Economic valuation of mangrove ecosystem environmental services based on green economy

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Economic valuation of mangrove ecosystem environmental services based on green economy

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Abstract. One of the important agendas in current development is promoting mangrove forests as one of the green economic assets in Indonesia. The green economy concept emphasizes improving people's welfare but reducing the risk of environmental damage and scarcity of ecological functions. One approach that can be used to maintain economic activity and preserve the environment is the economic valuation approach. Therefore, this study aims to measure the value of the economic benefits of mangrove ecosystem services as one of the concepts of the green economy as an effort to support government programs to realize the mangrove ecosystem as a green economic asset in Indonesia. The economic valuation method used to calculate the mangrove ecosystem's environmental services in Takalar Lama Village, Mappakasunggu District, Takalar Regency. The value of mangrove ecosystem environmental services calculated in this study is the value of abrasion resistance, the importance of preventing seawater intrusion, the value of crab feed providers, the value of carbon sequestration, the value of oxygen production, and the value of maintaining biodiversity. The results revealed that the value of the benefits of mangrove forest environmental services as a barrier to abrasion was IDR 32,457,189/ha/year or IDR 973,715,670/year, the value to prevent seawater intrusion was IDR 3,394.445,688/ha/year or IDR 101,833,370,640/year, the value of benefits as a provider of crab feed is IDR 544,320,000/ha/year or IDR 16,329,600,000/year, the annual carbon sequestration value is IDR 198,300.07/ha/year or IDR 5,949,002.1/year, the value of oxygen production is IDR 2,011,590/ha/year or IDR 60,347,700/year, and the value of biodiversity is IDR 637,376/ha/year or IDR 19,121,280/year so that the total value of environmental services for mangrove ecosystems based on green economics is IDR 3,974,070,143.1/ha/year (275,052.13 USD/ha/year) or IDR 119.222.104.292,1/year (8,250,663 USD/year).

1. Introduction

One of the critical agendas in current development is promoting mangrove forests as one of the green economic assets in Indonesia. A green economy is an economy resulting in increased human well-being and social equity but reduces environmental risks and ecological scarcity. The concept of a Green Economy emerged after the symptoms of climate change that caused environmental damage throughout the world due to economic activities [1]. One of the factors causing climate change is an increase in carbon dioxide in the atmosphere. The existence of the mangrove ecosystem is believed to be one of the efforts to reduce CO_2 content from the atmosphere because it has an ecological function as a carbon sink and storage in efforts to mitigate climate change [2]. In addition, mangrove forests also have an economic function as the main economic source for the community in the forestry sector as a producer of wood, a source of food, a source of cosmetic ingredients, and medicines.

The mangrove ecosystem in Takalar Lama Village, Mappakasunggu District, Takalar Regency is spread over coastal areas, estuaries, and rivers. The community uses the mangrove ecosystem as a place for spawning fish, crabs, taking firewood, windbreaks, and breaking waves, however the increasing of human activity and the number of people living around the area does not rule out the possibility that the community will expand the land by opening new land in the mangrove forest areas. Therefore, it can cause the loss of environmental services functions of the mangrove ecosystem.

Not only having an ecological (physical, chemical, and biological) function, but mangrove ecosystems also have environmental services function or environmental services, namely: as climate regulators, oxygen producers, and carbon sinks [3]. To anticipate these conditions, it is necessary to continuously raise awareness to the community about the functions and benefits of mangrove ecosystem services. In order to solve the problem, a research on the economic valuation of mangrove ecosystem environmental services needs to be carried out as one of the concepts of the Green Economy, so that it is known its contribution to the environment as well as provides an overview of the total value of the benefits of mangrove ecosystem environmental services which will be a reference in sustainable mangroves forest utilization as an effort to conserve mangrove ecosystems.

2. Materials and methods

2.1. Data collection

This research was carried out in the mangrove ecosystem of Takalar Lama Village, Mappakasunggu District, Takalar Regency, South Sulawesi Province, Indonesia. A purposive sampling method was used, the sampling method namely deliberately on the respondents with the consideration that the respondents are the people who get benefit from the mangrove ecosystem. The number of respondents as many as 74 people consisting of ten crab fishermen, a crab farmer, 62 people who use clean water, and an employee of the Public Works Office (PU) of Takalar Regency. The data was collected by interviewing the respondents using a questionnaire, then the data analyzed using the descriptive analysis method to identify the functions and benefits of mangrove ecosystem environmental services as well as the economic valuation analyzed to figure out the economic benefits of mangrove ecosystem services.

Some procedures are carried out to measure the economic benefits value of mangrove ecosystem environmental services, namely: identification of functions and benefits of mangrove ecosystem environmental services, quantification of all functions and benefits into monetary value, and estimation of the total economic value of mangrove ecosystem environmental services by adding up the entire value of the benefits of mangrove ecosystem environmental services including the value as a barrier to abrasion, value as a deterrent to seawater intrusion, value as a provider of crab feed, carbon dioxide absorption value, oxygen production value and maintaining biodiversity using value the market price method and the replacement cost method.

2.2. Data analysis

The method used to estimate the environmental service values of the mangrove ecosystem is described as follows:

2.2.1. Abrasion resistant value. The benefit of mangrove ecosystem environmental services as a barrier to abrasion is estimated through a replacement cost approach. The estimation of the mangrove ecosystem value as an abrasion barrier is approximated by the cost of constructing a breakwater. To calculate the mangrove forests value as abrasion resistance, the calculation formula according to Nilwan et al. (2003) in [4]:

$$\mathrm{NPA} = \mathrm{PLT} \times \mathrm{DT} \times \mathrm{Pgp} \times \mathrm{B} \quad (1)$$

Description:
NPA = Abrasion resistant value (IDR/ha/year)

PLT = Breakwater measuring length x width x height (m^3)
Pgp = Coastline length (m)
DT = Durability (years)
B = Standard cost of concrete (IDR)

The estimation of the cost of constructing a breakwater uses the data of the Work Unit Price Analysis (AHSP) issued by Rospita et al., (2017) with the provisions of the technical data of sinking breakwater construction, P = 150 m, L = 20 m, T = 5 m, amounting to IDR 2,921,147,000 [5].

2.2.2. Seawater intrusion prevention value. The economic benefits value of the environmental services of the mangrove ecosystem as a deterrent to seawater intrusion is calculated through the community expenditure approach to fulfill clean water for household purposes. The costs incurred by the community in buying clean water are estimated to be equivalent to the mangrove forests value as a deterrent to seawater intrusion because people will have difficulty getting clean and fresh water. In case of seawater intrusion, if the mangrove forest is damaged. The formula for calculating seawater intrusion prevention values is as follows [6]:

$$\text{NPI} = \text{JKK x JKbta x HA x HR} \quad (2)$$

Description:
NPI = Seawater intrusion preparation value (IDR/ha/year)
JKK = Number of Family Heads
JKbta = Total Water Needs/month
HA = Water Price (IDR/Month)
HR = Number of Days in 1 Year

2.2.3. Value as a crab feed provider. The benefits value of mangrove ecosystem environmental services as a provider of feed for crabs is assessed indirectly based on the resources that replace them, estimated to be equivalent to the catch of crabs in the waters around the mangrove forest multiplied by the amount of feed needed for each kilogram of crabs obtained times the price of crab feed [7]. The formula for calculating the crab feed producers' value of is as follows:

$$\text{NPP} = \text{Htk x Jpk x Hpk} \quad (3)$$

Description:
NPP = Value of crab feed providers (IDR/ha/year)
Htk = Crab catch (kg)
Jpk = Amount of Crab Feed Manufacturer (kg)
Hpk = Factory Crab Feed Price (IDR/kg)

2.2.4. Annual carbon sequestration value. The environmental services benefit value of mangrove ecosystems as annual carbon sinks is obtained by multiplying the CO_2 absorption value by the carbon price of US$5.8 per ton of CO_2 minus the transaction costs of reducing carbon dioxide sequestration emissions in the forestry sector of US$ 1.23 so that the net price of CO_2 absorption is US$ 4.57 per ton [8,9]. The exchange rate of the rupiah against the dollar, which is US$1, is IDR 14,610 (Bank International Indonesia, 2015). Carbon dioxide (CO_2) absorption is estimated using the Hardjana (2009) formula in [10] as follows :

$$\text{NJLsco} = \text{HJC x } CO_2 \quad (4)$$

Description:
$NJLSCO_2$ = Value of Environmental Services Carbon Sequestration (IDR/Ha)
HJC = Selling Price of Carbon (IDR/Ton, US$4.57= IDR 66,767.7)
CO_2 = Carbon Dioxide Uptake (Ton/Ha)

2.2.5. Oxygen production value (O_2). The benefits value of environmental services for mangrove ecosystems as oxygen producers is estimated by using the development formula of the CO_2 absorption formula by multiplying the CO_2 absorption value per unit area (Ton/Ha) by the conversion factor of CO_2 to O_2 atoms with the selling price of oxygen in the market as follows [10] :

$$NO_2 = CO_{2n} \times 0.73 \times HJO_2 \quad (5)$$

Description:
NO_2 = Oxygen Production Value (Ton/Ha)
CO_{2n} = CO_2 absorption per unit area (Ton/Ha)
0.73 = Equivalent number or conversion of element CO_2 to O_2 (atomic mass C=12 and O =16, $CO_2 \rightarrow$ (1x12) + (2x16) = 44; the conversion $\rightarrow$ (32:44) = 0.73)
HJO_2 = Selling price O_2 (IDR/Ton)

2.2.6. Value of biodiversity. The biodiversity value is approached by referring to the biodiversity value of mangrove forests in Indonesia, namely US$ 1,500//year or US$ 15/ha/year. The value used is the result of Ruitenbeek's research in 1992. The value is compounded to 2021 [11] as follows:

$$V_{2021} = V_{1992}\,(1+i)^t \quad (6)$$

Description:
V = Biodiversity value (IDR/ha/year)
i = Interest rate (%)
t = Number of time (years)

This value is then adjusted to the purchasing power and prices in the Takalar Lama Village because the purchasing power and prices prevailing in Bintuni Bay, West Papua is assumed to be different from the study location, so that expect the calculation results obtained to be more accurate, using the following formula:

$$NB = V \times M \frac{Takalar\ Regional\ Minumum\ Wage}{Papua\ Regional\ Minimum\ Wage} \quad (7)$$

Information:
NB = Biodiversity value Mangrove ecosystem in Takalar Regency in 2021
V = Mangrove ecosystem biodiversity value in West Papua
M = Area of mangrove ecosystem (Ha)
UMR = Regional Minimum Wage (IDR)

2.2.7. The total value of mangrove ecosystem environmental services. The total value of mangrove ecosystem environmental services is the sum of all the economic benefits of mangrove ecosystem services, namely: abrasion prevention value, seawater intrusion prevention value, crab feed provider value, annual carbon absorption value, and oxygen production value, with the following formula:

$$NJL_{EM} = NPA + NPI + NPP + NJL_{SCO2} + NO_2 + NB \quad (8)$$

Description:
NJLEM = Mangrove ecosystem environmental services value
NPA = Abrasion resistant value
NPI = Seawater intrusion prevention value
NPP = Value of crab feed providers
$NJLSCO_2$ = Carbon sequestration value
NO_2 = Oxygen production value
NB = Biodiversity value

3. Result and discussion

3.1. The value of mangrove ecosystem environmental services

Mangrove ecosystems have an economic function as producers of mangrove stands, firewood, nipa roofs, fish, crabs, and medicines [7]. Moreover, not only mangrove ecosystems have economic functions and ecological (physical, chemical and biological) functions, but also the ecosystems have ecological functions as environmental services or environmental services including as a climate regulator, oxygen producer and carbon sink [3].

The mangrove ecosystem environmental services values estimated from this research is the mangrove ecosystem environmental services value as abrasion resistant, seawater intrusion prevention, crab feed provider, carbon sequestration and oxygen production as follows:

3.1.1. Abrasion resistant value. The main mangrove forest ecosystem function is as a land protector from sea wave abrasion. The benefit of environmental services as an abrasion barrier is estimated through the cost approach of making a breakwater which is equivalent to the function of mangrove forest as an abrasion barrier. The benefits value of mangrove ecosystem environmental services as a barrier to abrasion is thought to be through a replacement cost approach. The estimation of the mangrove ecosystem value as an abrasion barrier is approached by calculating the cost of constructing a breakwater along the coast.

The cost of making a breakwater as an abrasion barrier is calculated by the reference is to the Regulation of the Minister of Public Works and Public Housing No. 28/PRT/M/2016 concerning Guidelines for Analysis of Work Unit Prices (AHSP) for Water Resources in 2016 issued by the Public Works Research and Development Agency in 2016. The estimated value of mangrove ecosystem environmental services as abrasion barrier is presented in Table 1.

Table 1. The mangrove ecosystem environmental services value as abrasion resistant

Description	Value
Breakwater size/PLT (m)	150 x 20 x 5
Standard Cost of Concrete (IDR)	2,921,147,000
Coastline Length (m)	5,000
Durability (years)	20
Abrasion Resistant Value (IDR/ha/year)	32,457,189

The length of the coastline in the Kungjung Mae covered by mangrove forests are 5,000 meters long. Based on the AHSP, making a breakwater with 150 m length, 20 m width, and 5 m height requires a cost of IDR 2,921,147,000. Therefore, building a 5,000 m breakwater along the coastline in the Kunjung Mae Environment with 20 years of durability requires as much as IDR 19,474,313 per 20 years. This value is then divided by 20 years to get the annual value. Thus, the value of the benefit of mangrove ecosystem environmental services as abrasion barrier is IDR 32,457,189/ha/year with an area of 30 ha of mangrove forest, so the value of mangrove ecosystem environmental services as abrasion barrier is IDR 973,715,670/year. This value reveals that the mangrove forests existence in Takalar Lama Village has enormous benefits for the environment and the surrounding community.

3.1.2. Seawater intrusion prevention. The value of the benefits of environmental services for the benefits of mangrove forests as a deterrent to seawater intrusion is calculated through a cost or community expenditure approach in fulfilling clean water for household purposes. This value is considered equivalent to the function of the mangrove forest as a deterrent to intrusion with the assumption that if the mangrove forest is lost, the community will have difficulty getting clean or freshwater due to seawater intrusion. The calculations are presented in Table 2.

Table 2. The mangrove ecosystem environmental services value as a seawater intrusion prevention

Description	Value
number of family heads (kk)	62
total water needs (m^3/month)	10.8
water price (idr/m^3)	416,660
number of days in 1 year	365
seawater intrusion prevention value (IDR/ha/year)	3,394,445,688

The number of family heads on the coast of Takalar Lama Village, especially in the Kungjung Mae neighborhood, is 62 families. The daily freshwater needs of each family are an average of 30 gallons of water/day for daily water needs or 10.8 m3/month for a gallon of clean, freshwater IDR.5,000 or IDR 416,660/m^3. Based on the results of the calculations in Table 2. the economic value of the environmental services of the mangrove ecosystem as prevention of sea water intrusion is IDR 3,394,445,688/ha/year, so that the value of mangrove ecosystem environmental services as a deterrent to seawater intrusion in the study location with an area of 30 ha of mangrove forest is IDR 101,833,370,640/year.

If the mangrove ecosystem is converted to other uses, the function of the environmental services of the mangrove ecosystem as a deterrent to seawater intrusion will be lost, so that people will find it difficult to get freshwater as a source of life. Similar to the results of research conducted by Polii et al., (2020) in the mangrove forest of Tngkaina Village, Bunaken District, Manado City indicates that the economic value of mangrove forests as a deterrent to seawater intrusion is IDR 1,781,200,000/year or IDR. 17,812,000,000/10 Years if it is projected in 10 years of use [12].

3.1.3. The value as a crab feed provider. Mangrove ecosystems produce litter which is a supplier of organic material for the mangrove ecosystem so that it can support the life of living things in it [13]. One of the mangrove forest functions is as a feeding ground for various types of marine life such as crabs. The value of the environmental services of the mangrove ecosystem as a provider of crab feed is calculated using a replacement cost approach. This value is estimated to be equivalent to the amount of feed needed for each kilogram of crabs caught around the mangrove forest multiplied by the price of factory crab feed. The value of the environmental services of the mangrove ecosystem as a provider of crab feed is presented in Table 3.

Table 3. The mangrove ecosystem environmental services value as crab feed provider

Description	Value
Crab Catch (kg/year)	3,888
Amount of Manufacturer Crab Feed per 1 kg of cultured crab (kg)	10
Factory Crab Feed Price (IDR/kg)	7,000
Value as Crab Feed Provider (IDR/ha/year)	544.320,000

The number of crabs caught around the mangrove forest from interviews with ten respondents was 3,888 kg/year. The price of factory crab feed is IDR 350,000/sack, then divided by 50 kilograms in one sack of factory feed, and the price of crab feed is IDR 7,000/kilogram. With a pond area of 0.5 ha, it produces 100 kg of crabs/one harvest, then divided by ten sacks of factory feed spent in one harvest, the feed requirement can be obtained is 10 kilograms/one kilogram of crabs. Based on these data, the value of the environmental services of the mangrove ecosystem as a natural feed provider was obtained by

multiplying the overall value of crabs in one year with the price of feed/kilogram and the need for feed/kilogram of crabs, thus as much as IDR 272,160,000/year with an area of 0.5 ha or IDR. 544,320,000/ha/year. The area of mangrove forest in Takalar Lama Village is 30 ha so that the value of the environmental services of the mangrove ecosystem as a provider of crab feed is IDR. 16,329,600,000/year. Research on the value of the benefits of mangrove forests as a producer of crab feed has also been carried out by Nanlohy (2015) in the mangrove forest area of Waiheru village, Ambon city, who explained that the value of the benefits of mangrove forests as a producer of crab feed was IDR. 12,193,167/year [14]. The value of the economic benefits of the mangrove ecosystem as a feed provider in the Tongke-Tongke mangrove forest, Sinjai Regency is IDR 2,338,650,000/ha/year [15]. This proves that not only do the mangrove forests provide economic benefits for the community, but also, they have environmental services that function as a provider of very large crab feed.

3.1.4. Annual carbon sequestration value. The existence of the mangrove ecosystem is believed to be one of the efforts to reduce CO_2 gas content from the atmosphere because it has an ecological function as a carbon sink and storage in efforts to mitigate climate change [2]. The mangrove ecosystem environmental services value as carbon sinks is presented in Table 4.

Table 4. The mangrove ecosystem services value as carbon sequestration

Description	Value
Annual carbon sequestration (tones/ha)	2.97
Selling price of carbon (USD/Ton)	4.57
Rupiah exchange rate in 2015 (IDR/1US$)	14,610
Selling price of carbon (IDR/ton)	66,767.7
Annual carbon sequestration value (IDR/ha/year)	198.300.07

Based on the research results of the mangrove forest of Mappakasunggu District, the total annual carbon absorption is 2.97 tons/ha/year [16]. Based on these data, the annual carbon sequestration value is IDR 198,300.07/ha/year with a mangrove forest area of 30 ha, the annual carbon absorption value is IDR 5,949,002.1/year, this value is obtained from the total carbon sequestration multiplied by the selling price of carbon sequestration of US$ 4.57 per year tons = IDR. 66,767.7)

3.1.5. Oxygen production value (O_2). One of the environmental services functions of the mangrove ecosystem is as a producer of oxygen; mangrove forests are capable of producing large amounts of oxygen. The environmental services value of the mangrove ecosystem as oxygen producer is presented in Table 5.

Table 5. The mangrove ecosystem environmental services value as oxygen producer (O_2)

Description	Value
Annual CO_2 uptake (Tons/ha/year)	2.97
Equivalent number or conversion of element CO_2 to O_2	0.73
Oxygen Production (Tons/ha/year)	2.17
Selling price of O_2 (IDR/Ton)	927,000
Oxygen (O_2) Production Value (IDR/ha/year)	2,011,590

The research result from Sribianti et al., (2012) reveals that the total annual carbon sequestration of mangrove forests in Mappakasunggu District is 2.97 tons/ha/year [16]. Based on these data, O_2 production is 2.17 tons/ha/year obtained from annual carbon uptake multiplied by the conversion factor of CO_2 to O_2 atoms of 0.73, when multiplied by the price of O_2 per ton in the market of IDR 927,000/ton, then the O_2 production value is IDR 2,011,590/ha/year. The area of mangrove forest in the research location is 30 ha, so that the value of the environmental services of the mangrove ecosystem as oxygen production is IDR 60,347,700/year.

3.1.6. Biodiversity preservation value. One of the mangrove ecosystem functions is as a biodiversity keeper (i.e, the environmental services of the ecosystem). of mangrove ecosystem environmental services value is calculated using a benefit transfer approach which is approached by using the value of the benefits of biodiversity. The biodiversity value refers to of mangrove forests' biodiversity value in coastal areas of Indonesia is US$1,500/km^2/year or USD15/Ha/year. This biodiversity value is calculated by multiplying the value of its benefits, which is USD15/hectare/year, with the rupiah exchange rate against the USD, which is IDR 14,610 then the value is compounded from 1992 to 2021 using the Minimum Regional Wage for Takalar and West Papua Regencies [9]. West in 2021, and the interest rate in the research year is 3.75%, thus the biodiversity value of the mangrove ecosystem in Takalar Village with an area of 30 hectares of mangrove forest is IDR 19,121,280/year. The calculation of the biodiversity value is presented in Table 6.

Table 6. The environmental services value of mangrove ecosystems as biodiversity preservation.

Description	Value
Kunjung Mae's biodiversity value (US$ per ha per year)	43.62
Exchange Rate (1 US$ = IDR)	14,610
West Papua Minimum Regional Wage	3,134,600
Takalar Regency Minimum Regional Wage	3,103,800
Mangrove Forest Area (Ha)	30
Interest Rate (%)	3.75
Biodiversity Preservation Value (IDR/ha/year)	637,376

Research conducted by [11] using the same calculation technique obtained the mangrove forest biodiversity value in Udik Customs of IDR 654,160/ha/year. The result explains that preserving the mangrove forest ecosystem is important so that economic and ecological benefits can be felt in the future.

3.1.7. The total economic value of mangrove ecosystem environmental services. The total value of the environmental services of the mangrove ecosystem is the sum of all the value of the benefits of the environmental services of the mangrove ecosystem in Takalar Lama Village, Mappakasunggu District Takalar Regency. The total value of the benefits of mangrove forest environmental services can be seen in Table 7.

Table 7. The total economic value of mangrove ecosystem environmental services

No	Types of Environmental Service Values	Economic Value (IDR/ha/year)	Economic Value (USD/ha/year)	Economic Value (IDR/year)	Economic Value (USD/year)	Percentage (%)
1	Abrasion Resistant Value	32,457,189	2,246.17	973,715,670	67,385.1	0.82
2	Seawater Intrusion Prevention Value	3,394,445,688	234,909.73	101,833,370,640	7,047,291	85.41
3	Crab Feed Provider Value	544,320,000	37,669.20	16,329,600,000	1,130,076	13.70
4	Annual Carbon Sequestration Value	198,300.07	13.72	5,949,002.1	411.6	0.005
5	Oxygen Production Value	2,011,590	139.21	60,347,700	4,176.3	0.051

6	Biodiversity Preservation Value	637,376	44.10	19,121,280	1,323	0.015
The Total Economic Value of Mangrove Environmental Services		3,974,070,143	275,052.13	119,222,104,292	8,250,663	100.00

Based on Table 7, the total value of the benefits of mangrove forest environmental services in Takalar Lama Village, Mappakasunggu District, Takalar Regency covering an area of 30 ha is IDR. 119.222.104.292/year (8,250,663 USD/year) or IDR 3,974,070,143/ha/Year (275,052.13 USD/ha/year). The total value consists of the value of the benefit of mangrove forest environmental services as a barrier to abrasion is IDR 32,457,189/ha/year or IDR 973,715.670/year, the prevention of seawater intrusion value is IDR 3,394,445,688/ha/year or IDR 101,833,370,640/year, the value of the benefit as crab feed provider is IDR 544.320.000/ha/year or IDR16.329.600,000/year, the annual carbon sequestration value is IDR 198.300.07/ha/year or IDR 5,949,002.1/year, the oxygen production value is IDR 2,011,590/ha/year or IDR 60,347,700/year and the biodiversity value is IDR 637,376/ha/year or IDR 19,121,280/year.

The benefits value of environmental services for mangrove ecosystems as a deterrent to seawater intrusion has the highest value of IDR 3,394,445,688/ha/year (234,909.73 USD/ha/year) or IDR 101,833,370,640/year (7,047,291 USD/year) with a percentage of 85.41%, while the lowest value is carbon sequestration of IDR 198.300.07/ha/year (13,72 USD/ha/year) or IDR.5,949,002.1/year (411,6 USD/year) with a percentage of 0.005%. the result proves that the mangrove forest has a very high value of environmental services, so that it is hoped that it can be used as a basis or reference for the government and the community in managing and utilizing mangrove ecosystems. The results showed that the mangrove forest in Takalar Lama Village, Mappakasunggu District, Takalar Regency, has an extremely large value of environmental services that can support the community's economy.

4. Conclusion

The study demonstrated that the total economic value of mangrove ecosystem environmental services in Takalar Lama Village, Mappakasunggu District, Takalar Regency is as much as IDR 119,222,104,292.1/year (8,250,663 USD/year) or IDR 3.974.070.143,1/ha/year (275,052.13 USD/ha/year). The benefits value of environmental services for mangrove ecosystems as a deterrent to seawater intrusion has the highest value of IDR. 3,394,445,688/ha/year (234,909.73 USD/ha/year) or IDR 101,833,370,640/year (7,047,291 USD/year) with a percentage of 85.41%, while the lowest value is carbon sequestration of IDR 198.300.07/ha/year (13.72 USD/ha/year) or IDR 5,949,002.1/year (411,6 USD/year) with a percentage of 0.005%. the result proves that the mangrove forest has a very high value of environmental services, so that it is hoped that it can be used as a basis or reference for the government and the community in managing and utilizing mangrove ecosystems. The approach, as presented in this study, can be used to measure the value of the economic benefits of mangrove ecosystem services as one of the concepts of the green economy as an effort to support government programs to realize the mangrove ecosystem as a green economic asset in Indonesia.

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References

[1] UNEP 2014 *Building Natural Capital: How REDD+ can Support a Green Economy* (Nairobi, Kenya: International Resource Panel)
[2] Rachmawati D, Setyobudiandi I and Hilmi E 2014 Potensi estimasi karbon tersimpan pada vegetasi mangrove di wilayah pesisir Muara Gembong Kabupaten Bekasi *Omni-Akuatika* **10** 85–91
[3] Sambu A H, Pi S, Sribianti I, Chadijah A and Pi S 2018 *Model pengelolaan mangrove berbasis ekologi dan ekonomi* (Penerbit Inti Mediatama)
[4] Tuwo A, dan Laut P E P and Ekologi P 2011 Sosial Ekonomi, Kelembagaan dan Sarana Wilayah *Surabaya Brilian Int.*
[5] Rospita J, Zamdial Z and Renta P P 2017 Valuasi ekonomi ekosistem mangrove di desa pasar ngalam kabupaten seluma *J. Enggano* **2** 115–28
[6] Harahab N 2010 *Penilaian ekonomi ekosistem hutan mangrove & aplikasinya dalam perencanaan wilayah pesisir* (Graha Ilmu)
[7] Sribianti I 2008 Valuasi Ekonomi Lahan Mangrove Pada Berbagai Sistem Pengelolaan Di Sulawesi Selatan *Disertasi Progr. Pascasarj. Univ. Hasanuddin, Makassar*
[8] Antinori C and Sathaye J a. 2007 Assessing Transaction Costs of Project-based Greenhouse Gas Emissions Trading *Environ. Prot.* 134
[9] The Word Bank 2011 *Words Development Indicators* (Washington DC 20433 USA)
[10] Purnawan E I 2016 Teknik Estimasi Cadangan Karbon Serapan Karbondioksida & Produksi Oksigen Hutan Alam Dipterocarpa 0–20
[11] Osmaleli, Kusumastanto T and Ekayani M 2013 Analisis Ekonomi Dan Kebijakan Pengelolaan Ekosistem Mangrove Berkelanjutan Di Desa Pabean Udik, Kabupaten Indramayu
[12] Polii V D, Durand S S and Andaki J A 2020 Nilai Ekonomi Tidak Langsung Ekosistem Mangrove Di Kelurahan Tongkaina Kecamatan Bunaken Kota Manado *AKULTURASI J. Ilm. Agrobisnis Perikan.* **8** 13–23
[13] Haris A, Damar A, Bengen D G and Yulianda F 2012 Produksi Serasah Mangrove dan Kontribusinya terhadap Perairan Pesisir Kabupaten Sinjai *Octopus J. Ilmu Perikan.* **1** 13–8
[14] Nanlohy H 2015 Valuasi ekonomi ekosistem hutan mangrove di desa waiheru kota ambon *Pena J. Ilmu Pengetah. dan Teknol.* **25** 15–21
[15] Sambu A H and Sribianti I 2016 The management of mangrove ecosystem based on mitigation: Case study in mangrove area of Tongke-Tongke, South Sulawesi *Int. J. Ocean. Oceanogr.* **10**
[16] Sribianti I, Daud M, Muthmainnah, M T, Abdullah A A and Anggreini W 2020 Estimasi Potensi Biomassa, Cadangan Karbon Dan Serapan Co2 Pada Beberapa Kerapatan Tegakan Mangrove Sebagai Upaya Mitigasi Perubahan Iklim (Forum Dosen Indonesia DPD Sulawesi Selatan) pp 129–36