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⁴ Economic Valuation of Mangrove Ecosystem Services in Sungai Apit District, Siak Regency, Riau Province, Indonesia

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Abstract. The mangrove ecosystem is one of the ecosystems that has high productivity in coastal and marine areas, especially in supporting the productivity of fishery resources. This is due to the function of the mangrove ecosystem as ecological and socio-economic. Therefore, to determine the high level of mangrove utilization in the coastal area of Siak Regency, an economic assessment of mangrove ecosystem services is necessary. This research aimed to study quantified mangrove ecosystem services in Siak Regency, Indonesia. Methods for data collection included field survey and interview, performed between July - August 2020. The economic value assessment comprised valuation on following service groups, i.e. supporting, provisioning, regulating and cultural services. The results showed that the economic value obtained from all studied services reached IDR 29,180,852,208 per year, IDR 24,747,680,000 per year, IDR 90,291,590,933 per year and IDR 9,245,925,366 per year, respectively. In conclusion, a total amount of economic value for mangrove ecosystem services in Sungai Apit District, Siak Regency was IDR 153,466,048,507,014 per year, which was equivalent to IDR 300,090,044,0 per hectare per year.

1. Introduction

Mangrove ecosystems provide numerous benefits for human well-being, especially for coastal communities that depend on fisheries productivity. The importance of mangrove comes from its significant role in terms of ecological and socioeconomic benefits. Ecologically, mangrove forest is home to many creatures that connect each other under complex food chains [1]. In terms of economic view, it produces wood, fuel, fish and honey, being livelihood for residents around the ecosystem [2].

Ecosystem services provided by natural resources comprises all goods and services that benefit and support human well-being [3], and therefore, these services are source of livelihoods for communities [4]. However, the state of these resources always experienced changes mainly due to utilization of the resources for human needs. In addition, ecosystem has been seriously altered by other factors, including social, culture and economy [5].

Indonesia is endowed with great mangrove ecosystem, and the third greatest mangrove ecosystem in the country locates in Province of Riau, estimated to cover 209,292.64 hectare [6]. In this site, sub-district of Sungai Apit in Siak Regency covers about 511.4 hectare of mangrove forest. In absence of serious concern, sustainability of the forest may disappear significantly due to anthropological pressures. The pressure cannot be avoided regarding the



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high demand for resources as impact of growing population. The threat can be worse as low efforts and desires in environmental conservation.

The depletion of mangrove forest could be accelerated due to lack of conservative actions on that ecosystem [7]. In addition, mangrove ecosystem is also perceived by people as waste land with low economic benefits. For this reason, conversion of mangrove forest into other uses having higher economic potential often receives justification. In case of mangrove ecosystem in Siak Regency, the area has been developed as tourism, oil mining, shipping route, residential areas. These activities undeniably prompted reduction of mangrove area and disturbed ecological functions services, including catch fisheries.

It has been estimated that mangrove forest in Indonesia reaches about 3 million hectares along 95,000 km of coastal line, which accounts for about 23% of mangrove forest throughout the world [8] In Sungai Apit, mangroves are grown in coast, which substantially serves as coast defense. Unfortunately, the abrasion existed in the area, estimated to reach 9,620 m, with the lowest tide of 55 m [9]. Abrasion in that site as well as people activities adversely affect the mangrove ecosystem. To tackle the emerging challenges, there is a need to quantify monetary value of the mangrove ecosystem as well as prepare further works for reaching its sustainability, and this was the objective of this research.

2. Methodology

The research was carried out between July – August 2020 in coast of Sungai Apit District, Siak Regency. Data collection comprised expert survey through in-depth interview with stakeholders according to purposive sampling approach [10]. The mangrove ecosystem in Sungai Apit, Siak Regency, was determined in this research since the residents in this area were dependent on mangrove ecosystem services for their livelihood.

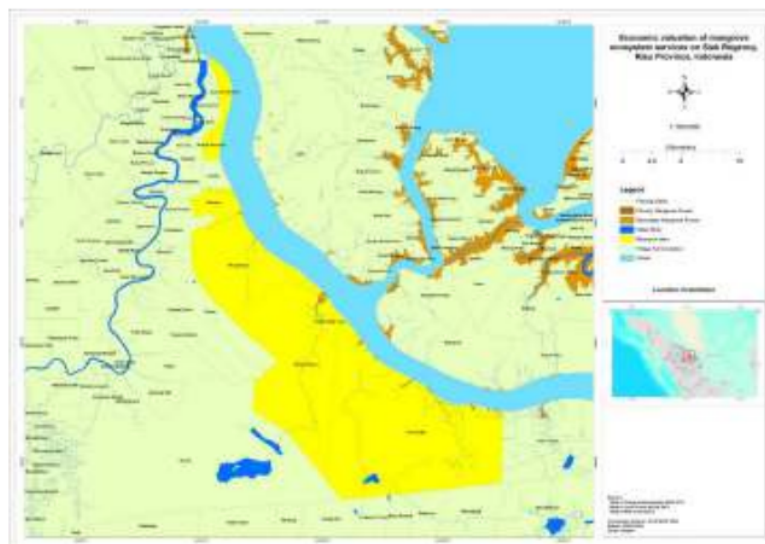


Figure 1 Research site

This research involved 88 respondents from various characteristics, including fishermen, tourists, and local communities. Identification of mangrove ecosystem services conformed to a reference [5], consisting of 4 criteria as follows: (a) supporting, (b) provisioning, (c) regulating and (d) culture services. The quantification of ecosystem services followed the procedure of economic valuation with regard to mangrove, using Total Economic Value (TEV) as follows:

$$TEV = DV + IV + OV + EV$$

where DV is value for supporting services, IV is value for provisioning services, OV is value for regulating services and EV is value for cultural services.

3. Results and Discussion

3.1 Mangrove Ecosystem Services

Mangrove is considered the most productive ecosystem [11], considering its huge advantages for coastal communities. The services are divisible into 4 categories: (a) supporting services, such as spawning ground, nursery ground, feeding ground and natural diversity; (b) provisioning services, such as fisheries production, honey production and fuel generation; (c) regulating services, such as climate change, flood control and sea water purification; and (d) cultural services, such as recreation, existence and heritage value [12].

3.2 Ecosystem Value from Supporting Services

Supporting services of mangrove ecosystem include spawning and nursery habitat for diverse marine biota and commercial fish species, composting, and source of biodiversity. To quantify the economic value, benefit transfer approach is applied.

As described by [1], mangrove ecosystem could produce compostable matters up to 3.47 g per m² per day, with fisheries production reaching up to 113.40 g per m² per year (equivalent to 1,134.01 kg per ha per year). Mangrove forest in Sungai Apit covers about 511.4 ha, indicating that fishery value reaches 579,932.714 kg per year. With average fish price of IDR 40,000 per kg, the fishery sector potentially provides value of IDR 23,197,308,560 per year. It is noteworthy that compostable matters derived from mangrove forest are source of nutrition as well as habitat for marine biota. [13] stated that mangrove ecosystem could give advantageous impacts on fisheries sector as long as the rehabilitation and conservation on that site was implemented accurately. The growing fisheries productivity becomes one of the strategic contributors to attain welfare for coastal communities.

Mangrove ecosystem may also function as spawning ground for marine biota. In this regard, quantification of its role as supporting services can be obtained using following formula: 511.4 ha (total area) × 287 trip per year × IDR 40,000 per kg (average fish price). Based on this calculation, the economic value of mangrove forest in terms of supportive function is IDR 5,870,872,000 per year.

Biodiversity is also deemed as the important role of mangrove ecosystem. The quantification followed the procedure by [14] as reported in [15]. It was estimated that economic value for mangrove ecosystem biodiversity reached 1,500 per km² per year (US\$ 15 per ha per year). With exchange rate from US\$ to IDR reaching 14,688, the biodiversity value was estimated to reach IDR 112,671,648 per year. High biodiversity in mangrove forest essentially contributed to fisheries productivity [16].

3.3 Ecosystem Value from Provisioning Service

Mangrove ecosystem in Sungai Apit provides numerous benefits for local communities, in form of fish and honey harvested for trade. In short, the ecosystem plays pivotal roles as provisioning services in fishery production, sources for woods and other forest products such as honey [17]. In this study, quantification of provisioning service is arranged according to its role in fishery and honey production [12]. To quantify this service, we compared the value of the products with actual price in the market. The quantity of catch fishery in the research site was recorded to be 732 kg per year, while the average

price was IDR 40,000 per kg. The fishermen in Sungai Apit amounts to 844 individuals. Using these inputs, we found the economic value for fisheries sector reaching up to IDR 24,712,320,000 per year.

The livelihood of local communities relies on fishery sector; thus, it provides significant impacts on income rate. As reported by [18], the production of fishery sector in 1977 was 1,489,000 tons; and 3% of the amount came from fish that relied on mangrove ecosystem. Research by [19] in Rokan Hilir, Indonesia, documented a lower fishery production compared with our current work.

Honey production in mangrove ecosystem of Sungai Apit concentrated on one village, i.e. Rawa Mekar Jaya. Market price is used to compare and quantify the economic value of the honey. We identified 20 honey collectors, producing a total amount of 416 kg per year, or 12 kg per individual per week. The honey can be harvested each 52 weeks, while the price is IDR 85,000 per kg. Based on inputs, the economic value of mangrove ecosystem in terms of honey production is IDR 35,360,000 per year.

3.4 Ecosystem Value from Regulating Service

Essential functions of mangrove ecosystem include protector against abrasion and sea water intrusion. [20] described that mangrove forest enabled to defense coastal line from wave and storm, while it also reduced intrusion of sea water. Theoretically, sea water intrusion in absence of mangrove ecosystem can be 2 – 3 times higher. In this work, calculation of economic value for protective functions towards abrasion by mangrove forest is based on total investment required for a constructed embankment. The finance reference for the assessment conformed the government standard on construction of embankment [21], reaching IDR 256,954,720,000 per year. As the result, investment for the construction was higher compared with previous report in sub-district Mandah, i.e. IDR 11,947,426,519.2 per year [22].

Furthermore, prevention of salt water intrusion by mangrove forest merits serious concern in respect to its regulating function. Existence of mangrove forest is essential to attenuate the intrusion, which means that it serves in provision of clean water for daily sustenance of coastal population. Absence of mangrove ecosystem implies that protection from salt intrusion as well as water bio-remediation is absent, which in turn, contributing to water scarcity. To quantify the economic value for this service, the valuation is based on the amount of water need in each household [23]. Population that needs access for clean water amounted to 30,842 households, with estimated water necessity of 104 gallons per year. Hence, we found that economic value of mangrove ecosystem as protectors from salt water intrusion was IDR 19,245,408,000 per year.

Transfer benefit is applied to estimate valuation of mangrove ecosystem regarding to its role as carbon sequester. The potential carbon production in Kelapa Pati village was 195.97 tons per ha, with carbon price in international market reaching up to US\$ 15 per ton (US\$ 1 = IDR 14,688). With total mangrove area of 511.4 ha and carbon production of 195.97 tons per ha, the economic value for the mangrove ecosystem service in carbon sequestration reached IDR 22,080,262,859 per year.

Nutrient cycle as the major function of mangrove ecosystem is essential related to production of nutrition, which also contributes to the stability of food webs. In this regard, the service could be represented by the necessity for nitrogen and phosphate often occurring in standard fertilizers. [18] stated that role of nutrient cycle in mangrove ecosystem of Muara Angke could reach 13.08 tons per ha per year, corresponding to phosphate of 2 kg per ha per year and nitrogen of 148 kg per ha per year. To ease the calculation, we used urea and SP-36 fertilizer as reference, using conversion factor of 2.221714 for nitrogen and 2.776949 for phosphate, respectively. Currently, the price of urea and SP-36 is estimated to reach IDR 4,000 per kg and IDR 3,750 per kg. The calculation shows that economic value of mangrove ecosystem as nutrient feeders is IDR 767,350,075 per year.

Besides, mangrove ecosystem is also important as oxygen producer. A former study by [24] discussed potential generation of oxygen in mangrove ecosystem via photosynthetic reaction principles, in relation to carbon in the mangrove forest. In this case, an estimated amount of oxygen produced is 0.499 m³ per ha per year, while the price of commercial oxygen often used in medical purpose is IDR 85,000 per m³. Thus, we obtained the economic value for mangrove ecosystem, i.e. IDR 19,560,000 per year.

3.5 Ecosystem Value from Cultural Service

Mangrove ecosystem may also provide cultural services, such as recreation and education [25]. The valuation was made according to expenditure for tourism activities, i.e. IDR 99,867 per individual, estimated using Travel Cost Method (TCM). The mangrove forest is visited by 9,600 individuals per year. From these inputs, we estimate the valuation of mangrove ecosystem as cultural services reaching up to IDR 958,720,000 per year.

The existing value of ecosystem services provided by the mangrove forest was obtained from judgment of local communities and tourism visitors. The estimated value is obtained to be IDR 8,282,205,366 per year, calculated from “willingness to pay”.

In addition, heritage value is an important element in valuation of a resource. It refers to the extent of attempts by local communities or individuals to conserve the ecosystem for further use by their next generation. The valuation is based on seed price. With density of 1,000 seeds per year, price of IDR 5,000 per seed and total area of 511.4 ha, the economic value of mangrove ecosystem was IDR 5,000,000 per year.

3.6 Total Economic Valuation (TEV)

TEV signifies the value collected from summation of economic values of each ecosystem service, as presented in Table 1. As a result, TEV for mangrove ecosystem service in Sungai Apit was IDR 153,466,048,507,014 per year (equal to IDR 300,090,044.0 per ha per year. The value was higher compared with previous valuation in sub-district Mandah, i.e. IDR 196,733,985 per ha per year (Mandela, 2020).

Table 1 TEV for mangrove ecosystem in Sungai Apit

No	Source	Value (IDR per year)	Percentage
1	Supporting services		
	Composting function and fishery production	23,197,308,560	15.12
	Spawning ground for marine biota	5,870,872,000	3.83
	Biodiversity of mangrove ecosystem	112,671,648	0.07
	Total	29,180,852,208	19.0
2	Provisioning services		
	Income from fishery trade	24,712,320,000	16.10
	Income from honey trade	35,360,000	0.02
	Total	24,747,680,000	16.1
3	Regulating services		
	Protection against abrasion	48,179,010,000	31.39
	Defense against seawater intrusion	19,245,408,000	12.54
	Carbon sink	22,080,262,859	14.39
	Source of nutrition	767,350,075	0.50
	Oxygen production	19,560,000	0.01
	Total	90,291,590,933	58.8
4	Cultural services		
	Recreation	958,720,000	0.62
	Existing value	8,282,205,366	5.40
	Heritage value	5,000,000	0.00
	Total	9,245,925,366	6.0
5	TEV	153,466,048,507,014	100

In this study, the greatest contributor to TEV is from supporting and regulating functions. This implies that mangrove ecosystem supporting the fishery is essential for local communities, primarily providing them the economical advantages. What we observe is concordant with results reported by [24], finding that income received the villagers is economically reliant on fishery sectors, such as fish, shrimps, and crabs.

4. Conclusion

Monetary value of ecosystem services gathered from 4 categories (i.e. supporting, provisioning, regulating and cultural) was obtained as follows: IDR 29,180,852,208 per year, IDR 24,747,680,000 per year, IDR 90,291,590,933 per year and IDR 9,245,925,366 per year, respectively. The total economic value of 511.4 ha mangrove ecosystem in Siak Regency was found to be IDR 153,466,048,507,014 per year or equal to IDR 300,090,044.0 per ha per year. Significant attempts for mangrove ecosystem sustainability are required, i.e. developing the use of mangrove forest with regard to sustainability, improving the carrying capacity in coastal area, as well as enhancing the positive actions by local community.

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