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Calculating Economic Valuation of Mangrove Forest in Bengkalis Regency, Indonesia

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ABSTRACT

This research aims to determine the total economic value of mangrove forests on Bengkalis Island, Bengkalis Regency, Indonesia. Data collection in the field was done through observation and interviews. The research was carried out from October 2020 to March 2021. The results showed that the total economic value of mangrove forests was US$ 5.8 million per year. This study uses Total Economic Value (TEV) as a framework for estimating the value of the benefits of mangrove forests in Bengkalis. In addition, another value taken into account in this study is the function of mangroves as abrasion barrier, barrier to seawater intrusion, and a provider of nutrients for marine biota. The results of this study underscore the importance of mangrove ecosystems for the economy of coastal areas.

1. INTRODUCTION

Mangrove forest is a typical forest type and grows along the coast or river estuaries which is influenced by tides and is often found in coastal areas and sloping areas in the tropics and sub-tropics [1-3]. The mangrove ecosystem is the boundary that connects land and sea ecosystems [4]. The combination of terrestrial and aquatic ecosystems makes the mangrove ecosystem full of productive resources [5].

As a community that forms an aquatic ecosystem, mangrove forests have multiple functions that cannot be replaced by other ecosystems, namely social, economic and environmental functions [6]. Ecologically, the mangrove forest functions as a habitat for fish, shrimp, shellfish and other types of biota for spawning and nursery areas for shrimp species [7]. Mangrove forests also function to maintain shoreline stability, protect beaches and riverbanks from waves, reduce the impact of hurricanes, tsunamis, and storm surges [8, 9]. Economically, mangrove forests provide fishery resources of commercial value, producing firewood, building materials, raw materials for charcoal, and other products of economic value [10, 11]. Social benefits such as places for social interaction and tourism services [12].

Problems that threaten the sustainability of ecosystems and the function of mangrove forests have been felt in most coastal areas of Indonesia, including in Bengkalis Regency which is one of the areas with the second largest mangrove forest in Riau Province after Indragiri Hilir [13]. The area of mangrove forest in Bengkalis Regency is about 29,330 ha. Of the total area, about 9,973 ha or 34% are in a severely damaged condition and around 19,357 ha or 64% are in moderately damaged condition [14]. The condition of mangrove forests in Bengkalis Regency is currently experiencing degradation, which is caused by changes in the surrounding environment and direct and indirect pressure on the existence of mangrove forests, where the use of mangrove forests by the community does not pay attention to sustainability aspects. Deforestation of mangrove forests directly affects the balance of marine fish ecosystems and coastal abrasion. In addition, the direct impact of damage to the mangrove forest ecosystem is the disruption of the availability of seeds and marine and aquaculture activities [15]. Indirectly, the damage to the mangrove forest ecosystem has an impact on decreasing fishermen's income, job opportunities, development and empowerment of coastal communities [16, 17]. The destruction of mangrove forests in Southeast Asia in general also has a negative impact on the risk of extinction and biodiversity. In addition, it also has negative implications on the provision of ecosystem services [18].

The magnitude of the benefits obtained in mangrove forests, has its own consequences for the mangrove forest, namely with the higher level of exploitation of the environment which often ends in severe environmental degradation. Therefore, it is necessary to conduct an assessment of the mangrove forest to determine the value that will be lost and the negative impact it will have on human life if the mangrove ecosystem is degraded [19, 20].

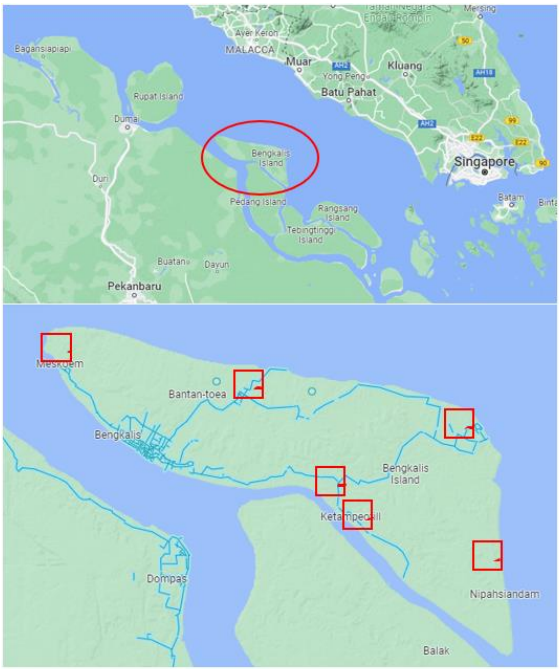
2. THEORY AND METHOD

2.1 Research location and time

This study was conducted in a mangrove forest area located on Bengkalis Island, Bengkalis Regency, more clearly the research location can be seen in Figure 1. The observation station consists of six villages, namely: Station 1 in Deluk village, Station 2 in Selat Baru village, Station 3 in Teluk Pambang, Station 4 at Perapat Tunggal, Station 5 at Pematang Duku Village and Station 6 at Ketam Putih Village. This research was conducted from October 2020 to March 2021.

2.2 Sampling method

Field data were taken through interviews with questionnaires. The sampling method in this research is using purposive sampling method with the number of respondents set as many as 195 people spread over six research stations and work as fishermen.



Source: Google Maps, 2022

Figure 1. Research site map

2.3 Economic valuation

The value of choice for mangrove forests usually uses the benefit transfer method, namely by assessing the estimated benefits from other places (where resources are available) and then these benefits are transferred to obtain a rough estimate of the benefit. The economic valuation of ecosystem services is a widely used tool in determining the impact of human activities on the environment by assigning economic values to services [21]. This study uses Total Economic Value (TEV) as a framework for estimating the value of the benefits of mangrove forests.

Conceptually, the total economic value of forest resources consists of: (1) use value and (2) non-use value. Furthermore, the usage value consists of direct use value (DUV) and indirect use value (IUD) and option value (OV). Meanwhile, non-use values are bequest value (BV) and existence value (EV). Based on the concept of economic value stated above, mathematically, Munasinghe [22] makes the following formula:

$$TEV=UV+NUV \text{ or } TEV=(DUV+IUV)+(BV+EV) \quad (1)$$

Analysis of the total economic value of mangrove forests was carried out using the formula from Munasinghe [22] as follows:

$$TEV=(DUV+IUV+OV)+(XV) \quad (2)$$

where, TEV=Total Economic Value; DUV=Direct Use Value; IUV=Indirect Use Value; OV=Option Value; XV=Existence Value.

2.3.1 Direct use value

The direct use value is calculated based on the contribution of natural resources and the environment in assisting the current production and consumption processes [22]. The direct use value is the sum of all market prices for direct benefits of mangrove forests, namely the benefits of forest products such as firewood, cigars for building and charcoal wood raw materials as well as the benefits of catching fishery products such as fish, shrimp, crabs, and biota. sea.

The direct use value is calculated by the following equation:

$$DUV=\sum_{i=1}^{n} DUVi \quad (3)$$

where, DUV=Direct use value; DUVi=DUV1+DUV2+DUV3…… etc.

2.3.2 Indirect use value

Indirect benefits are values that are felt indirectly for goods and services produced by natural resources and the environment [23]. Thus, indirect use value is the functional benefits of ecological processes that continuously contribute to society and ecosystems. For example, a mangrove forest functions as a wave absorber or beach protector from coastal abrasion, a barrier to sea water intrusion, a nursery ground, and a spawning ground as well as a feeding ground for aquatic biota. In this study, the direct use value is limited to its function as coastal protection, prevention of seawater intrusion and nutrient provider. The indirect use value of mangrove forests is calculated using the following equation:

$$IUV=\sum_{i=1}^{n} IUVi \quad (4)$$

where, IUV=Indirect use value; IUVi=IUV1+IUV2+IUV3…… etc; IUV1=Indirect benefits for abrasion resistance; IUV2=Indirect benefits for seawater intrusion; IUV3=Direct benefits of nutrient providers.

2.3.3 Option value

Choice value is based on the willingness of consumers to pay for forest resources that have not been used or willingness to pay to avoid the risk of not being available in the future. Indonesia's mangrove forests have a biodiversity value of USD 1,500 per km^2 or USD 15 per ha per year [24]. This value applies to all mangrove forests in Indonesia, the value of the selected benefit is obtained by the equation: OV=USD 15 per ha x mangrove forest area.

2.3.4 Existence value

Existence values have value because of the satisfaction of a person or community with the existence of an asset, even though the person concerned has no desire to use it. The value of existence is given by someone to natural resources and the environment solely as a form of concern because it has provided aesthetic, spiritual and cultural benefits. To estimate the existence value, the Contingent Valuation Method (CVM) method is used. The Contingent Valuation Method can be likened to an approach to measure how much you want to pay. The value of the presence of mangrove forests is calculated by the equation:

$$EV=\sum_{i=1n}^{n} (\underline{EVi}) \quad (5)$$

where, EV=Existence value; N=Number of respondents taken; EVi=Existence value of respondent-i.

3. RESULTS AND DISCUSSION

3.1 Direct use value

The direct benefit (direct use value) of the mangrove ecosystem in the coastal area of Bengkalis Regency, was identified from several mangrove ecosystem utilization activities carried out by the community directly as a fulfillment of their needs and livelihoods. The economic benefits of mangrove forest products are assessed directly by considering 9 types of local commodities, including firewood, cigar wood, charcoal wood, fish, shrimp, crabs, shell, snails, and nipah leaves. The method used to calculate the estimated direct benefit value of mangrove forests is the market value calculation method. Details of the estimated direct benefit value of mangrove forests are presented in Table 1.

Based on the estimated value of direct benefits of mangrove forests as in Table 1, it shows that the value of direct benefits of mangrove forests is USD 197,282.36. The highest type of utilization of direct benefits of mangrove forests is fishing production activities of USD 131,740.23 or 66.78%, this indicates that the potential of coastal resources can be used for fisheries [25]. Then the use of shrimp occupies the second position at USD 30,954.63 or 15.69%, while the utilization of wood charcoal raw materials is in the third position with a total production of USD 13,320.68 or 6.75%, followed by the utilization of cigar wood at USD 6,934.07 or 3.51%, the use of crabs at USD 6,934.07 or 3.51%. USD 5,551.05 or 2.81%, nipah leaf utilization was USD 5,154.86 or 2.61%, furthermore the use of firewood was USD 1,438.96 or 0.73%, the use of snails was USD 1,244.27 or 0.63% and the lowest type of utilization was local resource utilization of USD 943.60 or 0.48% of the total utilization. direct.

3.2 Direct use value

Indirect benefits from mangrove forests are benefits that cannot directly provide benefits in the form of money or fulfill human needs. These benefits are obtained from an ecosystem indirectly such as protecting coastlines from waves, and providing organic material for biota that live in it [26]. The indirect benefits of mangrove forests in Bengkalis Regency that are measured or assessed for economic benefits are: the benefits of mangrove forests as a barrier to abrasion, the benefits of mangrove forests as a barrier to sea water intrusion, and the benefits of mangrove forests as a provider of nutrients. Details for each form of utilization are presented in Table 2.

Based on the estimated value of indirect benefits of mangrove forests as in Table 2, it shows that the value of indirect benefits of mangrove forests in Bengkalis Regency is USD 5,085,645.27. The highest type of utilization of indirect benefits of mangrove forests is the function of mangrove forests as abrasion resistance of USD 2,287,849.11 or 44.99%, followed by the benefit function of mangrove forest as a nutrient provider of USD 1,829,762.36 or 35.98% and the lowest benefit of mangrove function as a barrier to seawater intrusion was USD 968.033.81 or 19.03%.

3.2.1 Benefit value as abrasion barrier

The indirect benefits of mangrove forests are physically estimated through the function approach of mangrove forests as abrasion resistance which is estimated through replacement costs with the cost of building a wave retaining wall. According to data from the Public Works Department of Bengkalis Regency in 2017 to build a sheet pile building at the fishing port in RT 03 RW 06 Hamlet Baran, Kelapapati Village with a length of 129 m, width 2.5 m and height 2.05 (pxWxH) with a durability of 20 years required a fee. of USD 33,038.62 or about 256.11 per meter. Assuming the inflation rate in 2021 issued by the Ministry of Finance is 3%, the cost of building sheet piles with a size of 129 x 2.5 x 2.05 m will be USD 263.80 per meter. The length of the coastline on Bengkalis Island is 173,455.44 meters (Indonesian Earth Map 2017). So that the total sheet pile construction cost is 173,455.44 multiplied by USD 263.80 so that the result is USD 45,756,982.10. The calculated value per year is USD 45,756,982.10 then divided by 20 years, so that the cost of mangrove benefits as an abrasion barrier is USD 2,287,849.11 per year as shown in Table 2.

Table 1. Estimated direct value of mangrove forest

No	Benefit Type	Benefit value (USD)	Operational and Investment Cost (USD)	Net Benefit Value (USD)	Percentage (%)
1.	Firewood	2,791.30	1,352.31	1,438.96	0.73
2.	Cigar wood	9,108.48	2,174.33	6,934.07	3.51
3.	Charcoal raw material	16,606.77	3,285.94	13,320.68	6.75
4.	Fish	160,024.41	28,282.79	131,740.23	66.78
5.	Shrimp	33,621.43	2,666.51	30,954.63	15.69
6.	Crab	7,375.77	1,824.66	5,551.05	2.81
7.	Shell	1,756.78	813.19	943.60	0.48
8.	Snail	1,887.12	642.85	1,244.27	0.63
9.	Palm leaves	6,481.36	1,326.49	5,154.86	2.61
	Total Value	**239,651.43**	**42,369.07**	**197,282.36**	**100.00**

Table 2. Value of indirect benefits of mangrove forests in Bengkalis Regency

No	Benefit Type	Benefit value (USD)	Percentage (%)
1	Abrasion Resistant	2,287,849.11	44.99
2	Seawater intrusion barrier	968,033.81	19.03
3	Nutrient provider	1,829,762.36	35.98
	Total Value	**5,085,645.27**	**100.00**

3.2.2 Benefit value as retaining seawater intrusion

The indirect benefit value for the benefits of mangroves as a barrier to seawater intrusion is calculated through a cost or community expenditure approach in fulfilling clean water for household purposes. This value is considered equivalent to the function of the forest as a barrier to intrusion because if the area does not have mangrove forests, the community will have difficulty getting clean water for household purposes. Based on the results of interviews with respondents at the research location, information was obtained that the amount of water needed for each family for drinking and cooking water needs is 2 gallons of water/day with a price per gallon of water of USD 0.42. Based on the calculation results, it is obtained that the costs that must be incurred by one family per year are USD 0.42 multiplied by the water requirement per day which is 2 gallons, then multiplied by the number of days in one year which is 365 days, then the result is USD 304.99 per year, with in other words, the research location with a total of 3,174 families, the cost incurred is USD 304.99 multiplied by 3,174 families, the result is USD 968.033.81 per year. Details of the value of benefits as a barrier to seawater intrusion as shown in Table 2.

3.2.3 Benefit value as nutrient provider

In addition to physical benefits, other indirect benefits are biological benefits. Biological benefits from indirect use as a provider of nutrients (nutrients) that are useful for the stability of the food cycle in the waters. Estimation of the economic value of the benefits of mangrove forests as a provider of nutrients is carried out using a replacement cost approach, namely the costs used to buy fertilizers that are equivalent to nitrogen and phosphorus elements contained in mangroves. The results of the study by Santoso [27] stated that the litter loss in the Muara Angke mangrove area was 13.08 tons/ha/year, which is equivalent to the value of Phosphorus 2 kg/ha/year and Nitrogen 148 kg/ha/year. The value of the economic benefits of providing nutrients is calculated in the form of urea and SP-36 fertilizer. The conversion factor of nitrogen into urea fertilizer is 2.221714, while the conversion factor of phosphorus into SP-36 fertilizer is 2.776949. The non-subsidized price of Urea fertilizer is assumed to be USD 0.56/kg while the SP-36 fertilizer price is assumed to be USD 0.49/kg. Based on the calculation, the result is USD 1,826,280.75 per year as shown in Table 3.

3.3 Option value

The benefits of choosing mangrove forests in Bengkalis Regency refer to the value of the benefits of biodiversity. According to Ruitenbeek [24], the biodiversity value in Bintuni Bay, Papua, amounting to USD 1,500 per km^2 per year can be used for Indonesian mangrove forests. The preferred value is obtained by multiplying the biodiversity value of USD 1,500 per km^2 per year or USD 15 per ha per year with the Rupiah exchange rate against the US Dollar, which is IDR 13,895, (5 January 2021), so that the value is USD 5 per ha per year. This result is multiplied by the total area of mangrove forest on Bengkalis Island which is 9,842.00 ha, then the benefit value of mangrove forest selection is USD 147,630 per year.

3.4 Existence value

Existence value is a value that is not generated from market institutions and has nothing to do with the protection function of productive assets or the production process directly or indirectly. The value of the existence of mangrove forests on Bengkalis Island is the value given by the community, both local residents and visitors to the area for spiritual, aesthetic and cultural benefits. The benefits of the existence of mangrove forests in the coastal area of Bengkalis Regency are calculated using the CVM (Contingent Vallution Method) approach.

The average value of WTP (Wilingness To Pay) obtained from 195 respondents as shown in Table 49 is USD 47.05/ha/year. This value is then multiplied by the area of mangrove forest on Bengkalis Island which is 9,842.00 ha. Thus, the value of the benefits of the existence of mangrove forests is 463,029.72/ha/year. Details of the estimated value of the existence benefits are presented in Table 4.

3.5 Total benefit value of mangrove forest

The total benefit value of mangrove forest is the sum of the direct benefit value, indirect benefit value, option benefit value and existence value. Based on the results of the economic valuation analysis as shown in Table 5, it shows that the value of indirect benefits is the highest at USD 5,085,645.27 or around 86.36%, this shows that the indirect benefits of mangrove forests have a very large role in generating economic value even though the benefits are not felt directly [28]. Then in the second position is the value of the existence benefit of USD 463,029.72 or about 7.86%, followed by the direct benefit value of USD 197,282.36 or about 3.35%. Meanwhile, the value of the option benefit has the lowest value of USD 142,837.64 or around 2.43%.

Table 3. Estimated economic value of mangrove forests as nutrient providers

No	Calculation Type	Unit	Value
1	Litter Potential	Tons/ha/year	13,08
2	N content	Kg/ha	148
3	P content	Kg/ha	2
4	Nitrogen conversion factor to Urea fertilizer		2,221714
5	Phosphorus conversion factor into fertilizer SP-36		2,776949
6	Convert to Urea Fertilizer	USD /ha	0.023
7	Convert to SP-36. Fertilizer	USD /ha	0.00039
8	Price of Urea Fertilizer	USD /ha	0.56
9	SP-36 Fertilizer Price	USD /ha	0.49
10	Value per hectare of Urea Fertilizer	USD /ha	183.17
11	Tilapia per hectare from SP-36. Fertilizer	USD /ha	2.75
12	Value per hectare of Fertilizer	USD /ha/year	185.91
13	Mangrove Area	Ha	9.842,00
	Estimated Value of Benefits	IDR/ha	1,829,762.36

Table 4. Estimated value of existence benefits

No	Existence Value Range (USD /ha)	Number of Respondents	Total Value (USD)
1.	Less than 69.75	172	5,988.36
2.	69.76– 104.62	11	957.44
3.	104.63– 139.50	3	365.57
4.	139.51– 174.37	2	313.34
5.	174.38– 209.24	2	382.98
6.	209.25– 244.12	4	905.22
7.	244.13– 278.99	1	261.12
	Total	195	9,174.03
	Total average		675.641
	Area of mangrove forest		9.842,00
	Existence benefit value		463,029.72

Table 5. Estimated Value of Total Mangrove Forest Benefits in Bengkalis District

No	Benefit Type	Benefit value (USD)	Percentage
1	Immediate benefits	197,282.36	3.35
2	Indirect benefits	5,085,645.27	86.36
3	Choice benefits	142,837.64	2.43
4	Existence benefits	463,029.72	7.86
	Total Value	5,888,794.99	100

4. CONCLUSIONS

The results of the economic valuation show that the total economic value of mangrove forests in Bengkalis Regency is USD 5,888,794.99 per year, the highest benefit value is the indirect benefit value of USD 5,085,645.27 per year, or 86.36%, followed by the existence benefit value of USD 463,029.72 per year, or 7.86%, the direct benefit value of USD 197,282.36 per year or approximately 3.35%, and the lowest benefit value is the option benefit value of USD 142,837.64 per year or approximately 2.43%.

The results of research with Total Economic Value (TEV) economically lead to efforts to balance between economic needs and environmental sustainability, especially mangrove forests. The results of this study underscore the importance of mangrove ecosystems for the economy of coastal areas. In addition, the results of the study practically underline the importance of preserving mangrove forests as a support for the wealth of marine ecosystems and biodiversity. This in turn will sustain the livelihoods and income of fishermen. For this reason, recommendations related to the preservation of mangrove forests to ensure environmental sustainability as well as the local economy need to be put forward.

As a practical recommendation, the local government together with the local community need to develop a coastal area management plan by determining the zoning boundaries of the allotment. This spatial layout will in turn determine the conservation zone and the general use zone so that the existence of the mangrove forest can be maintained. Besides that, local governments need to carry out conservation efforts, joint management with related parties, especially involving local communities and providing guidance for the community to preserve mangrove forests, empowering the economy by utilizing forest resources in a sustainable manner.

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