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Economic Value of Mangrove Ecosystems in Amahai Country, Central Maluku Regency

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Abstract

The mangrove ecosystem of the State of Amahai provides the function of protecting the coast, biota habitat, fishery utilization space, ecotourism, and social benefits for the community. This research aims to identify forms of utilization, calculate measurable Total Economic Value (TEV), analyze policy implementation, and formulate an expected sustainable management model. The research uses a descriptive quantitative approach supported by interviews, observations, documentation, and policy reviews. The main data was obtained through questionnaires of 51 purposively selected community respondents as well as interviews with the state government, regional apparatus, State BUM, cage owners, and youth organizations. Valuation is carried out by approaching market prices, replacement costs, willingness to pay, and benefit transfer. The results showed that 98.0% of respondents knew about mangroves and all respondents acknowledged the function of coastal protection. A total of 22 respondents used the area, especially for fish and coastal biota. The value of direct benefits is estimated at IDR 78,296,667 per year, the indirect benefits of coastal protection are IDR 1,505,000,000 per year, the existence value of IDR 200,640,000 per year, and the value of options in an area of 17.37 ha is IDR 4,253,479 per year. The sum of the components produces a measured TEV of IDR 1,788,190,145 per year. Central Maluku Regency Regional Regulation Number 6 of 2021, Central Maluku Regent Decree Number 556-361 of 2021, and Amahai State Regulation Number 04 of 2025 have provided direction and basis for authority, but have not yet regulated mangrove management in an operational and detailed manner. Therefore, a collaborative management model based on conservation and community economic empowerment was formulated through input flows, processes, outputs, and outcomes. The model places ecological protection, environmentally friendly use, institutional strengthening, regulation, supervision, and empowerment as a management unit.

INTRODUCTION

Mangrove ecosystems are one of the main ecosystems in coastal areas because they connect ecological, economic, and social functions in one space. Ecologically, mangroves act as coastal protectors, control of seawater abrasion and intrusion, sediment catchers, as well as *spawning grounds*, nursery *grounds*, and foraging for fish, shrimp, crabs, mollusks, and other biota. Economically, mangroves provide fishery products, food and raw materials, cultivation spaces, as well as tourism and education services. These functions show that mangrove damage not only reduces the quality of the environment, but can also reduce the benefits received by coastal communities (Rusila Noor et al., 2012; Sambu et al., 2018).

The 2021 National Mangrove Map records the area of Indonesia's mangroves of 4,120,263 ha consisting of existing mangroves and potential habitats. Maluku Province has 181,901 ha of mangroves. At the Central Maluku Regency level, data from the Central Statistics Agency in 2015 recorded around 7,057.40 ha of mangroves spread across various sub-districts. The data confirms

the position of mangroves as an important natural resource asset for the archipelago and coastal areas of Central Maluku.

The country of Amahai is close to Masohi City and has a mangrove ecosystem, fishery and cage activities, as well as the tourist attraction of the Warano Mangrove. Proximity to market centers and services opens up opportunities for economic development, but at the same time increases the pressure on the use of coastal space. The data on the area of the Amahai mangroves is also not uniform: about 10 ha based on local information from the state government, 17.37 ha based on data from the Environment Agency, and 62 ha in the 2024 Amahai Country Profile. This study uses 17.37 ha as the main estimate because it is the most specific district technical data for the Land of Amahai.

The results of observations and interviews show that the Amahai mangroves are generally still considered good and function to protect the coast and support the existence of biota. The community uses the area to look for fish, shrimp, crabs, shellfish, and bia; The area is also related to cages, ecotourism, education, and research. However, management of dealing with waste, the possibility of wood use, damage to tourism facilities, budget limitations, weak supervision, and the lack of regular ecological monitoring. This condition shows that economic utilization needs to go hand in hand with ecosystem protection.

The value of most mangrove services is not formed through market transactions. Revenue from tour tickets or the sale of fishery products captures only a small portion of the benefits, while the functions of coastal protection, the value of existence, and the value of options for future use are often not recorded. The Total Economic Value Framework allows direct benefits, indirect benefits, option values, and existence values to be calculated in one transparent system. This information can be the basis for comparing conservation benefits with damage costs, prioritizing financing, and strengthening policy arguments (Safoan, 2011; Salakory et al., 2017).

Relevant policies are in place. Central Maluku Regency Regional Regulation Number 6 of 2021 provides direction for sustainable tourism development and places the Amahai Mangrove Ecotourism as a natural tourism attraction. The Decree of the Regent of Central Maluku Number 556-361 of 2021 stipulates Amahai as a tourist country, while Amahai State Regulation Number 04 of 2025 provides the basis for local authority for spatial planning, State BUM, tourism development, state forest maintenance, and waste management. However, the three instruments have not regulated in detail zoning, carrying capacity, permits, financing, benefit sharing, monitoring, supervision, and special sanctions for mangroves.

Previous research in Waiheru, coastal Ambon City, and Ambon Bay Baguala shows that indirect benefits are often the largest component in mangrove valuation (Nanlohy, 2013; Talakua, 2013; Salakory et al., 2017). However, the values between locations cannot be directly compared due to differences in extent, socio-ecological conditions, price years, and component coverage. The gaps to be filled by this study are the use of the latest field data on the scale of the Amahai Country, the association of valuation results with the implementation of district and state policies, and the formulation of the expected collaborative management model, so that it can be translated into operational steps.

Thus, research does not stop at the calculation of monetary value. Valuation is placed as economic evidence which is then met with policy conditions, institutions, community participation, and management needs. This approach is important so that the economic value of mangroves becomes the basis for maintaining ecological functions and improving community welfare.

1.2 Problem Formulation

Based on this background, the research questions are formulated as follows:

1. What are the forms of utilization of the mangrove ecosystem in the Land of Amahai?
2. What is the economic value of the mangrove ecosystem in the Land of Amahai based on measurable components?
3. How is the implementation of policies in supporting the economic value and sustainability of mangrove ecosystems in the Land of Amahai?

4. What is the expected management model for the sustainable management of mangrove ecosystems and in accordance with the conditions of the Land of Amahai?

1.3 Research Objectives

In line with the formulation of the problem, this study aims to:

5. Identify forms of mangrove ecosystem utilization in the Land of Amahai.
6. Analyze the direct benefits, indirect benefits, choice values, existence values, and total economic value of mangrove ecosystems.
7. Analyze policy implementation in supporting the economic value and sustainability of mangrove ecosystems.
8. Formulate the expected management model for sustainable mangrove management in the Land of Amahai.

Literature Review and Conceptual Framework

Mangrove Ecosystem, Function, and Utilization

The term mangrove is a word that comes from a combination of the Portuguese *mangue* and the English *grove* (Macnae 1968 in Rusila Noor et al., 2012). Mangrove ecosystems are located at the transition of land and sea so that they become a link for the flow of organic matter, sediment, and nutrients. Its root, crown, and litter structures form habitats that support aquatic productivity, reduce wave energy, and stabilize shorelines. This character causes the benefits of mangroves to be assessed as an ecosystem unit, not just based on products that are harvested directly (Rusila Noor et al., 2012; Sambu et al., 2018).

The existence of mangrove ecosystems has three main functions, namely physical, biological/ecological, and economic functions. Physical functions include windbreaking, filtering pollutants, wave arresters, flood control and preventing seawater intrusion into land. Biological/ecological functions as *spawning grounds*, *nursery grounds*, and feeding grounds for fish and other marine life. The function of the economy as a source of seeds, wood production for raw materials and building materials, foodstuffs and medicines (Romimortato Juwana, 2001 in Lekatompessy 2018).

The use of mangroves can be in the form of direct results, such as fish, shrimp, crabs, shellfish, wood, foodstuffs, and medicinal materials; as well as indirect services, such as coastal protection, biota habitat, and environmental regulation. In certain areas, mangroves are also used for ecotourism, education, research, and community business development (Bengen, 2001; Rusila Noor et al., 2012). Traditional use on a household scale can provide food benefits and cost savings. However, the value of these benefits is often not recorded because the results are not always sold and the units used are local.

Uncontrolled utilization can increase pressure through logging, space conversion, pollution, garbage, and the use of destructive fishing gear. Therefore, the development of economic benefits needs to follow carrying capacity, zoning, environmental standards, and supervision involving the community and the government (Bengen, 2001; Suryanti et al., 2019).

Approach to Economic Valuation of Mangrove Ecosystems

The valuation of the economic value of mangrove ecosystems aims to measure the value of the benefits provided by mangroves into monetary measures, so that market and non-market services can be considered in decision-making. The *Total Economic Value* framework groups benefits into use value and non-use value. The use value consists of direct benefits, indirect benefits, and option values; Non-purpose value includes the value of existence and, in certain studies, the value of heritage (Safoan, 2011).

Direct *Use Value* (DUV) comes from the direct use of resources, such as fishery products, cages, tourist tickets, or other products that have quantity and price. Indirect *Use Value* (IUV) benefits come from environmental services, such as coastal protection, wave energy reduction, abrasion control, and habitat function. Option *Value* (OV) reflects the value of maintaining the possibility of future resource utilization and biodiversity. Existence *Value* (EV) is the value provided by the

community because the ecosystem still exists and is preserved, even though it is not directly utilized.

The method of measuring values needs to be adjusted to the character of benefits and the availability of data. Market prices are used when quantities and prices can be observed; *replacement costs* are used as a proxy for the value of environmental services if artificial infrastructure with comparable functions is available; *The Contingent Valuation Method* measures non-market benefits through *Willingness to Pay* (WTP); and benefit transfer using values from previous studies with explainable adjustments.

This study calculated the measured TEV of DUV, IUV, OV, and EV. The value of inheritance is not calculated separately because the questionnaire instrument does not explicitly distinguish it from the value of existence. The biological habitat function is also not monetized separately to avoid double counting with the benefits of fisheries that have been included in the DUV.

Implementation of Mangrove Management Policy

Policy implementation is the process of turning formal goals and provisions into actions, outputs, and impacts. Edwards III (1980) explained that the success of implementation is influenced by communication, resources, the disposition of the implementers, and the bureaucratic structure. These four dimensions help assess whether policy directions have been understood, supported by resources, accepted by implementers, and implemented through a clear division of labor.

In mangrove management, the existence of regulations does not automatically guarantee the protection of the area. Policy directions need to be translated into boundaries and zoning, permitted and prohibited activities, permit procedures, management structures, financing, benefit-sharing, monitoring, supervision, and sanctions. The implementation analysis therefore compares the content of the policy with the field conditions and operational needs of management (Ely et al., 2021).

Sustainable and Collaborative Management

Sustainable management aims to maintain ecosystem integrity, maintain equitable economic benefits, and strengthen institutions in the long term. Collaborative management is needed because mangroves are related to government authority, community rights and knowledge, customary institutions, business activities, and conservation interests. Effective collaboration requires common goals, agreed data, division of roles, coordination forums, transparency, and periodic evaluation (Suryanti et al., 2019; Ely et al., 2021).

In the context of Amahai, the Regency Government, the State Government, the State Saniri Agency, customary institutions, the State BUM, community groups, youth, women, and supporting elements need to be placed in one system. Utilization can be carried out as long as it does not reduce ecological functions, follows the carrying capacity, and provides fair benefits to the local community. Management models must balance ecological protection with environmentally friendly economic utilization and provide adaptive monitoring and learning mechanisms (Ely et al., 2021).

Conceptual Framework of Research

The research starts from the identification of mangrove conditions and areas, community characteristics, forms of utilization, local prices, and policy frameworks. The data is analyzed to produce measurable DUV, IUV, OV, EV, and TEV. The results of the valuation are then combined with the conditions of policy implementation and institutional needs to formulate the expected management model.

RESEARCH METHODS

Location, Time, and Research Methods

The research was carried out in Amahai Country, Amahai District, Central Maluku Regency. The main data collection takes place in July-August 2025, while processing, document verification, and writing are carried out until 2026. The location was chosen because it has a mangrove ecosystem,

fishery and cage activities, Waerano Mangrove tourist attractions, customary institutions, and relevant state policies.

The approach used is quantitative descriptive. Quantitative data was obtained from questionnaires, calculations of frequency of utilization, price, quantity, WTP, and valuation calculations. Interviews, observations, documentation, and policy reviews are used to explain the numbers, check the consistency of information, and interpret policy implementation.

Populations, Samples, and Data Sources

The population of the community refers to the 2024 Amahai Country Profile, which is 3,180 people or 816 heads of families. The questionnaire respondents totaled 51 people who were selected purposively by considering proximity, knowledge, or linkage with coastal areas and mangrove ecosystems. In addition, institutional and policy information was obtained from separate respondents, namely the State Government, regional apparatus, State BUM/tourism managers, cage owners, and youth organizations. Secondary data includes the 2024 Amahai Country Profile, mangrove area and condition data, market prices, estimated talud costs, and district and state regulations.

Data Collection Techniques

The data collection techniques used are: (1) Field Research, which is by observation and interviews with respondents to obtain accurate data such as the forms of utilization carried out by the community; and (2) *Library Research*, which is studying and observing various literature, written reports, and related documents from sources or related parties.

Data Analysis Techniques

The analysis is carried out in four stages: namely data collection and verification, identification and valuation of benefits, quantification of all components into the value of the rupiah, as well as policy analysis and formulation of management models.

1. Questionnaire stage and interviews with respondents related to mangrove ecosystems in Amahai Country. In the implementation of surveys in the field, three complementary question models are used, namely open-ended questions, closed-ended questions, and agree or disagree questions.
2. The stage of identification of forms of utilization of mangrove forest ecosystems. This stage aims to obtain data on various benefits of mangrove ecosystems which include: DUV calculated from the results of fisheries utilization, gross receipts for tourist tickets, and one unit of observed cage. IUV is limited to beach protection services using talud replacement fees in accordance with the 2025 PUPR Office Budget Implementation Document (DPA). EV was calculated from the average WTP of respondents extrapolated to 816 households over 12 months. OV uses a benefit transfer of US$15 per ha per year at an exchange rate of Rp16,325 per US$ on July 18, 2025 (Bank Indonesia, 2025; Safoan, 2011).

   DUV = value of utilization results + tourism receipts + observed cage value

   IUV = (protected beach length x talud cost per meter) / useful life

   EV = (number of WTPs / number of respondents) x number of KK x 12 months

   OV = US$15/ha/year x rupiah exchange rate/US$ x mangrove area

   TEV = DUV + IUV + OV + EV
3. Stage of quantification of all benefits and functions into monetary value (Rupiah) This stage is carried out after all benefits and functions of the mangrove forest ecosystem have been successfully identified. According to Safoan (2011), the quantification techniques used are:
   a. Market value is used to classify commodities that can be directly marketed. This method is mainly to assess the direct benefits of mangrove forest ecosystems, for example forest products, fishery products (fish and other fishery biota).

b. Indirect pricing is used when the market mechanism fails to provide value to the resource component being studied. The calculation method carried out is the *replacement cost* method. This method can be used to assess the indirect value of the mangrove ecosystem.

c. Contingent Valuation method, used to quantify the benefits of the existence of the mangrove forest ecosystem being studied. One of them is to see the willingness *to pay (*WTP) by the community.

4. Expected Policy Analysis and Management Method Analysis.

The policy analysis uses content analysis of 3 (three) policies relevant to the management of mangrove ecosystems in the Country of Amahai, namely Regional Regulation of Central Maluku Regency Number 6 of 2021 concerning the Master Plan for Tourism Development for 2021-2025, Decree of the Regent of Central Maluku Number 556-361 of 2021 concerning the Determination of Tourism Administrative Lands and Lands, and Amahai State Regulation Number 04 of 2025 concerning the List of State Authorities Based on Rights of Origin Proposals and Local Authorities on a State Scale. The content of the document is mapped based on policy direction, authority, institutional, environmental protection, empowerment, and form of implementation. The findings of the document were then compared with the results of questionnaires, interviews, observations, and valuation data to determine the suitability between normative provisions and empirical conditions. The next stage assesses the conditions of implementation through four dimensions, namely communication, resources, disposition, and bureaucratic structure. Each dimension is described descriptively based on the convergence or difference in information between informants and documentary evidence. Gap analysis is used to identify aspects that are already available, still general, or unregulated, such as zoning, carrying capacity, licensing, financing, benefit-sharing, monitoring, supervision, and sanctions (Edwards III, 1980; Ely et al., 2021).

The method of formulation of the expected management model is carried out by synthesizing the results of economic valuation, ecological conditions, community participation, policy implementation analysis results, and institutional needs. These components are then synthesized into *the input–process–output–outcome* flow.

RESULTS AND DISCUSSION

Conditions of Mangrove Regions and Ecosystems

The land of Amahai is bordered by the Land of Sehati to the north, the Land of Soahuku to the south, the Amahai manor territory to the east, and Elpaputih Bay to the west. The distance is about 1.3 kilometers from the center of the sub-district and 6 kilometers from the center of Central Maluku Regency. The 2024 Amahai State Profile recorded 3,180 residents in 816 households. The livelihoods of the community are diverse; Fishermen as the main occupation were recorded at 12 people. The low number of fishermen as the main occupation does not mean low interaction with mangroves because some residents use fish or biota on an occasional basis for household consumption.

Data sources provide different broad figures. The State Government locally knows about 10 ha. The Environment Agency recorded 17.37 ha and assessed its condition as good, while the 2024 Amahai Country Profile recorded 62 ha consisting of 50 ha in good condition and 12 ha damaged. Data from the Fisheries Service of 839.3 ha is on the scale of Amahai District, so it is not directly proportional to the area of the Amahai Country. The study used 17.37 ha as the main estimate, but the discrepancies indicate the need for shared spatial verification. Data on the area and condition of mangroves can be seen in Table 1 below.

Table 1. Differences in the area of data and the condition of mangroves in the country of Amahai

Source	Area/coverage	Conditions	Interpretation
State Government	Approx. 10 ha	Generally good	Locally known or managed core areas
Environment Agency	17.37 ha	Good; There is no regular monitoring.	The most specific district technical data for Amahai
State Profile 2024	62 ha	50 ha is good; 12 ha damaged	Administrative records; Need for Spatial Verification
Fisheries Service	839.3 ha in Amahai District	Both at the sub-district scale	Not directly proportional to the area of the Land of Amahai

Source: interviews and research documents, 2025; processed.

All respondents admitted that mangroves protect beaches from abrasion. The owner of the cage adds the function of dampening the waves and also provides fish seeds. Government respondents mentioned their function as a habitat for fish, birds, crabs, shellfish, and other biota, but there were no species inventories and density data of these species.

The threats and problems identified include waste, possible use of wood, space conversion, damage to tourist facilities, and limited supervision and budget. The sighting of crocodiles in the waters around mangroves was also found to be a safety factor that reduced tourist comfort and limited the development of certain cultivations.

Knowledge, Attitudes, and Community Utilization

Respondents consisted of 28 women (54.9%) and 23 men (45.1%), with an average age of 45.04 years and a range of 19-74 years. As many as 98.0% of respondents knew about mangroves and 84.3% knew flora or fauna related to the area. All respondents stated that mangroves protect from abrasion, need to be preserved, are willing to take part in protecting, and are willing to work together. A total of 50 respondents (98.0%) also stated that they were willing to contribute to preservation. The very high level of approval shows that the community has a basis of social awareness and is willing to contribute voluntarily to the preservation of mangrove ecosystems.

In addition, the young generation in youth organizations also supports the development of mangroves and ecotourism. They mentioned the planting experience in 2022, the need for *broadwalk*/bridge repairs, cage and tourism opportunities, and the importance of youth participation spaces. The results of the respondents' answers are summarized in Table 2 below.

Table 2. Respondents' knowledge, attitudes, and participation (n=51)

Indicator	Yes	%	No	%
Knowing mangroves	50	98,0	1	2,0
Knowing the flora/fauna of mangroves	43	84,3	8	15,7
Utilizing mangroves	22	43,1	29	56,9
Mangroves protect against abrasion	51	100,0	0	0,0
Mangroves need to be preserved	51	100,0	0	0,0
Willing to take care of	51	100,0	0	0,0
Willing to work together	51	100,0	0	0,0
Willing to donate	50	98,0	1	2,0

Source: Community questionnaire, 2025; processed.

As many as 22 out of 51 respondents (43.1%) use mangroves both to obtain fishery products and biota, for tourism activities, and for other needs in limited quantities. The most frequent form of utilization is to look for fish and collect shrimp, crabs, shellfish, or bia. Because the respondents' answers are plural, the number of mentions is greater than the number of users. The use of fish generally takes place one to two times per month with a yield of about three to five fish per activity and is dominant for household consumption. Biota results are reported with local units such as *baking sheets, buckets* or *bags*. The form and character of utilization can be seen in Table 3 below.

Table 3. Direct use form on 22 users

Form of utilization	Number of mentions	Utilization character
Fishing	15	Generally 1-2 times/month, around 3-5 fish per activity, dominant consumption
Shrimp/crab/shellfish/bia	15	The unit of output is a bucket, baking sheet, or bag; Dominant consumption
Tourism/leisure	2	Use of space and scenery services
Firewood	1	limited; Need to be handled
Natural remedies	1	Limited

Source: Community questionnaire, 2025; processed.

The utilization results are not converted into kilograms because the units of answer are diverse and there is no weighing. However, additional local price data allows conservative matching of yield units to local units, namely *for* utilization that has frequency and quantity records. The matching is used to estimate the value of savings from household spending, not the biological volume of fishery catches.

The State Secretary mentioned about four cages, while the profile recorded six units. Interviews with cage owners show production of 5-10 kilograms per month at a price of IDR 35,000 per kilogram. The difference in the number of units, activeness, and absence of production data for each unit caused the study to count only one observed unit, without multiplying it to all the cages.

Economic Valuation of Mangrove Ecosystems

The valuation includes direct benefits, indirect benefits in the form of coastal protection, the value of existence, and the value of options. Each component is calculated using the market price approach, replacement cost, *willingness to pay* (WTP), and benefit transfer according to the characteristics of the data. The results of the calculation are then summed to obtain the *Total Economic Value* (TEV) of the mangrove ecosystem in the country of Amahai.

Reference Prices

The economic valuation process requires a reference price that is in accordance with the type of benefit and unit of result reported by the respondent. The market price is used for commodities that can be assessed per kilogram, while the utilization results are matched with local units in the form of *tampa*. For the ecological benefits of coastal protection, talud construction costs are used as a proxy for replacement costs. The prices and basic assumptions used in the calculation are presented in Table 4.

Table 4. Commodity reference price, local units, and replacement costs

Commodities/references	Pricing	Usage
Fish Caught in the Binaya Market	IDR 14,800/kg	Market price context for the fourth week of July 2025
Fish kite/momar Binaya Market	IDR 16,800/kg	Market price context for the fourth week of July 2025
Skipjack Fish Binaya Market	IDR 22,200/kg	Market price context for the fourth week of July 2025
Grouper/bobara cage fish	IDR 35,000/kg	Calculation of one cage

Fish from Utilization	IDR 20,000 per tampa containing 4–5 heads	Shadow value of consumption results
Shrimp/crab/shellfish/bia	IDR 120,000 per tampa	Shadow value of consumption results
Talud or Coastal security	IDR 3,500,000/m; 10 years old (according to the PUPR Office Budget Implementation Document for 2025)	Proxy cost in lieu of beach protection

Source: Trade and Industry Office; interview; and Central Maluku Regency PUPR Office.

The market price per kilogram is used as a context and for the cage. The utilization results are assessed in local units because the reported quantity is not kilograms. The talud price is used only as a proxy for replacement *cost*, but this value does not indicate the physical development plan at the research site.

4.3.2 Direct Benefit Value

The value of direct benefits is calculated only from components that have traceable quantity, frequency, and price data. The results of fish and biota utilization were assessed with local *units of tampa*; tourism receipts were calculated on a gross basis from an average of 165 visitors per month with a ticket of Rp10,000; and the value of cages was limited to one unit observed with an average production of 7.5 kg per month and a price of Rp35,000 per kg.

The value of utilization from fisheries in the mangrove ecosystem by the community is known to consist of fish with a value of IDR 2,426,667 and for shrimp, crabs, shellfish, or bia of IDR 52,920,000 per year. So that the value of direct utilization of marine life in the mangrove ecosystem in the country of Amahai is IDR 55,346,667. For mangrove ecosystem tourism, the gross revenue is estimated at IDR 19,800,000 per year. In addition, cage owners also conveyed profits of around IDR 262,500 per month or IDR 3,150,000 per year. So that from the calculation of the total direct *use value* (DUV) of the mangrove ecosystem in the Land of Amahai it was found to be Rp78,296,667 per year. The estimated value of the direct benefits of each utilization component can be seen in Table 5.

Table 5. Estimated value of observed direct benefits

Components	**Basic data**	**Simple calculations**	**Value (Rp/year)**
Fishery/biota products	Frequencies and local units	Fish 2,426,667 + biota 52,920,000	55.346.667
Tour tickets	165 visitors/month; IDR 10,000	165 x 10,000 x 12	19.800.000
One cage unit	7.5 kg/month; IDR 35,000/kg	7.5 x 35,000 x 12	3.150.000
Number of DUVs	Three scalable components	55.346.667 + 19.800.000 + 3.150.000	78.296.667

Sources: questionnaires, local price data, and interviews, 2025; processed.

Indirect Benefit Value

The most consistent evidence regarding indirect benefits is protection from abrasion and waves. All respondents stated that mangroves protect the beach, and cage owners attributed it to the protection of business areas and the availability of seeds. Other benefits in the form of fish habitat and biota also often appear in interviews with the community.

The indirect benefits of mangrove ecosystems are mainly reflected in the function of protecting the coast from abrasion and wave energy. The value of the function is estimated using a replacement cost approach, namely with a 4,300-meter talud replacement cost, a cost of IDR 3,500,000 per meter, and a useful life of 10 years. The replacement capital cost of IDR

15,050,000,000 was then annualized to an IUV of IDR 1,505,000,000 per year. The parameters and stages of calculating indirect benefits can be seen in Table 6.

Table 6. Estimated indirect benefits of coastal protection

Parameters	Value	Calculation/interpretation
The length of the beach is expected to be protected	4,300 m	4.3 kilometres
Talud Fee (according to the DPA of the PUPR Office 2025)	IDR 3,500,000/m	Reference cost for 2023
Capital replacement costs	IDR 15,050,000,000	4,300 × IDR 3,500,000
Benefit life	10 years	Assumptions from the source document
Annual IUV	IDR 1,505,000,000/year	IDR15.05 billion ÷ 10

Source: PUPR Office of Central Maluku Regency; data processed.

The result of this indirect benefit value is the projection that mangroves have the same function as talud as a protector of coastal areas, but it is not the budget value of talud development and does not state that the entire coastline requires structures with the same design. Biological habitat benefits are not added to avoid double counting with fishery yields in the DUV.

4.3.4 Value of Existence

Existence *Value* (EV) shows community appreciation for the existence of mangroves, even though the benefits are not always obtained through direct utilization. This value is estimated through the *willingness to pay* (WTP) of each household per month to support mangrove conservation. Of the 51 respondents, 41 people chose IDR 10,000 per month, one person was not willing to pay, and another respondent chose a nominal between IDR 5,000 to IDR 500,000. The total sample WTP of IDR 1,045,000 yielded an average of IDR 20,490.20 per household per month. The WTP distribution was then used to estimate the value of existence at the population level of 816 heads of families for 12 months. So that the total value of EVs is estimated at IDR 200,640,000 per year. The distribution of answers and the results of the annual estimate can be seen in Tables 7 and 8.

Table 7. Distribution of willingness to pay per household per month

WTP (Rp)	Frequency	%	Contribution to total WTP (Rp)
0	1	2,0	0
5.000	4	7,8	20.000
10.000	41	80,4	410.000
20.000	2	3,9	40.000
25.000	1	2,0	25.000
50.000	1	2,0	50.000
500.000	1	2,0	500.000
Total	51	100,0	1.045.000

Source: Community questionnaire, 2025; processed.

Table 8. Estimated existence value (population 816 households)

Scenario	WTP per KK/month	Formula	EV (Rp/year)	Interpretation
Average of all data	20.490,20	20,490.20 × 816 × 12	200.640.000	Main estimates

Median	10.000	10,000 × 816 × 12	97.920.000	Typical values of respondents

Source: Questionnaire and State Profile 2024; processed.

One answer of Rp500,000 increases the average score, so the median Rp10,000 needs to be presented as a comparison. With the median, the annual value is IDR 97,920,000. For contribution planning or preservation funds, the median reflects the majority choice; Implementation must still be preceded by deliberation, clarity of mechanisms, exceptions for vulnerable households, and reporting on the use of funds.

Value of Choice

Option *Value* (OV) describes the value that is maintained for the possible use of mangrove ecosystems in the future. The estimated value of the option uses a benefit transfer of US$15 per ha per year, an exchange rate of Rp16,325 per US$, and a main area of 17.37 ha. The value per hectare is IDR 244,875 and the annual OV is IDR 4,253,479. Given that there are differences in information about mangrove area, the calculation is arranged in three area scenarios so that the influence of data variations on the value of the choice can be seen transparently. The results are presented in Table 9.

Table 9. Preferred value scenario based on mangrove area

Broad scenario	**Value/ha/year**	**OV (Rp/year)**	**Uses**
10 ha	IDR244,875	2.448.750	Core area boundaries according to local information
17.37 ha	IDR244,875	4.253.479	Main estimates based on DLH data
62 ha	IDR244,875	15.182.250	Administrative profile scenario

Source: Parameter US$15/ha/year; BI exchange rate of Rp16,325/US$ on July 18, 2025; processed.

The range of choice values shows the direct impact of broad inequality on the outcome of the score. Since the value per ha is the same, the yield changes proportionally to the area.

4.3.6 Total Economic Value of Mangrove Ecosystems

The sum of DUV, IUV, EV, and OV results in a measurable *Total Economic Value* (TEV) of IDR 1,788,190,145 per year. IUV dominated 84.16%, followed by EV 11.22%, DUV 4.38%, and OV 0.24%. The dominance of indirect benefits is in line with other mangrove research in Maluku which confirms that the function of coastal protection is a very important ecosystem service even though it does not generate direct cash receipts.

The composition shows that the main benefits of mangroves do not appear as cash income. If policies only assess tourism revenue or business results, most of the ecosystem value will be overlooked. TEV can be used as material for the preparation of protection priorities, budgeting, ecotourism development, community empowerment, and opportunity cost evaluation if the area is damaged. However, this value must be used with caution because the benefits of coastal protection are calculated by proxy of replacement costs and not all habitat services, carbon, social value, and utilization units can be monetized. Therefore, TEV is a measurable economic value according to research data, not the talud development budget or the market value of mangrove areas. The results of the TEV recapitulation can be seen in Table 10.

Table 10. Recapitulation of the Total Economic Value of the Mangrove Ecosystem of Amahai State

Components	Method	Value (Rp/year)	Serving (%)
Direct benefits (DUV)	Market price/shadow value	78.296.667	4,38
Indirect benefits (IUVs)	Replacement costs	1.505.000.000	84,16
Value of existence (EV)	Average WTP	200.640.000	11,22
Option value (OV)	Transfer of benefits	4.253.479	0,24
Total Economic Value (TEV)	Summing up	1.788.190.145	100,00

Source: Research data processing results, 2025.

Implementation of Mangrove Management Policy

Policies relevant to the management of mangrove ecosystems in the Amahai Country are at the level of Central Maluku Regency and Amahai Country. Normatively, the implementation of mangrove management policies in the Land of Amahai can be explained through the Regional Regulation of Central Maluku Regency Number 6 of 2021 which places nature conservation, sustainability, cross-sector integration, partnerships, and community empowerment as the principles of tourism development. The Amahai Mangrove Ecotourism is included as a Cluster II natural tourism attraction. Regent Decree Number 556-361 of 2021 strengthens it by designating Amahai as a tourist country and Waerano Mangrove as one of the potentials. At the local or state level, Amahai State Regulation Number 04 of 2025 provides the basis for the preparation of programs according to the authority of the state. Relevant spaces include planning and space utilization, development of State BUM, tourism potential, forest maintenance, green open space, waste management, potential data collection, and strengthening community groups. This basis allows the State Government to develop mangrove institutions and programs while still paying attention to the division of district authority.

The three instruments have provided recognition, direction, and the basis of authority, but have not yet established special operational rules for mangroves. Regional regulations and regent decrees emphasize the development of destinations and the determination of tourist status, while state regulations are still in the form of a list of general authorities. There are no detailed arrangements regarding boundaries and zoning, carrying capacity, permitted and prohibited activities, environmental management standards, management structures, licensing, financing, benefit sharing, monitoring indicators, reporting, supervision, and sanctions. These operational shortcomings, accompanied by limited coordination, budget, community capacity, and periodic data, make the implementation of policies not fully guarantee the protection and utilization of mangroves consistently and sustainably.

Empirically, the use of mangroves for biota catching, ecotourism, and research shows that this area has provided direct and indirect benefits to the community. The total economic value referenced in the study of IDR 1,788,190,145 per year confirms that mangroves are not only environmental assets, but also regional economic assets. This value is highly dependent on the quality of the ecosystem. Therefore, waste disposal, limited development funds, weak supervision, and lack of solid local institutions not only threaten ecological functions, but can also reduce economic benefits. Management policies must bridge conservation and utilization through orderly, fair, and appropriate arrangements in accordance with the carrying capacity of the area.

Table 11. Contributions and gaps in policy instruments

Policy instruments	Contribution to management	Key gaps

Central Maluku Regency Regulation No. 6/2021	Direction of sustainable tourism, conservation, empowerment; Amahai Mangrove as an attraction of Cluster II	Has not yet regulated the technical management of mangroves at the location
Regent Decree No. 556-361/2021	Designating Amahai as a tourist land and Waerano Mangrove as potential	Administrative recognition without operational ecological governance
Amahai State Regulation No. 04/2025	The basis of space authority, State BUM, tourism, state forests, garbage, and community groups	It is still a public authority; has not contained zoning, procedures, financing, supervision, and special sanctions

Source: Central Maluku Regency Government (2021a, 2021b), Amahai State Government (2025), and research analysis results.

From the communication dimension, the policy direction has been known through the status of tourist countries and regional development programs, but has not been translated into technical instructions, SOPs, and consistent socialization to all actors. As a result, the community has general support for conservation, but has not yet obtained the same certainty regarding the limits of use, procedures, and responsibilities of each party.

From the resource dimension, Amahai has the State Government, customary institutions, State BUM, community groups, and the support of several regional apparatus. However, budgets, spatial data, periodic ecological data, technical capacity, tourism facilities, waste management, and monitoring systems are still limited. The difference in data area and number of cages shows that information resources are not yet managed in a single shared database.

From the dimension of disposition, government and social support is a strong asset: all respondents support preservation and mutual cooperation, while 98.0% are willing to contribute. However, such support needs to be translated into commitment, a measurable benefit-sharing program and responsibility.

From the dimension of the bureaucratic structure, authority is spread to various parties and there is no special management mechanism and structure that determines who plans, implements, monitors, receives revenue, finances maintenance, and takes action against violations. This fragmentation increases the risk of overlap or a void of responsibility.

Table 12. Policy implementation according to Edwards III dimensions

Dimensions	**Key evidence**	**Conditions**	**Strengthening priorities**
Communication	The direction of tourism and conservation has been recognized	Has not been translated into consistent technical instructions and SOPs	Socialization of rules, zoning, rights, obligations, and procedures
Resources	Available government, State BUM, customary institutions, groups, and OPD support	Budget, spatial-ecological data, facilities, capacity, and monitoring are limited	Shared databases, financing, training, tools, and monitoring systems
Disposition	100% support preservation/mutual cooperation; 98% are willing to donate	Social support is strong, but it has not been organized into routine activities	Participatory forums, work plans, incentives, and accountability

Dimensions	Key evidence	Conditions	Strengthening priorities
Bureaucratic structure	The authority is in the district, state, customary, and BUM Negeri	There is no mechanism and structure for managing and distributing operational work	Management units/forums, SOPs, coordination, reporting, supervision, and sanctions

Source: Edwards III (1980), interviews, questionnaires, documents, and research analysis results, 2025.

Based on this analysis, the implementation of the policy has given a positive direction, but the results have not been optimal. Strengthening needs to be focused on State Government institutions and customary institutions, division of roles between parties, monitoring and enforcement of rules, community capacity building, and the development of ecotourism and productive businesses that do not damage mangroves. The community needs to be placed as the main actor, not just as a user of resources. Through the coordination of the government, BUM Negeri, community groups, customary institutions, and supporting parties, mangrove management can maintain the sustainability of the area while maintaining and increasing economic benefits for the people of Amahai.

Expected Sustainable Management Model

The expected model is collaborative management based on conservation and community economic empowerment. This model uses a collaborative approach to balance ecological, social, economic, and institutional interests. Management is not directed at exploitation, but neither does it stop at passive protection; The use of mangrove ecosystems in the Land of Amahai is allowed as long as it does not reduce ecological functions and provides fair benefits to the community.

The basis of the model's thinking rests on three findings: First, mangroves function to protect beaches, resist seawater intrusion, provide biota habitat, and maintain coastal balance. Second, mangroves provide economic benefits through fisheries, coastal products, ecotourism, education, and research. Third, management still faces institutional limitations, supervision, financing, supporting facilities, and coordination. On that basis, this model places the community, the State Government, customary institutions, State BUM, Regency Government, and supporting elements in one system that integrates protection, environmentally friendly use, regulation, and empowerment.

Operationally, the model works through the relationship of *inputs, processes, outputs* and *outcomes*. *Model inputs* include the potential of mangrove resources, economic value from valuation, coastal communities, local and customary institutions, government support, and management policies. Agreement on regional boundaries and baseline data is also an important initial input because differences in extent can affect zoning, division of authority, monitoring, and calculation of benefits.

The management process consists of five components. First, ecological protection through the prevention of logging and land conversion, waste and pollution control, rehabilitation, and periodic monitoring of vegetation and biota. Second, the use of an environmentally friendly economy through traditional fisheries, limited management of coastal products, ecotourism, environmental services, education, and research.

Third, institutional strengthening and collaboration. The Regency Government provides policy direction, technical guidance, environmental supervision, funding support, and coordination across regional apparatus. The State Government prepares local programs, facilitates waste management, strengthens the State BUM, empowers community groups, and collects data on the potential and conditions of the region. The State Saniri Agency and customary institutions support deliberation, social supervision, and the application of norms based on local wisdom. BUM Negeri

develops ecotourism services and environmentally friendly economic businesses, while community groups are the implementers of protection and utilization.

Fourth, regulation and enforcement of rules through special operational rules for mangroves which are prepared through deliberation and coordinated with the Regency Government. The rules at least contain the boundaries and zoning of the area, carrying capacity, permitted and prohibited activities, environmental and waste management standards, management structure, rights and obligations of the parties, financing and benefit-sharing mechanisms, monitoring, reporting, supervision, and sanctions. Enforcement of the rules is carried out through formal supervision and social supervision by the community and customary institutions. This approach strengthens compliance because it relies on authority, a sense of belonging, and shared responsibility.

Fifth, education, empowerment, and research to improve community knowledge, awareness, and skills through counseling, training, environmental education, and strengthening business capacity. Periodic research and data collection provide a scientific basis for updating economic value, monitoring, evaluation, and adjustment of management policies.

The process is expected to produce outputs in the form of more protected areas, more orderly economic utilization, increased community participation, stronger management institutions, and more effective supervision and rules. The final outcome is the preservation of mangrove ecosystems, the sustainability of ecological and economic functions, the improvement of community welfare, and collaborative and sustainable coastal governance.

The application of this model requires cross-sector coordination so that there is no overlap of roles, the preparation of special operational rules for mangroves, business development that is in accordance with the carrying capacity, community capacity building, and data-based periodic monitoring. Thus, this model does not stop as a conceptual framework, but can be used as a basis for policy formulation, empowerment programs, financing, supervision, and operational steps at the level of the Amahai State and Central Maluku Regency.

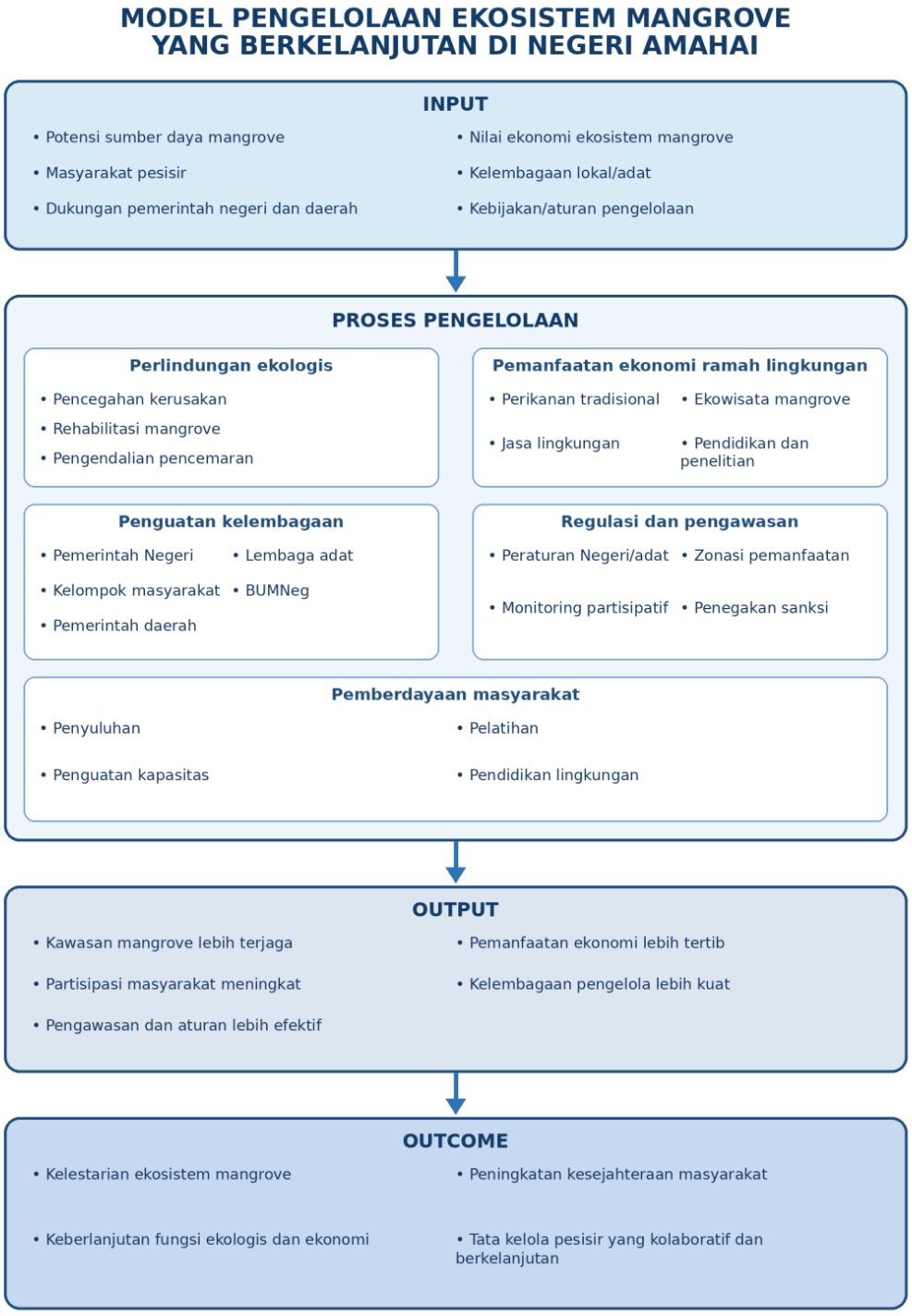

Figure 1. Sustainable mangrove ecosystem management model in the Land of Amahai

CONCLUSION

1. The mangrove ecosystem of the State of Amahai functions as a coastal protector, biota habitat, fishery utilization space, cages, ecotourism, education, and research. Mangrove area information differs according to source, namely 10 ha, 17.37 ha, and 62 ha; The study used 17.37 ha as the main estimate. Conditions are generally good, but they face waste, possible wood use, damage to tourist facilities, limited budget and supervision, and the lack of routine ecological monitoring.

2. As many as 98.0% of respondents knew about mangroves and all respondents recognized the function of protecting beaches and supporting conservation, and 22 out of 51 respondents used the area, especially for fish and coastal biota. DUV is estimated at IDR 78,296,667 per year, IUV IDR 1,505,000,000 per year, EV IDR 200,640,000 per year, and OV IDR 4,253,479 per year. The sum of the components produces a measurable TEV of IDR 1,788,190,145 per year with indirect benefits as the largest component.
3. The implementation of the policy has obtained a basis through Central Maluku Regency Regional Regulation Number 6 of 2021, Central Maluku Regent Decree Number 556-361 of 2021, and Amahai State Regulation Number 04 of 2025. The three instruments provide direction for tourism development, conservation, empowerment, and local authority, but have not yet established mangrove-specific operational rules that contain boundaries and zoning, carrying capacity, permitted and prohibited activities, environmental management standards, management structures, licensing, financing, benefit sharing, monitoring indicators, reporting, supervision, and sanctions. Operational shortcomings accompanied by limited coordination, budget, community capacity, and periodic data, make the implementation of policies not fully guarantee the protection and utilization of mangroves in a consistent and sustainable manner.
4. The sustainable management model that is expected to be suitable for the Amahai Mangrove Ecosystem is a collaborative management model based on conservation and community economic empowerment. The model works through *input–process–output–outcome flows* and integrates ecological protection, environmentally friendly economic utilization, strengthening local institutions and collaboration between parties, regulation and enforcement, as well as education, empowerment and research. The success of the model depends on role sharing, agreed baseline data, periodic coordination, financing, and measurable monitoring.

5.2 Suggestions

1. The Amahai State Government and the State Saniri Agency need to develop rules or operational standards for mangroves that contain boundaries and zoning, permitted and prohibited activities, safety, complaint mechanisms, financing, benefit sharing, monitoring, and proportionate sanctions.
2. The Central Maluku Regency Government through the relevant regional apparatus needs to verify the area and condition of mangroves spatially, build basic ecological data, support rehabilitation and waste management, and form cross-sector coordination for tourism and business development that is suitable for carrying capacity.
3. State BUM Negara, customary institutions, community groups, youth, and women need to be involved in ecotourism management, participatory supervision, environmental education, environmentally friendly businesses, and transparent recording of income and costs. Some of the economic benefits need to be realised for the protection and maintenance of the area.
4. The implementation of valuations and policies needs to be evaluated periodically. The next research is recommended to conduct geospatial mapping, biota and carbon inventory, recording catches throughout the year, measurement of replacement costs supported by technical studies, and probability surveys so that economic estimates and policy impacts are stronger.

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