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# Economic analysis of management option for sustainable mangrove ecosystem in Tangerang District, Banten Province, Indonesia

PR Marlianingrum<sup>1, 2</sup>, T Kusumastanto<sup>3, 4</sup>, L Adrianto<sup>4, 5</sup> and A Fahrudin<sup>4, 5</sup>

<sup>1</sup> Doctoral Program of Tropical Ocean Economics, Bogor Agricultural University, Indonesia;

<sup>2</sup> Management Study Program, STIE Muhammadiyah Jakarta, Indonesia

<sup>3</sup> Tropical Ocean Economics, Department of Resource and Environmental Economics, Faculty of Economics and Management, Bogor Agricultural University, Indonesia

<sup>4</sup> Center for Coastal Marine Resources Studies, Bogor Agricultural University, Indonesia

<sup>5</sup> Department Aquatic Resource Management, Faculty Fisheries and Marine Sciences, Bogor Agricultural University, Indonesia.

Corresponding author: peggyratna@gmail.com (PR Marlianingrum)

**Abstract.** Ecosystem services are very important for human life, but until now part of these ecosystems as a resource asset that contributes to the country's economy has not been evaluated further. Mangrove ecosystems are one of the ecosystems that grow in alluvial sludge in coastal areas and river estuaries. They have a very important role to support fishery productivity as habitat of nursery and spawning grounds for aquatic biota. Based on those conditions, this study is directed to explore ecosystem services of ecology economic value to enhance mangrove sustainability. The analysis from data of 2017 on mangrove ecosystem of Tangerang District, Banten showed that the total economic value of mangrove ecosystems per hectare is IDR. 49.260.590,16. The analysis of optimal resource allocation can be concluded that optimal of mangrove area is 415,89 Ha with total economic value IDR.20.486.986.843,00. Conversion of mangrove ecosystems into several land changes will have an impact on the habitat that lives in it also has a negative effect on the income of coastal communities who use it, that have to be managed carefully. Economic valuations based on ecosystem services can enhance sustainable management of mangrove ecosystems and provide welfare to coastal communities who use them.

## 1. Introduction

Mangrove ecosystems are one of the coastal ecosystems that have ecological and economic functions for coastal communities. Mangrove ecosystems are rich in biodiversity and adaptation places that have a very important role in supporting fisheries productivity, as nursery ground and spawning ground for various types of aquatic biota [5]. Mangroves are environments with special characteristics in which the forest floor is flooded by water, salinity also fluctuates the surface of the water which is influenced by the tides of the sea water [6]

Mangroves in the world are estimated at 19.9 million hectares, while for the Asian region, the mangrove area is estimated to be between 32% - 41.5% of the world's mangroves. Indonesian mangrove areas are 3.86 million hectares which is the largest mangrove area in the world (18-23%) which can be found throughout the Indonesian archipelago [11]. The extent of mangrove forests in Indonesia decreases from year to year, which is estimated at 1.1% per year and the damage to this ecosystems are

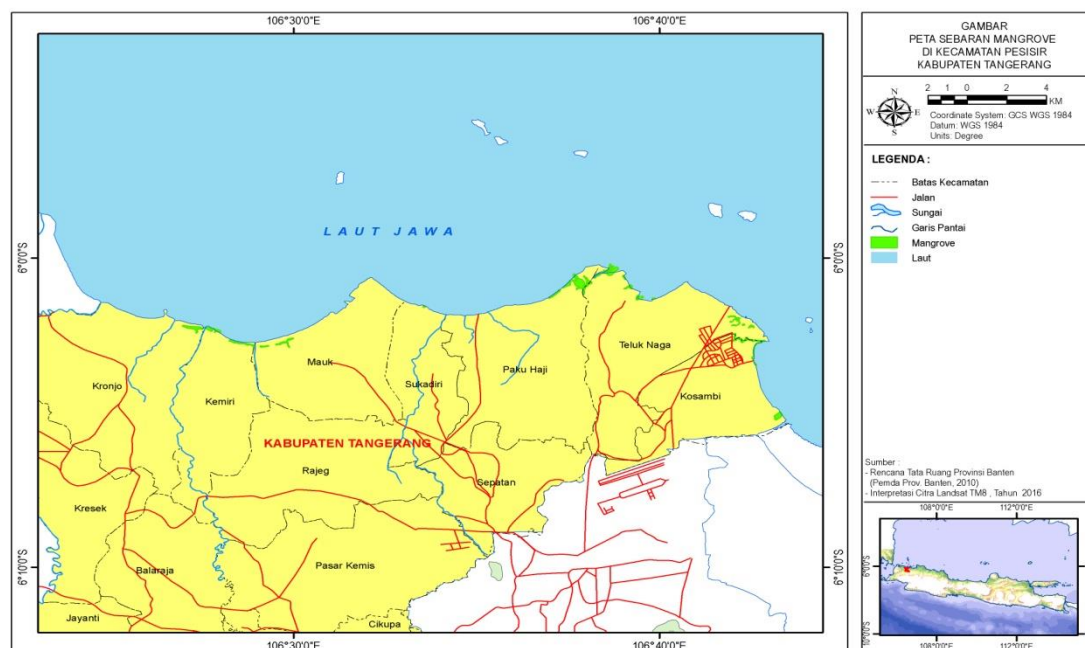


currently estimated to be in the red zone [6]. The decline in the area of mangrove forests is caused by activities that convert mangrove forests into various uses, including: switching functions to housing, opening of ponds, expansion of marine sand mining areas, tourism industry, logging of mangrove forests for fuelwood, charcoal and building materials, as well as cultivation area.

Economic valuation based on ecosystem services is very important to maintain sustainable management [12]. Some calculations of focus on mangrove ecosystems are carried out with various valuation methods can assist the government in making sustainable management policies for mangrove ecosystems [14].

The mangrove ecosystem in Tangerang Regency has decreased from year to year, based on data from the Tangerang District Environmental Agency in 1996 reaching 487.5 hectares and continuing to decline, until 2014 it remained to 246.454 Ha. The condition of mangroves which is on average in a damaged condition is due to an increase in human needs and industrial progress, which among them have experienced land conversion for aquaculture, settlements, sand mining, logging of mangroves to be used as charcoal and industrial development areas [1]. Mangrove ecosystem areas are important in order to have regulating, provisioning, culturing and supporting functions.

This study is directed to identify, map and evaluate the economic use of mangrove ecosystem areas, explore ecosystem services to preserve mangroves, knowing the role of mangrove ecosystems that are the basis for policy making of management in Tangerang district. Map of the distribution of mangroves in Tangerang Regency covering an area of 415,89 Ha in several districts shown in Figure 1.



**Figure 1.** Mangrove distribution image interpretation map per district in Tangerang Regency.

## 2. Method

Ecosystem services are benefits provided by ecosystems for humans, which contribute to making human life prosperous [14].

Ecosystem services according are divided into [7]:

- Provisioning Services, such as food sources, providers of clean water, raw materials (wood), sources of medicine and others.
- Supporting Services, such as sources of nutrition, primary production, habitat for species, maintenance of genetic diversity.
- Regulating Services, such as maintaining climate change, protecting from flooding, wastewater treatment, prevention and maintenance of soil fertility.

- Cultural Services, such as education, recreation, tourism, religion (spiritual experience), aesthetic appreciation and inspiration for culture, art and design.

Economic valuation analysis based on ecosystem services and based on the function of mangrove ecosystems, in order to obtain data on various types of benefits and functions are displayed as follows:

1. Provisioning Services (PS)

Mangrove ecosystem services as providers are direct benefits or Direct Use Value (DUV), namely the benefits that can be obtained directly from mangrove ecosystems, such as fuelwood and fishery resources [3].

2. Supporting Services (SS)

Supporting services are indirect benefits or Indirect Use Value (IUV), namely the benefits obtained from an ecosystem indirectly, as the sustainability of resources which is the value of biodiversity, spawning areas, care and foraging (spawning ground, nursery ground and feeding ground) [3].

3. Regulating Services (RS)

Regulating services are ecosystem services that are assessed from estimates using a replacement cost / damage approach avoided costs applied to the function of the mangrove ecosystem as a break water approached by calculating the costs needed to build a protected breakwater along the coast Mangrove ecosystem, useful to protect from storms, floods and abrasion retention. In addition it also assesses mangrove ecosystems as carbon storage.

4. Cultural Services (CS)

Cultural services is a cultural service ecosystem service that is assessed from education and recreation.

Total Economic Value (TEV) is formulated as follows:

$$TEV = PS + SS + RS + CS \quad (1)$$

Where :  
 PS = Provisioning Services  
 SS = Supporting Services  
 RS = Regulating Services  
 CS = Cultural Services

### 3. Result

Tangerang Regency is one of the districts located in Banten Province. To evaluate the economic resources of mangroves in Tangerang Regency, a first classification of the functions and benefits of mangrove resources as presented in Table 1 and the level of value based on the functions and benefits of mangrove ecosystems in Tangerang Regency are presented in Table 2.

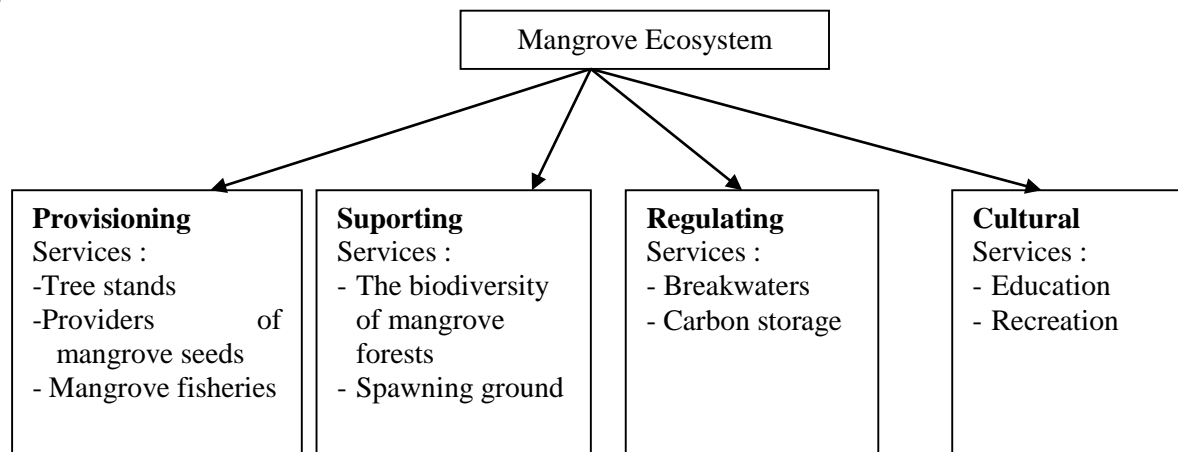
**Table 1.** Classification of functions and benefits of mangrove ecosystems.

No	Value Typology	Classification of Functions and Benefits	Valuation Method
1.	Provisioning Service	Tree Stand	Market price
		Mangrove Seed Providers	Market price
		Mangrove fisheries (bait providers)	Market price
2.	Supporting Services	Biodiversity of mangrove ecosystem	Benefit transfer
		Spawning ground	Production function approach
3.	Regulating Services	Breakwater	Replacement cost
		Carbon storage	Damage avoided cost
4.	Cultural Services	Education	Surrogate market price
		Recreation	Surrogate market price

**Table 2.** Levels of values based on the functions and benefits of mangrove ecosystems.

Key Parameters	Intensity (Importance)		
	High	Medium	Low
Wood potential	X		
Mangrove seedling providers	X		
Fishery	X		
Education		X	
Recreation		X	
Biodiversity	X		
Coastal stabilization and abrasion controllers	X		
Spawning ground	X		

Mangrove ecosystem services are divided into provisioning services, supporting services, cultural services and regulating services [7]. Mangrove ecosystem services in Tangerang District as shown in Figure 2.

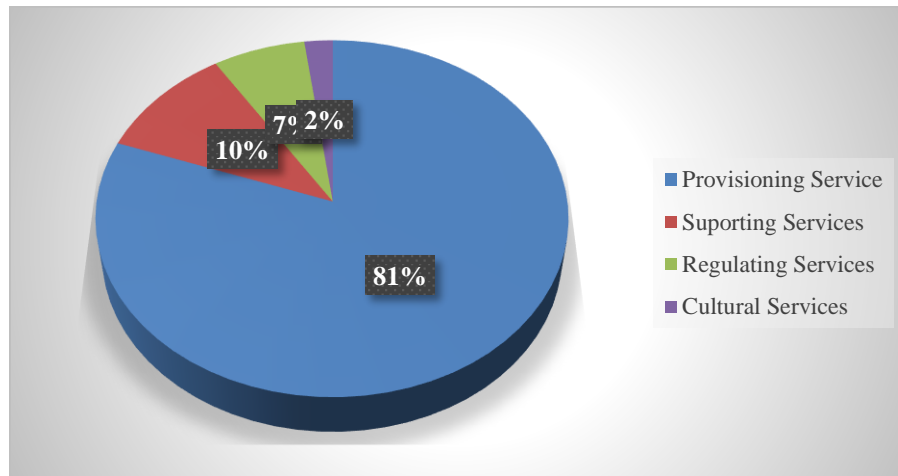
**Figure 2.** Mangrove ecosystem services in Tangerang District.

The results of the analysis of the benefits of mangrove ecosystem services in Tangerang Regency in total have a value of IDR. 20.486.986.843,00 with an area of 415,89 Ha (Table 3) which is the total economic value of mangrove resources. The total economic value in Tangerang Regency from service provisioning, support services, regulating services and cultural services per hectare is IDR. 49.260.560,16.

**Table 3.** Economic Value of Tangerang District Total Mangrove Ecosystems in 2017.

No	Ecosystem Services	Classification of Functions and Benefits	Total Economic Value (IDR)
1	Provisioning Service	Tree Stand	143.412.768,00
		Mangrove Seed Providers	408.000.000,00
		Mangrove fisheries (bait providers)	15.947.922.000,00
2	Supporting Services	Biodiversity of mangrove ecosystem	90.456.075,00
		Spawning ground	2.050.115.000,00
3	Regulating Services	Breakwater	207.500.000,00
		Carbon storage	1.206.081.000,00
4	Cultural Services	Education	43.500.000,00
		Recreation	390.000.000,00
<b>Total Economic Value</b>			<b>20.486.986.843,00</b>

The highest total economic value from ecosystem services are from provisioning services (80,53 %), secondly from support services (10,44%), the following regulating services (6,89%) and the last from cultural services (2,11%).



**Figure 3.** Total economic value from ecosystem services of mangrove ecosystem in Tangerang District.

## 4. Discussion

### 4.1. Provisioning Services

#### a. Tree Stand Value

Based on the results of the Citra Landsat SPOT 6 satellite image analysis, it is known that in the area of Tangerang District in 2017 there were mangrove forests covering an area of 415,89 ha. The main types of mangrove trees are *Avicennia alba*, *A. marina*, *Rhizophora mucronata* and *Sonneratia caseolaris* and have an average density of 58 trees / 100m<sup>2</sup> with a potential of 4,8 m<sup>3</sup> / ha / year [9]. Based on the research conducted, it was found that the average price of mangrove wood was IDR. 90.000,00 / m<sup>3</sup>, so the value of mangrove wood in this location was IDR. 432.000,00 / ha / year or the total value of mangrove wood in Tangerang District was IDR. 179.664.480,00.

The stand cost is calculated at 30% of the stand value, so that the value is IDR.129.600,00 / ha / year. The total cost of managing the Tangerang Regency mangrove ecosystem is IDR. 53.899.344,00. Thus, the value of the net direct benefit of mangrove forests from the stand value is IDR. 143.412.768,00.

#### b. Provider of Mangrove Seeds

The direct value of benefits from the mangrove ecosystem in the next Tangerang Regency is the provider of mangrove seeds. Mangrove seedling production in Tangerang Regency is 150.000 seeds a year, where the price of one mangrove seedling is an average of IDR. 4.000,00 so that the total value of the mangrove seedlings reaches IDR. 600.000.000,00 in a year. The mangrove nursery costs IDR. 800,00 per day per seedling, 1000 seedlings a day, can be harvested for 8 months, so the overall nursery costs reach IDR. 192.000.000,00. Thus the net benefits of mangrove seed providers reach approximately IDR. 408.000.000,00.

#### c. Mangrove Fisheries

The value of mangrove fisheries is one of the direct benefits of the mangrove ecosystem. Bait fish is a fish used for bait in capture fisheries activities in Tangerang Regency. The main type of bait fishery is Belanak fish. The average price of Belanak fish is IDR. 12.000,00 per kilo gram. Within a year the production of mullet is approximately 34 quintals per ha, so the value of mangrove fisheries is approximately IDR. 40.800.000,00 per ha / year. So that the overall benefit in a year with a mangrove area of 415,89 ha is IDR.16.968.312.000,00. While the cost of exploiting mangrove fisheries based on

survey results is approximately IDR. 2.700,00 per kilogram. With investments calculated as much as IDR. 3.000.000,00 per year and annual fixed costs of IDR 3.000.000,00, so that the total cost reaches IDR 1.020.390.000,00. So that the net benefits obtained are IDR. 15.947.922.000,00.

#### 4.2. *Supporting Services*

##### a. Biodiversity of the Mangrove Ecosystem

The benefits of biodiversity from mangrove ecosystems in Tangerang Regency are the benefits of choice. Mangrove forests in Indonesia have a biodiversity value of US \$ 1.500 per square kilometer or US \$ 15 per ha [13]. With US \$ 1 equal to IDR. 14.500,00 and mangrove area of 415,89 ha. So that the value of mangrove ecosystem biodiversity in Tangerang Regency is approximately IDR. 90.456.075,00.

##### b. Spawning Ground

The second indirect benefit of mangrove ecosystems in Tangerang Regency is as a place for spawning. Calculation of these benefits by using the formula of the regression relationship model between mangrove forest area, fishing effort (effort) with shrimp production [8]:

$$h=0,0268EM +1,141E-05 E^2 \quad (2)$$

where: h = shrimp production,  
E = is Effort and  
M = is the area of mangrove forest (ha).

If the area of mangrove forest in Tangerang Regency is 415,89 ha with an average fishing effort (effort) of 2.164, it means that shrimp can be produced at 24,119 kg per year. The price of shrimp in Tangerang Regency is IDR. 85.000,00 / kg, then the benefits of the mangrove ecosystem as spawning ground is IDR. 2.050.115.000,00.

#### 4.3. *Regulating Services*

##### a. Breakwaters

Indirect benefits of mangrove ecosystems in Tangerang Regency are the first as breakwaters which are the value of storm protection services [2]. The physical function as a breakwater is approached by calculating the costs needed to build a breakwater along the coast protected by mangrove ecosystems. Based on the research, it was found that the price of cement in Tangerang Regency was IDR. 71.000,00 per zak and the price of sand was IDR. 175.000,00 per cubic meter, so to build a breakwater building with a size of 1 m x 10 m x 2,5 m with a durability of 10 years a fee of IDR 12.500.000,00 is needed. The length of the coastline protected by mangrove forests in Tangerang Regency reaches 50 kilometers. The value of the cost of building a breakwater building is then multiplied by one third of the length of the coastline protected by the mangrove ecosystem which is 16,6 kilometers. So the total cost needed to make the breakwater building is IDR. 2.075.000.000,00 where the annual value is IDR. 207.500.000,00.

##### b. Carbon Storage

Another indirect benefit of mangrove ecosystems is as carbon storage. Pearce and Moran [10] explain that carbon can be stored in mangrove forests ranging from 36 to 220 tons per ha. Frankhauser [4] calculated that the value per ton of carbon amounted to US \$ 20. Based on field observations it was calculated that mangrove ecosystems in Tangerang Regency could absorb 200 tons of carbon per year, considering that the Tangerang Regency area was in the tropics so that its carbon uptake was relatively large. If 1 US \$ is calculated as IDR. 14.500,00 then the economic value of carbon sequestration in Tangerang Regency's mangrove ecosystem is approximately IDR. 2.900.000,00 per ha or the total is IDR. 1.206.081.000,00.

#### 4.4. Cultural Services

##### a. Education

Another direct benefit of mangrove ecosystems is education. This is relevant because mangrove ecosystems are often used for research and education activities. To reach Tangerang Regency from Jakarta, a IDR. 50.000,00 trip is needed. While the cost of living in Tangerang Regency is approximately IDR. 200.000,00 per day. The research activities in the Tangerang Regency mangrove ecosystem averaged around seven days. Based on the survey, it was obtained data that the research in a year was carried out three times with the number of researchers on average as many as ten people. The benefit of commuting is IDR. 1.500.000,00, while the benefit when staying is IDR. 42.000.000,00, so the net benefit from the education benefit is IDR. 43.500.000,00.

##### b. Recreation

The last direct benefit identified was recreation. Recreational activities in Tangerang Regency have not taken place much, however, almost the same as research activities, the required costs to Tangerang Regency reach IDR.50.000,00 round trip. While the cost of living is IDR. 200.000,00 per day and the length of stay is three days. Within a period of one year tourism activities were visited by 300 visitors in three coastal tourist sites namely Tanjung Pasir beach, Tanjung Kait beach, and Cangkir islands with an estimated visit each time two times a year. Thus, the value of the mangrove ecosystem benefits from recreational benefits is IDR. 390.000.000,00.

#### 5. Conclusion

Mangrove ecosystems have a high economic value that should be maintained and managed properly, with the availability of data and information on the condition of mangrove ecosystems in Tangerang Regency can be a reference in managing sustainable mangrove ecosystems and contributing to the welfare of coastal communities, especially utilization of mangrove ecosystems.

This study has been able to identify, map and evaluate the economic use of the mangrove ecosystem area, explore ecosystem services to be able to preserve and manage mangroves to be better. Cultural services and regulating services of mangrove ecosystems must be improved by giving awareness to the community of the importance of mangroves, so that the role of mangrove ecosystems can be the basis for management policy making in Tangerang Regency.

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