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Carbon stock of mangrove ecosystem and role blue economy in Pangandaran West Java

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Abstract. The mangrove ecosystem is a forest area that grows in coastal areas and is located at a distance of 200 meters from the shoreline. Mangroves are one of the blue-carbon ecosystems that can absorb CO_2 through the process of photosynthesis and store carbon in the form of biomass in the soil. Mangroves are the second largest store of carbon stocks in waters after coral reefs. The availability of mangrove ecosystem carbon stock data is very important as a baseline in the greenhouse data inventory from blue carbon ecosystems. Blue carbon can be used as a reference for the welfare of coastal communities commonly called the blue economy, the blue economy focuses on generating economic growth from the fisheries and marine sector in Indonesia. Marine ecosystems are also impacted by climate change. Based on data from WWF's Living Blue Planet Report 2015, the number of marine populations decreased by 49% in the period 1970-2012. The data is closely related to the sustainable economic growth of the marine fisheries sector, in this case, the mangrove ecosystem. Analysis of mangrove ecosystems using circle plots carried out measurements of tree diameter and length and identification of tree species according to predetermined subplots then analyzed the amount of carbon stock using the Allometric Equation Model. The result obtained is that 80% of mangrove habitat conditions are still very good so they can contribute to producing a total stored carbon stock (blue carbon) of 55.98 tons/ha this can be an ecosystem service for the surrounding community that can increase the blue economy in the Pangandaran area of West Java.

1 Introduction

Mangrove ecosystems are forest areas that grow in coastal areas and are located on the shoreline. Mangroves are one of the blue carbon ecosystems that can absorb CO_2 through the process of photosynthesis and store carbon in the form of biomass in the soil [6]. Plants absorb inorganic carbon in the air (CO_2) and convert it into organic carbon in the form of carbohydrates through the process of photosynthesis [5]. The results of photosynthesis will be circulated to all parts of the plant and stored in the form of biomass [12]. Mangroves have another function that can reduce CO_2 gas in the atmosphere and when compared to most tropical forests, mangrove forests can store more carbon [4]. Mangroves are the second largest store of carbon stocks in the waters after coral reefs. It is estimated that mangrove forests can absorb CO2 from the atmosphere by 25.5 million tons/year [10].

Blue Carbon is the amount of carbon emissions and greenhouse gases that can be absorbed, stored, and released by coastal and marine ecosystems. *Blue carbon* can be used as a reference for the welfare of coastal communities commonly called the blue economy, The blue economy focuses on generating economic growth from the fisheries and marine sector in Indonesia. The availability of mangrove ecosystem carbon stock data is very important as baseline data in the inventory of greenhouse gas data from blue carbon ecosystems [1][19]. The Indonesian government has included the coastal and marine sectors, including the important role of blue carbon ecosystems, into the priority sectors of low-carbon development efforts to mitigate climate change [1][2].

Mangrove forests in Indonesia absorb an average of 52.85 tons CO_2/ha/year of carbon [8]. Biomass as carbon storage is called a carbon sink. Known biomass values can be used to estimate carbon stocks stored in plant dry matter vegetation consisting of carbon content [9]. Carbon is stored in carbon pools. according to [11] There are four carbon pockets: Above Ground Biomass (AGB), Bottom Ground Biomass (BGB), dead organic matter, and soil carbon.

Blue carbon and blue economy are two interrelated concepts. Blue carbon refers to the reserves of carbon emissions stored, sequestered, and released by coastal and marine ecosystems such as mangroves, seagrass beds, and tidal swamps. Meanwhile, the blue economy is the concept of sustainable economic development by utilizing marine and coastal resources wisely.

These two concepts are interrelated because blue carbon can be an important resource in supporting the blue economy. The potential of blue carbon in Indonesia is huge, especially in terms of mangrove forest management. In addition to being able to absorb carbon in the atmosphere higher than land, the ocean as a blue

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carbon sink has the ability to store carbon for millions of years more than tropical forests on land.

Therefore, mangrove forest management can provide multiple benefits for the environment and economy. In addition to reducing carbon emissions, mangrove forest management can also improve the welfare of the surrounding community through various economic activities such as tourism, fisheries, and agriculture.

2 Material and Methods

2.1 Study Site

This research was conducted in Cijulang Village, Batu Karas District, Pangandaran Regency. Tools and materials used in the study are GPS, sewing meters, roll meters, aluminum foil, furnaces, calipers, plastic samples, cameras, analytical scales, phlox, knives, raffia rope, ATK, and Personal Protective Equipment (PPE).

2.2 Types and Sources of Data

Data collection using circle plots in the plot was carried out measuring the diameter and length of trees and identifying tree species according to predetermined subplots. The procedure for measuring the diameter of stands as high as 1.3 m is regulated in SNI 7724 of 2011. The calculation of biomass in trees, saplings, and seedlings (AGB) is carried out by an allometric equation model which is a method without damage but by estimating [11].

Measurement of the diameter of the tree trunk is carried out at the height of the adult chest (*Diameter at Breast High*) which is 1.3 m from ground level. Measurement of mangrove trunk and root biomass is carried out by allometric method based on the diameter of the tree trunk, then the biomass obtained is converted into carbon value.

The equation model used is adjusted to the characteristics of the mangrove habitat (Table 1). Subsurface biomass calculations were performed using a regression model between W and ρD^2 yielding a root weight allometric equation [7]. as follows:

$$W = 0.199 \text{ x } \rho^{(0,899)} \text{ x } D^{(2.22)}$$

Where: W=BGB biomass of root weight; ρ= specific gravity of species (Table 1); D= diameter of the rod (cm).

Table 1. Tree Biomass Allometric Equation Model

Species	Allometric Model	Source	ρ	Source
Rhizophora apiculata	w = $0.43(D^{(2.14)})$	(Ruslianto et al., 2019)	1,05	(Kauffman dan Donato, 2012)
Avicennia marina	w = $0.1848(D^{(2.3524)})$	(Dharmawan dan Siregar, 2008)	0,65	(Zanne et al 2009)
Bruguiera gymnorizha	w = $0.0754(D^{(2.505)})$ 0.741	(Kauffman dan Donato, 2012)	0,741	(Kauffman dan Donato, 2012)
Ceriops decandra	w = 0.251 (0.725) $(D^{(2.46)})$	(Komiyama et al., 2005)	0,96	(Kauffman dan Donato, 2012)

Description: w = biomass; D = rod diameter / DBH 1.3 m; ρ = specific gravity of rod.

The calculation of carbon storage of mangrove stands is carried out by multiplying the value of biomass by the carbon fraction using the SNI 7724 of 2011 formula as follows:

$$C = 0,47 \text{ x } B$$

Where: C = Carbon storage (kg); B = Biomass (kg); 0.47 = Carbon fraction.

3 Result and Discussion

The result obtained is that 80% of mangrove habitat conditions are still very good based on the area of mangrove cover and density according to standard issued by Kepmen LH No. 201 of 2004, mangrove areas are said to be very good categories if the percentage value of cover is >75% so they can contribute to producing a total stored carbon stock (*blue carbon*) of 55.98 tons/ha, this can be an ecosystem service for the surrounding community that can increase the blue-economy in the Pangandaran area of West Java.

Table 2. Biomass Value of Mangrove Species Stands

Species	Total Species	Diameter at Breast High (DBH) (cm)	Above Ground Biomass (AGB) (ton/ha)
Rhizophora apiculata	15	0,52	145,90
Avicennia marina	30	11,32	210,89
Bruguiera gymnorizha	8	8,37	77,48
Ceriops decandra	20	0,24	42,22

Based on Table 2, the highest AGB biomass value is found in the *Avicennia marina* species where this species dominates the mangrove ecosystem area in Pangandaran, which found as many as 30 species, followed by *Ceriops decandra* species as many as 20 species. The value of AGB biomass is the largest because AGB is the sum of the biomass of stems, branches, stalks, and leaves. This is explained by [3], the relationship between diameter and tree biomass shows a linear relationship the greater the circumference of the tree trunk affects the biomass value of a tree.

Based on research [13] mangroves classified as hardwood types store a lot of carbon compared to softwood types, the carbon content in each mangrove species will differ from each other depending on the specific gravity of the wood (wood density). The higher the specific gravity of the wood, the higher the biomass content.

Table 3. Carbon Storage Results of Mangrove Species Stands

Species	Above Ground Biomass (AGB) (ton/ha)	Carbon storage (ton/ha)	Absorption CO_2 (ton/ha)
Rhizophora apiculata	145,90	68,57	251,53
Avicennia marina	210,89	99,11	363,57
Bruguiera gymnorizha	77,48	36,41	133,57
Ceriops decandra	42,22	19,84	72,78
Average	**119,12**	**55,98**	**205,36**

Based on Table 3, the results of carbon storage of mangrove species show that the highest carbon storage is found in the *Avicennia marina* species at 99.11 tons/ha, while the lowest carbon storage is found in the *Ceriops decandra* species at 19.84 tons/ha due to the high carbon storage of a mangrove forest area seen from the high biomass in the area, high biomass is known from the number of trees with large trunk diameters and high density.

The average value of carbon storage obtained in this study was 55.98 tons/ha, this value is greater than the results of the study [8] with an average of 52.85 tons CO_2 /ha/year. This is influenced by the average diameter of the tree trunk and the number of mangrove species. According to research [14], the value of biomass and stored carbon content can differ in various mangrove ecosystems depending on the diversity of species, trunk size, and density in the area. The diameter of the trunk / DBH can be different in each region, this is due to the physical conditions of the waters and the environment that affect the size of nutrients that enter the mangrove ecosystem area.

Reducing the release of emissions can minimize the amount of CO_2 in the atmosphere and increase the number of carbon-absorbing plants. So it is necessary to preserve the forest by replanting or reforestation. The important role of mangrove forests in carbon absorption and storage needs to be used as a reference for climate change mitigation to improve mangrove management in accordance with the function of mangrove forests [20].

The relationship between blue carbon and the blue economy is that blue carbon refers to carbon emission stocks stored, absorbed, and released by coastal and marine ecosystems such as mangroves, seagrass beds, and tidal swamps. Meanwhile, the blue economy is the concept of sustainable economic development by utilizing marine and coastal resources wisely.

The blue economy is an economic model that encourages the implementation of sustainable development, namely developing marine and fisheries industrialization that emphasizes growth, job creation, and encouraging technological innovation. With the existence of mangrove ecosystem areas that have ecological functions, the community is expected to be able to improve the economy by utilizing it. In principle, the blue economy optimizes existing marine potential by prioritizing ecosystem principles and striving to produce output optimally but still paying attention to the surrounding environment (not causing emissions and good waste treatment) in this case regarding livelihoods that directly utilize the mangrove ecosystem.

Livelihoods that utilize mangrove ecosystem areas include fishermen, traditional fish fishing, ecotourism guides, pond businesses, and sellers of mangrove products.

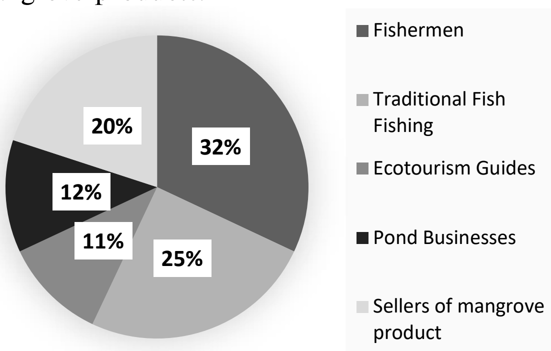

Fig. 1. Livelihood Diagram

Based on Figure 1, The number of livelihoods that utilize mangrove ecosystem areas are Fishermen at 32%, Traditional Fish Fishing at 25%, Sellers of mangrove products at 20%, Pond Businesses at 12%, and Ecotourism Guides at 11%. The livelihoods dominated by fishermen are around 32% who use mangrove ecosystems as nursery grounds, feeding grounds, and spawning grounds. Usually, these fishermen look for small pelagic fish and benthos for consumption and resale.

Fishermen are the most dominating livelihood in coastal areas. The fishermen will catch fish in coastal and marine areas. Marine resources are the focus for fishermen, quality catches will affect fishermen's income.

The blue economy concept prioritizes three things, namely growth, community welfare, and environmental health. Blue economy as a concept of new marine and fisheries development will be directed at balanced economic development between the utilization of marine and fisheries resources with management efforts
environment optimally and sustainably. Blue Economy can be seen as an action that relies on the comprehensive economic development of the people to achieve overall national development. The linkage between blue carbon and the blue economy will synergize with the implementation of the triple track strategy, namely pro-poor, pro-growth, pro-job, and pro-environment programs [15].

The role of the community in mangrove management is very important, the higher the blue carbon in the mangrove ecosystem area, the more biota around it that can be utilized by the community and can directly benefit the livelihood aspects of the surrounding community, therefore the mangrove ecosystem needs to be maintained. The function of blue carbon in addition to playing a role in mitigating climate change also plays a role in the economic sustainability of local communities. Therefore, the importance of long-term monitoring and sustainable management of mangrove ecosystems. The existence of blue carbon in mangroves will be a survival for the surrounding community which uses mangrove ecosystem areas as a source of livelihood, so this will be closely related to the blue economy system which has three priority concepts, namely growth, community welfare, and environmental health.

4 Conclusion

The results obtained are that 80% of mangrove habitat conditions are still very good so that they can contribute to producing a total stored carbon stock (blue carbon) of 55.98 tons/ha and the dominant livelihood utilizing mangrove ecosystem areas, namely fishermen as much as 32%, this can be an ecosystem service for the surrounding community that can increase the blue economy in the Pangandaran area of West Java.

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