65 tons C / Ha. The mangrove silvo-ecotourism area in Tanjung Piayu Village, Batam City is part of an ecosystem that is being rehabilitated showing its success as an ecosystem that is able to play a role in storing carbon and absorbing CO2 emissions so that it can function towards climate change mitigation efforts.

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