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Total Economic Value of Mangrove Ecosystems in Amahai Village Central Maluku District

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ABSTRACT

The characteristics of mangrove ecosystems as public goods have great potential for degradation if they continue to experience pressure and the absence of sustainable management. The impact will be reduced economic value and require considerable rehabilitation costs to overcome other negative impacts that may occur in the community. This study was conducted to estimate the total economic value of mangrove ecosystems in Amahai Village, Central Maluku District. Respondents are 30 local communities selected by purposive sampling and 1 owner of the mangrove tourism by total sampling. Data analysed using quantitative methods. The results showed that the utilisation of mangrove resources by local communities consisted of fish, shrimp, crab, eco-tourism, research and education. The total economic value (TEV) with an area of 43.9 ha is IDR 5,899,162,139/year or IDR 134,377,270/ha/year, which consists of direct use value IDR 189,839,601/year, indirect use value IDR 5,619,753,331/year, option value IDR 21,025,247/year, existence value IDR 49,560,000/year, and bequest value IDR 18,983,960/year. This economic value indicates that the mangrove ecosystem plays an important and strategic role in the lives of local communities. Therefore, this value can be a source of information for the government as a policy holder in managing mangrove ecosystems in Amahai Village.

INTRODUCTION

Mangrove ecosystems management is inseparable from community involvement, there are people who depend on the existence of mangroves for life fulfilment. People who live around mangroves utilise fish, shrimp, crabs, firewood, and others that come from mangrove areas (Suharti *et al*., 2016 cited by Lugina *et al*., 2019). However, its contribution to the economic system is very difficult to do, this is because there is no market that is able to value the whole thing. In fact, when viewed from the condition of mangrove ecosystems, both those that have been damaged and those that are still good, have enormous economic value.

Lack of information on the value of natural resources and the environment leads to environmental degradation and the resulting economic costs because it is not uncommon for natural resources to be undervalued and markets fail to signal the true scarcity of coastal resources (Perring, 2016; Ruban *et al*., 2021). Therefore, an economic valuation is needed that includes an assessment of the overall benefits of mangrove ecosystems to the local communities. It aims to provide the economic value of a resource (Parmawati, 2019), so that it is expected to help decision makers to determine public policies related to natural resource management and the environment.

The mangrove ecosystems in Amahai Village is utilised by the local community as a location for fish, shrimp, crabs, and other types of marine biota that live in mangrove ecosystems, as a settlement and the construction of tourist attractions that are privately owned and managed by the local community with an average of 150 visitors per month. It is also often used as a place for educational and research activities. In addition, indirect functions including protecting the coast from abrasion, high waves, and so on. Direct use value of mangrove ecosystems that are known to have high economic value, the indirect use value also has great economic value but the community still does not realise the importance of these indirect value.

The problem that occurs in some areas is that the socio-economic functions and ecological functions of mangrove ecosystems are not balanced, where in one place there is massive exploitation of mangrove ecosystems without regard to their ecological functions and on the other hand they are not managed so as not to provide sustainable socio-economic benefits for the surrounding community. Previous research conducted by Setiawan (2018) found that mangrove ecosystems degradation in this study was caused by the conversion of the land into tourist attractions and crab ponds. According to Setyawan *et al*. (2006) cited by Setiawan (2018), the rate of damage to mangrove ecosystems is very fast due to pond development, mangrove ecosystems logging, environmental pollution, reclamation and sedimentation, mining. Other factors are caused by natural factors such as storms, tsunamis, rising land surfaces (as a result of earthquakes) and others.

Mangrove ecosystems in Amahai Village require management policies to prevent overexploitation that leads to damage and loss of benefits. This study aims to provide accurate information on the total economic value of mangrove ecosystems based on the quantification of all components of economic value. Thus, without waiting for damage/degradation, the economic value information can be a recommendation for mangrove ecosystems management policies for sustainable utilisation.

METHODS

This research was conducted from January to May 2024 in Amahai Village, Central Maluku District using the survey method. Primary data collected in the form of interviews with mangrove ecosystems users, secondary data obtained from the Government of Amahai Village and the Public Works Office of Central Maluku District regarding the cost of making coastal embankments. The sample used consists of:

a. Households of mangrove ecosystem users using purposive sampling method, the number is determined using the Slovin formula as follows (Ahaya *et al*., 2022):

$$n = \frac{N}{1+N(e)^2} \quad n = \frac{91\ KK}{1+91\ KK\ (15\%)^2} \quad n = 29{,}86 = 30$$

Where:
n = Number of samples (people)
N = Total population (people)
e = Error limit (15%)
1 = Constant number

b. The owner of the mangrove tourism uses total sampling method, which is a sampling technique when all members of the population are used as samples (Sugiyono, 2019). The owner totalled 1 person who was used as a sample.

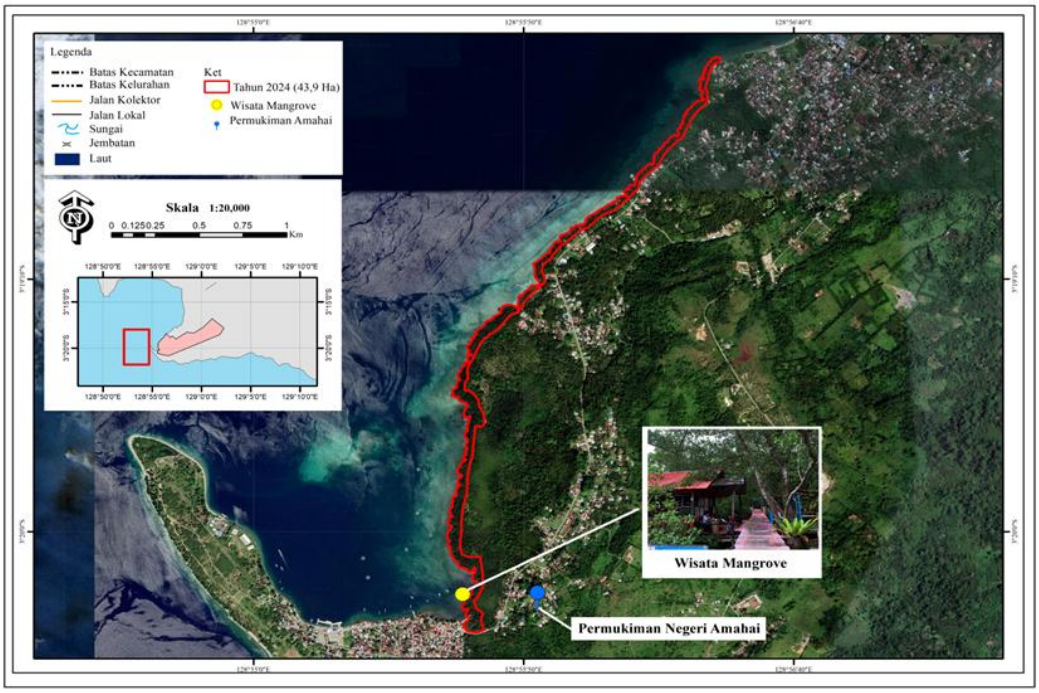

Figure 1. Research Location

Champ *et al*. (2001) cited by Fauzi (2014) stated that economic valuation should be an important part of public policy because economic valuation will be a vital source of information in conducting a more comprehensive cost benefit analysis of public policy. The economic valuation of mangrove ecosystems benefits is carried out by identifying and calculating the total economic value components consisting of:

a. Direct Use Value

The total value of direct use can be obtained by the following formula (Olfie, 2011 cited by Nurfadillah, 2017):

$$ML = ML_1+ML_2+ML_3+ML_4+ML_5$$

Where:
ML = Direct use value (IDR/yr)
ML_1 = Value of fish (IDR/kg)
ML_2 = Value of shrimp (IDR/kg)
ML_3 = Value of crab (IDR/kg)
ML_4 = Value of tourism (IDR)
ML_5 = Value of research and education (IDR)

The calculation of direct use value is based on the actual market price (Bishop, 1999 cited by Nurfatriani, 2006). According to Nurdin *et al*., (2021), the value of the benefits of fish,

shrimp and crabs based on market prices can then be calculated income or net benefit value using the following formula:

$$\pi = TR - TC$$

Where:
π = Income (IDR)
TR = Total revenue (IDR)
TC = Total cost (IDR)

The value of tourism, research and education is calculated using the replacement cost method, which is from the income of tourist attractions per year obtained from the results of multiplying the price of tourist entrance tickets by the average number of visitors per year (Rosadi *et al*., 2020). The calculation of the value of research and education uses the amount of practical or research costs obtained multiplied by the number of researchers in one year (Maharmingnastiti *et al*., 2015).

b. Indirect Use Value

Calculation of indirect use value uses the following formula:

$$MTL = MTL_1 + MTL_2 + MTL_3$$

Where:
MTL = Indirect use value/indirect benefit (IDR/yr)
MTL_1 = Value as abrasion barrier (IDR/yr)
MTL_2 = Value as a food provider for crabs (IDR/yr)
MTL_3 = Value as carbon sequestration (IDR/yr)

Indirect use value of mangrove ecosystems as abrasion barriers can be estimated using the replacement cost approach, which is all costs incurred to build embankments (Ariftia, 2014). To calculate it, the following formula can be used (Sibrianti & Suratmi, 2017):

$$NPA = PP \times BPTPP$$

Where:
NPA = Abrasion resistance value (IDR/yr)
PP = Beach length (m)
BPTPP = Cost of making a coastal protection embankment (IDR)

Other indirect benefits of the mangrove forest ecosystem, as a food provider for crabs, can be calculated through a replacement cost approach. This value is estimated to be equivalent to the amount of feed required for each kilogram of crabs from crab catches around the mangrove ecosystem multiplied by the price of crab feed. It can be formulated as follows (Baderan, 2013):

$$NPP = T \times Pk \times H$$

Where:
NPP = Value of feed provider (IDR/yr)
T = Crab catch (kg)
Pk = Crab feed (kg)
H = Crab feed price (IDR)

Mangrove ecosystem also function as carbon sequestration, the value can be obtained using the benefit transfer method, with the following equation (Harahap, 2010 cited by Nanlohy, 2015):

$$NPK = LM \times KMKt \times HK$$

Where:
NPK = Value of carbon sequestration (IDR/yr)
LM = Mangrove area (Ha)
KMKt = Carbon sequestration capability (417,04 tonnes/ha)
HK = Carbon price (US$ 6/tonne)

c. Option Value

The option value can be calculated using the benefit transfer method, which is derived from an approach to the biodiversity value of mangrove ecosystems in Indonesia (Ruitenbeek, 1992; Widiastuti *et al*., 2016; Johari *et al*., 2023). Option value can be formulated as follows:

$$OV = Vb \times L$$

Where:
OV = Option value (IDR/yr)
Vb = Mangrove ecosystem biodiversity value (US$ 30/ha/yr) (Johari *et al*., 2023)
L = Mangrove area (Ha)

d. Existence Value

Calculated using the Contingent Valuation Method/CVM, which is a direct method of economic valuation through questions of people's willingness to pay (WTP) (Fauzi, 2014), to get the total value of the respondent's willingness to pay (WTP) the following equation is used:

$$TWTP = \sum_{i=1}^{n} WTPi \left(\frac{ni}{N}\right) P$$

Where:
TWTP = Total value of willingness to pay (IDR/month)
WTPi = The willingness to pay value of the i-th respondent (IDR/month)
Ni = Number of respondents i who are willing to pay at WTP
N = Number of samples (people)
P = Total population (people)
I = The i-th respondent who is willing to pay (i=1,2,...,n)

e. Bequest Value

Bequest value of mangrove cannot be calculated using the market value approach. Therefore, it can be calculated with the thought approach. Because of this, it is estimated that the bequest value is not less than 10% of the direct use value of mangrove ecosystems (Ruitenbeek, 1992 cited by Aco, 2015).

f. Total Economic Valuation

Total economic value is the quantification of all use values into monetary value. Total economic valuation can be obtained using the following formula (Turner, 2016):

$$TEV = DUV + IUV + OV + EV + BV$$

Where:
TEV = Total Economic Value (IDR/yr)
DUV = Direct Use Value (IDR /yr)
IUV = Indirect Use Value (IDR /yr)
OV = Option Value (IDR /yr)
EV = Existence Value (IDR /yr)
BV = Bequest Value (IDR /yr)

RESULTS

Direct Use Value

Direct use value relates to direct output that can be consumed by the community to meet their needs and improve community welfare, obtained through the market value approach of various mangrove forest commodity products studied at the research site.

Table 1. Direct Use Value

No	Type of Utilisation	Direct Use Value (IDR/year)	Percentage (%)
1	Fish	24,462,692	12.89
2	Shrimp	14,620,314	7.70
3	Crab	26,956,595	14.20
4	Mangrove Tourism	18,000,000	9.48
5	Research and Education	105,800,000	55.73
	Total	189,839,601	100.00

Source: Primary Data Processed, 2024

Indirect Use Value

Indirect use value is the benefit obtained from natural resources and environmental services without having to actually consume them (Fauzi, 2014). Environmental services owned by the mangrove ecosystems of Amahai Village are as an abrasion barrier, natural food provider for crabs, and as carbon sequestration.

Table 2. Indirect Use Value

No	Type of Utilisation	Indirect Use Value (IDR/year)	Percentage (%)
1	Abrasion Barrier	3,852,064,098	68.55
2	Crab Feed Provider	14,015,473	0.25
3	Carbon Sequestration	1,753,673,760	31.21
	Total	5,619,753,331	100.00

Source: Primary Data Processed, 2024

Option Value

The option value in this study was calculated using the benefit transfer method approach, which assesses the estimated benefits from elsewhere, then the benefits are transferred to obtain a rough estimate of the benefits from the environment. The method was approached by calculating the biodiversity benefits of the mangrove area.

Table 3. Option Value

Type of Utilisation	Mangrove Area (ha) (ha)	Biodiversity Value (US$/ha)	Biodiversity Value (IDR/ha)	Option Value (IDR/year)
Biodiversity	43.9	30	478,935	21,025,247
Total				21,025,247

Source: Primary Data Processed, 2024

Existence Value

WTP analysis was conducted on 51 people of Amahai Village, consisting of 31 users and 20 people of Amahai Village who knew the existence of mangrove ecosystems. The analysis

was conducted by asking the community's willingness to spend money to maintain and preserve the benefits of the mangrove ecosystems of Amahai Village.

Table 4. Distribution of Respondents' Willingness to Pay

No	Bid WTP (IDR/Month)	Number of Person
1	5,000	6
2	10,000	23
3	15,000	15
4	20,000	3
5	25,000	1
6	30,000	0
Total		48

Source: Primary Data Processed, 2024

Table 5. Calculation of K-M-T Technique

Bid WTP	5,000	10,000	15,000	20,000	25,000	30,000
Acceptance	6	23	15	3	1	0
Acceptance Rate (fj)	0.125	0.48	0.31	0.06	0.02	0.00
fj - fj+1	0.35	0.17	0.25	0.04	0.02	0.00
Bid x Freq	1770.83	1666.67	3750	833.33	520.83	0.00
Mean WTP (IDR/Month)			5,000			

Source: Primary Data Processed, 2024

Table 6. Total Willingness to Pay

Mean WTP (IDR/month)	Number of Households	Total WTP (IDR/month)	Total WTP (IDR/year)
5,000	826	4,130,000	49,560,000

Source: Primary Data Processed, 2024

Bequest Value

The bequest value of the Amahai Village mangrove ecosystem is IDR 18.983.960/yr.

Total Economic Value

Total economic value is the sum of all benefit values of a resource. Based on the calculation of the value of all benefits, the total economic value owned by mangrove ecosystems in Amahai Village.

Table 7. Total Economic Value

No	Type of Value	Benefit Value (IDR/yr)	Percentage (%)
1	Direct Use Value	189,839,601	3.22
2	Indirect Use Value	5,619,753,331	95.26
3	Option Value	21,025,247	0.36
4	Existence Value	49,560,000	0.84
5	Bequest Value	18,983,960	0.32
Total		5,899,162,139	100.00

Source: Primary Data Processed, 2024

DISCUSSION

Direct Use Value

The average fishing frequency was 19 trips/month and 222 trips/year by 30 respondents/fishermen, with production of 163 kg/month and 1,960 kg/year. The types of fish caught were kawalinya/selar (*Selar* sp), bubara/kuwe (*Caranx sexfasciatus*), lema/puffed fish (*Rastrellinger* sp), sikuda (*Lethrinus ornatus*), and grouper (*Epinephelus* sp). The caught fish is sold at IDR16,000/kg, with an average cost of IDR6,897,308/year.

Shrimp catching was conducted by 5 respondents, the type of shrimp caught was tiger shrimp (*Penaeus monodon*) with an average selling price of IDR45,000/kg. The average frequency of shrimp catching was 10 trips/month and 115 trips/year, production volume was 36 kg/month and 432 kg/year and the average cost incurred was IDR4,819,686/year. Crab catching was carried out by 6 respondents, with an average catching frequency of 15 trips/month and 176 trips/year and production volume of 30 kg/month and 360 kg/year. The catch was sold at IDR90,000/kg and the average cost incurred was IDR5,443,405.

Mangrove tourism is privately owned and managed by the community, with 1 owner. This location is equipped with various facilities that make an entrance fee charged to visitors of IDR 10,000/person. The average number of visits in Amahai Village mangrove tourism is 150 people/month or 1,800 people/year. Research and education activities are carried out by students around Amahai District and academics. Based on the results of interviews with owner, in 2023 there were 44 people conducting research and education activities, consisting of 2 groups of elementary school students, where each group consist of 20 people, 3 lecturers, and 1 student. The costs incurred to conduct educational and research activities are based on the Ministry of Education, Culture, Research, and Technology regarding practicum and research costs based on education levels, for elementary students which is IDR 20,000/person, undergraduate students IDR 2,500,000/person, and IDR 100,000,000/group of lecturers.

Indirect Use Value

The cost of making abrasion barriers was obtained from the Public Works Office of Central Maluku District Amahai Sub-District. The coastal embankment built has a size of 43 m x 2.2 m x 2.6 m (p x l x t), with a durability of 5 years, a total cost of IDR175,800,000 is required or around IDR4,088,572/m (Public Works Office of Central Maluku District, 2023). The length of the coastline in Amahai Village is 4,711 m (Government of Amahai Village, 2024).

The value of mangrove ecosystem as natural food providers was approached using the regression equation of mangrove ecosystem area and crab production as done by Walpole, (1988) cited by Tupan *et al*., (2005) namely $Y = a + bX$. The regression analysis conducted resulted in the regression equation: $Y = a + bX = 42.162 + 10.864X$. The area of mangrove ecosystem in Amahai Village is 43.9 ha, this means that $\hat{Y} = 42,162 + 10,864\ (43.9) = 519,092$, meaning that the estimated area of mangrove ecosystem can produce 519.092 grams/year of crabs. Then based on the price of crab feed of IDR4,500/gram and the need for feed per crab of 6 grams (Talakua, 2013), the indirect use value as a provider of feed is IDR14,015,473/year.

The calculation of indirect use value as a carbon sequestration using benefit transfer method refers to the research of Rahman *et al*. (2017), because the types of mangroves studied are the same, namely *Rhizophora* sp, *Bruguiera* sp, *Sonneratia* sp, and *Nypa* sp, so it is assumed to have the same carbon sequestration value. The area of mangrove in Amahai Village is known to be 43.9 ha (Government of Amahai Village, 2024). The value of the ability to absorb carbon from mangroves based on previous research used as a reference is 417.04 tons/ha. Then the price of carbon in the voluntary market is known to be US$ 6/tons, adjusted to the rupiah exchange rate against US$ 1 which is IDR15,964.50 (on 10 May 2024). The

exchange rate will then be multiplied by the carbon price in US$, resulting in a carbon price of IDR95,787/tons.

Option Value

According to Johari *et al*., (2023), the value of biodiversity owned by mangrove forests is 30 US$ / ha / year, this value can be used throughout the mangrove forests in all regions of Indonesia if the mangrove forest ecosystem is ecologically important and naturally maintained. The biodiversity value is transferred to the rupiah exchange rate against US$ 1 which is IDR 15,964.50 (on 10 May 2024). The exchange rate will then be multiplied by the biodiversity value in US$, resulting in a value of IDR478,935/ha/year.

Existence Value

Based on the willingness to pay question (yes or no), 48 people (94%) were willing to pay while 3 people (6%) were not willing to pay. Respondents who were willing to pay were given a follow-up question, namely a willingness to pay value offer consisting of IDR5,000, IDR10,000, IDR15,000, IDR20,000, IDR25,000, and IDR30,000 (Based on the Structure and Tarif of Retribution for Waste/Cleaning Services in the Regional Regulation of Central Maluku District Number 07 of 2018 on Retribution for Waste/Cleaning Services). The distribution of willingness to pay shows that the higher the bid WTP, the less willingness to pay by respondents, and vice versa (Matondang *et al*., 2020). Mean WTP through the K-M-T calculation technique obtained a mean WTP of IDR5,000, this means that respondents are willing to pay a fee of IDR 5,000/month as a form of contribution in preserving the existence of mangrove ecosystems in Amahai Village. The total value of willingness to pay (TWTP) is IDR4,130,000/month or IDR49,560,000/year. This value can be used by the government to formulate sustainable mangrove ecosystems management policies in Amahai Village.

Bequest Value

The bequest value of mangrove forests cannot be calculated with a market value approach, therefore the heritage value can be calculated with a thinking approach. According to Ruitenbeek (1992) in Aco (2015), it is estimated that the bequest value is not less than 10% of the total value of direct use value. Based on the calculations, the total value of direct use value is IDR189,839,601/year, 10% of this value results in a value of IDR18,983,960/year.

Total Economic Value

The total economic value of mangrove ecosystems in Amahai Village in 2024 with an area of 43.9 ha is IDR5,899,162,139/year, or IDR134,377,270/ha/year. This relatively large economic value indicates that the mangrove area is a very important and strategic ecosystem for the lives of local communities. On the other hand, this value also illustrates the amount of economic loss if the mangrove ecosystems is damaged. When compared to all values, the highest benefit value is the indirect use value of IDR5,619,753,331/year or 95,26%, indicating that people in coastal areas, especially Amahai Village, understand the potential of mangrove ecosystem services that are important for life. The lowest benefit value is the value of bequest value, which is IDR18,983,960/year or 0,32%, this is because there are no endemic animals living in the mangrove ecosystems of Amahai Village that can allow calculations to produce high values.

CONCLUSION

Mangrove ecosystems resources utilised by local communities in Amahai Village are fish, shrimp, crabs, eco-tourism, and as a place of research and education. The total economic value with an area of 43.9 ha is IDR5,899,162,139/year or IDR134,377,270/ha/year, which consists

of direct use value of IDR189,839,601/year, indirect use value of IDR5,619,753,331/year, option value of IDR21,025,247/year, existence value of IDR49,560,000/year, and bequest value of IDR18,983,960/year. The economic value of mangroves can increase public investment in the form of knowledge of the intrinsic value of natural resources. Therefore, this value can be the basis for the government as a policy holder in managing mangrove ecosystems in Amahai Village, so that it can supply environmental products and services for the welfare of the community. Furthermore, research related to community-based management models is needed to support the sustainability of the mangrove ecosystem.

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