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Estimation of Carbon Stocks in Mangrove Stands at Bagek Kembar Mangrove Ecotourism Sekotong West Lombok

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Abstract. The Bagek Kembar mangrove ecotourism area, Sekotong, West Lombok has been designated as one of the mangrove essential ecosystem areas in West Nusa Tenggara. One of the ecological services of a mangrove ecosystem is carbon storage. Mangrove forests can store carbon four times higher than the world's tropical rainforest. This study aimed to assess the amount of carbon stored in mangrove stands in the Bagek Kembar mangrove ecotourism area, Sekotong West Lombok. This study uses a random sampling method, which is the placement of random plots in each mangrove zoning. The mangrove zoning is divided based on the distance from the sea and the river starting from 50 meters, 100 meters, 150 meters, 200 meters, 250 meters, and 300 meters. In addition, the mangrove area was divided into two mangrove statuses, which are natural mangrove succession and rehabilitation, and 10% of the 5x5 meter observation plot sample was taken. So that there were 286 observation plots obtained. Calculation of mangrove biomass using allometric equations. The results of the estimation study of carbon deposits on mangrove stand biomass in the Bagek Kembar Mangrove Ecotourism area of a average of 6 zonings amounted to 10,738.49 kg/ha².

1. Introduction

Indonesian mangrove ecosystem plays a complex role, which is economical, socio-cultural, hydrological, and climatological [1]. In climate regulation, mangrove produces oxygen and absorbs carbon dioxide. Mangrove forest ecosystems can store carbon four times higher than the tropical rain forests [2]. Based on data from the NTB Provincial Forestry Service in 2011, the area of NTB's mangrove forests was 18,356.88 hectares, with a good mangrove condition of 8,471.95 hectares. In Lombok Island, mangrove growth at the coast of Sekotong, in which the area reaches 307.17 hectares but suffered damage of 118.83 hectares [3].

The Government through the Directorate General of Sea Space Management, Coastal and Marine Resources Management Center (BPSPL), the Ministry of Maritime Affairs and Fisheries, West Nusa Tenggara Working Area has made efforts to conserve mangroves in the Sekotong area through the rehabilitation of the Bagek Kembar coastal area in 2016. This program is carried out by expanding the mangrove area and utilizing it as an ecotourism area. The Bagek Kembar Ecotourism area was once a former pond area. Furthermore, in 2018 this area was also named by the NTB Natural Resources Conservation Center (BKSDA) as an essential mangrove ecosystem (KEE).

However, even though it has been named as KEE and ecotourism area, this area often occurs in the illegal logging and clearing of land by the community for salt ponds and meeting the needs of firewood salt making.



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Community behavior in the form of illegal logging and land clearing for salt ponds reduces the value of benefits to the Bagek Kembar mangrove ecotourism area as a carbon sink. Therefore, before fatal ecosystem damage occurs, research is needed to find out how much carbon sequestration this region can obtain. Mangrove ecosystems and carbon emissions have close links with efforts to world ecosystems improvement [4].

2. Methods

This research was conducted in July 2019 in the Bagek Kembar Mangrove Ecotourism Area. The study uses a random sampling method, namely random sampling in each specified zone. In this study, the Bagek Kembar Mangrove areas are divided into six zones based on its distance from the sea and river, which are 50 m, 100 m, 150 m, 200 m, 250 m, and 300 m respectively. Then the sample was taken randomly, as much as 10% of the area in each zone using a 10x10m square for trees, 5x5m for poles, and 2x2m for seedlings.

The tools and materials used are rope, calipers, tape meters, soil tester, zip lock, GPS (Global Positioning System), camera, and stationery. The data needed is the stem diameter for the measurement of biomass and uptake of mangrove carbon stocks and data on environmental parameters such as moisture, pH, and salinity.

2.1 Carbon Sampling Map of Mangrove Bagek Kembar Ecosystem

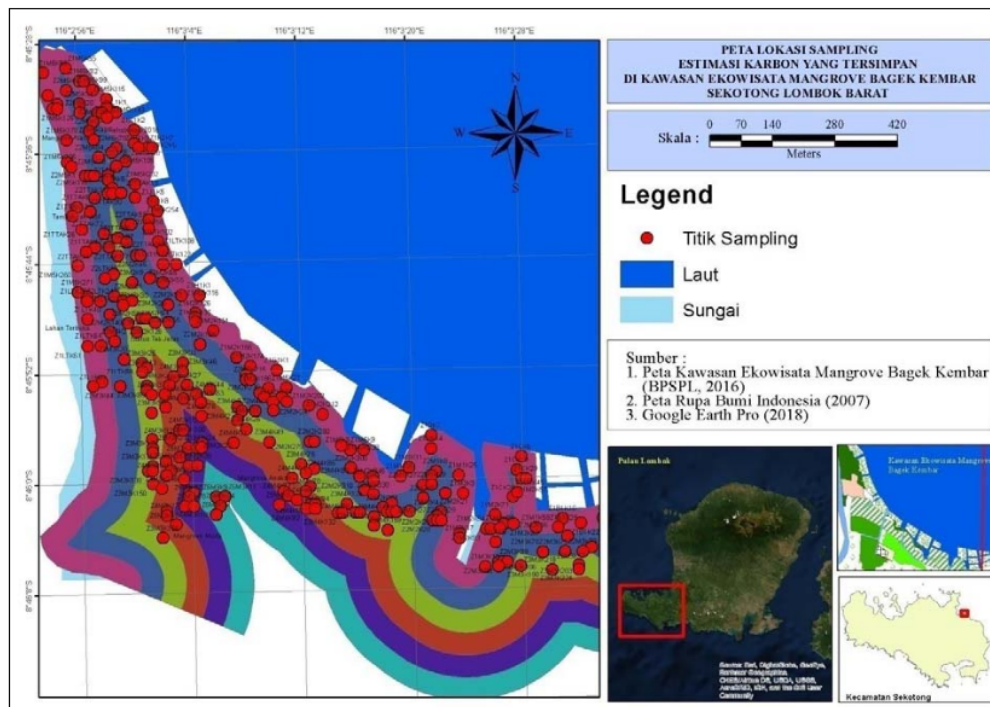


Figure 1. Map of Bagek Kembar

2.2 Measurement of Biomass and Mangrove Carbon Absorption Stock

Mangrove biomass data is obtained by measuring individual density based on the formulas from [1], DBH (Diameter at Breast Height), and density determination (ρ). DBH data and density (ρ) obtained were further processed using allometric equations developed by [5] and [6].

$$\text{Density} = \frac{\text{Numbers of individuals}}{\text{Sample Plot Area}}$$

Table 1. Allometric equation some species of mangrove

Species of Mangrove	Allometric equation	Source
Family Rhizophoraceae		
<i>Rhizophora apiculata</i>	$W_{\text{Top}}: 0.235\text{DBH}^{2.42}$ $W_{\text{R}}: 0.00698\text{DBH}^{2.61}$	[7]
<i>Rhizophora</i> spp.	$W_{\text{Top}}: 0.128\text{DBH}^{2.60}$	[8] [9]
	$W_{\text{R}}: 0.00974(\text{D}^2\text{H})^{1.05}$ $\text{H}: \text{D}/(0.02\text{D}+0.678)$	[10]
<i>Rhizophora stylosa</i>	$W_{\text{Top}}: 0.128\text{DBH}^{2.60}$ $W_{\text{R}}: 0.261\text{DBH}^{1.86}$	[10]
Family Acanthaceae		
<i>Avicennia marina</i>	$W_{\text{Top}}: 0.308\text{DBH}^{2.11}$ $W_{\text{R}}: 1.28\text{DBH}^{1.17}$	[5]
Common equation	$W_{\text{Top}}: 0.251\text{DBH}^{2.46}$ $W_{\text{R}}: 0.199\rho^{0.899}\text{D}^{2.22}$	

The carbon stock stored in mangrove forests is obtained from the total amount of mangrove biomass found in the area, which is then multiplied by the carbon concentration (C) contained in the plant, which is around 46%. The total carbon stock calculated by multiplying the total biomass by concentration C, as follows [11]:

$$\text{Absorption of stock carbon} = \text{total biomass} \times 0.46$$

3. Results

Six mangrove species found in the rehabilitation area of the Bagek Kembar Mangrove Ecotourism areas, including *Avicennia marina*, *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, and *Lumnitzera racemosa*. Based on the results of the study found the density of mangrove species as in Table 2.

Table 2. Density Individual of Ecotourism Mangrove Rehabilitation Bagek Kembar

No.	Code Zone	Area (Ha)	Species Mangrove	Type Growth	Density (ind/m ²)
1.	Zone 1	14	<i>Avicennia marina</i> <i>Rhizophora apiculata</i> <i>Rhizophora mucronata</i> <i>Rhizophora stylosa</i>	Poles	21.62
2.	Zone 2	12	<i>Avicennia marina</i> <i>Rhizophora stylosa</i> <i>Lumnitzera racemosa</i>	Poles	6.00
3.	Zone 3	7.09	<i>Avicennia marina</i> <i>Avicennia alba</i> <i>Rhizophora stylosa</i> <i>Lumnitzera racemosa</i>	Poles	3.79
4.	Zone 4	3.91	<i>Avicennia marina</i> <i>Avicennia alba</i> <i>Rhizophora stylosa</i>	Poles dan Seedlings	3.32
5.	Zone 5	1.43	<i>Avicennia marina</i> <i>Rhizophora stylosa</i>	Seedlings	0.26
6.	Zone 6	0.54	<i>Lumnitzera racemosa</i>	Trees	0.12

Table 3. Estimation Results Carbon Stock Ecotourism Mangrove Bagek Kembar

No.	Code Zone	Biomass	Carbon Stock (kg/ha ²)
1.	Zone 1	303.24	139.49
2.	Zone 2	2,520.82	1,159.58
3.	Zone 3	303.43	139.58
4.	Zone 4	30.42	13.99
5.	Zone 5	72.75	33.46
6.	Zone 6	136,836.60	62,944.85
	Average	23,344.54	10,738.49

4. Discussion

The zoning division in this study illustrates the original condition of the Bagek Kembar Mangrove Ecotourism area. Each zone, with an equal portion of 10%, was drawn randomly. Six species of mangrove were found at the study site, which are *Avicennia marina*, *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, and *Lumnitzera racemosa*. The density in the Bagek Kembar Mangrove Ecotourism area is relatively low due to the imbalance utilization of its resources. Local people are still doing the illegal cutting as well as converted to salt ponds and used as fuel. Therefore, the function of mangroves as carbon storage will be affected.

The highest carbon deposit is at zone 6, although the density and area were the lowest amounts, this zone composed of tree category therefore it will be high biomass. Stored carbon in zone 4 was low due to the conversion of the mangrove in this area, as well as in zone 1. Zone 5 is similar condition in which the mangrove had been illegally cutting and converted to ponds (Figure 2).



Figure 2. Illegal Logging at Zone 5

Table 4. Environmental Parameters Ecotourism Mangrove Rehabilitation at Bagek Kembar

No.	Code Zone	pH	Moist	Salinity
1.	Zone 1	7.16	10	19
2.	Zone 2	6.75	10	18
3.	Zone 3	6.75	10	14
4.	Zone 4	7	10	24
5.	Zone 5	6.75	9.78	17
6.	Zone 6	7	8.97	18

5. Conclusion

Mangrove ecosystem at Bagek Kembar Ecotourism Area consists of 6 species, includes *Avicennia marina*, *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, and *Lumnitzera racemosa*. Carbon storage in each zone has a different value. The difference is due to differences in the category of mangroves. The average carbon stored in the Bagek Kembar Ecotourism Area is 10,738.49 kg/ha².

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