Economic valuation of the mangrove ecosystem in Purwodadi Sub-district, Purworejo Regency, Central Java

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Abstract. Deforestation of mangroves caused by land conversion into ponds occurs on the southern coast of Purwodadi Sub-district, Purworejo Regency, Central Java. In fact, the mangrove ecosystem has an important role related to global climate change that is happening at this time. Mangroves have the ability to absorb more carbon than other types of forests. Since 2011, there was a mangrove rehabilitation program conducted in three villages in Purwodadi Sub-district, which was initiated by the Purworejo Regency Marine and Fisheries Service. Over time, the conditions of mangroves in each village varied. This study aims to calculate the economic value of mangrove ecosystems in the three villages of Purwodadi Sub-district, namely Gedangan, Jatikontal, and Jatimalang Villages. The method used is TEV (Total Economic Value) which consists of an analysis of direct use value using the market price approach, indirect use value using the replacement cost approach, the option value using the benefits transfer, and the existence value using the WTP method (Willingness to Pay). The results of the study show that the total economic value of mangroves in Gedangan Village is IDR 7,816,788,994.00, in Jatikontal Village in the amount of IDR 10,524,895,152.00, and in Jatimalang Village in the amount of IDR 3,645,653,186.00.

1. Introduction

Deforestation of mangroves is one of the important issues in Indonesia when it is associated with global climate change. Mangrove ecosystems have the ability to absorb more carbon than other forest types [1,2,3]. Therefore, the existence of mangrove ecosystems needs to be maintained so as not to diminish even disappear. The phenomenon of deforestation has been rampant in Indonesia since the 1980s. Indonesia has been recorded as a group of countries that lost the largest mangrove in the world, even though Indonesia is a country that has the largest area of mangrove in Asia, with an area equivalent to 23% of the area of mangrove [4]. In 1980, the area of mangrove in Indonesia reached 4.25 million ha, in 1990 it decreased to 3.53 million ha, and in 2000 the area of mangrove in Indonesia was 2.9 million ha. The average decline in mangrove area per year in 1980-1990 was 72.33 ha, while in the period 1990-2000 the decline in mangrove area reached 60.07 ha per year [5].

The loss of mangroves or mangrove deforestation is due to anthropogenic activities, which include the construction of residential areas, industry [4,6,7,8], tourism, agriculture [6,8], shrimp ponds [4,6], fisheries [7,8], as well as mining activities and salt ponds [8]. Among these anthropogenic activities, the conversion of mangroves into shrimp ponds is the dominant factor causing damage and loss of mangroves in Southeast Asia, one of them in Indonesia [5,9,10]. In Indonesia, the area of shrimp
farms has increased. In 1990, the area of the pond reached 269 ha and then in 2001, the area of the pond was recorded at 438.01 ha [5].

The phenomenon of mangrove function conversion into shrimp and fish ponds was also found in the southern coastal region of Purwodadi Sub-district, Purworejo Regency, Central Java. The existence of mangrove functions in this area has a significant impact on the reduction of mangrove stands [11]. The level of damage to mangroves in Purworejo District, Central Java for trees is categorized as damaged (rare) [11]. In fact, the mangroves found in Purworejo Regency are included in nature conservation areas that have the function of protecting the life support system, preserving the diversity of plants and animals, as well as sustainable living natural resources and their ecosystems [12]. In addition, based on BNPB data (2013), it is stated that the southern coastal region of Purworejo has a high risk of the tsunami disaster. The southern coast of Purworejo was ranked third in the tsunami disaster vulnerability in Central Java [13].

Since 2011, a mangrove rehabilitation program has been carried out in three villages in Purwodadi Sub-district, which was initiated by the Purworejo Regency Marine and Fisheries Service. Over time, the conditions of mangroves in each village varied. There is a better stand density, but some are cut down again to be made into ponds. In Gedangan Village, the dense mangrove stands were made into mangrove education tourism and have been running for three years. In Jatikontal Village, mangrove ecosystems have been initiated into arboretums since the end of 2017. As in the village of Jatimalang, mangroves are only left alone and some local community uses them directly. The variation in conditions and utilization carried out in the three villages is interesting to study regarding the economic valuation of mangrove ecosystems in order to become part of the road map for determining the strategy for mangrove management in Purwodadi Sub-district. Economic valuation is useful to know the positive and negative impacts of environmental management measures that are valued in rupiah [14].

2. Research Methodology
This research was conducted in Purwodadi Sub-district, Purworejo Regency, Central Java, which involved three villages, namely Gedangan, Jatikontal, and Jatimalang. Purwodadi Sub-district is located at 109° 47’ 28” BT-110° 8’ 20” BT and 7° 32’ 32” LS-7° 54’ 54” LS [15]. The study was conducted from January to April 2019.

![Figure 1. Research Location](image-url)
In calculating the value of the mangrove ecosystem, researchers use the total economic value (TEV), which is the sum of the various values, as follows:

\[ TEV = DUV + IUV + OV + EV \]  

(1)

Notes:
- DUV = direct use value
- IUV = indirect use value
- OV = option value
- EV = existence value

The direct use value in this study is calculated from the number of fish, shrimp, and crab catches by the community using a market approach. Data was collected through interviews with communities in three villages. Analysis of indirect use value calculated from seawater intrusion prevention services and carbon sink services using a replacement cost approach. The option value is calculated using the benefits transfer approach of biodiversity values according to the results of a study from Ruitenbeek (1992) which states that the biodiversity value of mangrove forests in Indonesia is USD 15/ha/year [16]. The existence value is calculated using the WTP method (Willingness to Pay).

The parameters used to calculate each value along with the calculation method are described in the scheme of calculating the economic valuation of the mangrove ecosystem (Figure 2.)

### Figure 2. Schematic calculation of economic valuation of mangrove ecosystems.

### 3. Result and Discussion

#### 3.1. Direct Use Value

The direct benefit of the existence of mangrove ecosystems in Purwodadi Sub-district felt by the community is as a source for catching fish, shrimp, and crabs. The community catches fish, shrimp, and crab using traditional fishing gear, such as ‘wuwu’, nets, and spears. Table 1. illustrates about the economic value obtained from the production of fish, shrimp, and crab in Purwodadi Sub-district.
Table 1. The economic value of the production of fish, shrimp, and crab.

| Village   | The total catch in a week (IDR) | The total catch in a year (IDR) |
|-----------|---------------------------------|---------------------------------|
| Gedangan  | 343,500                         | 7,666,920,000                   |
| Jatikontal| 214,333                         | 10,082,224,320                  |
| Jatimalang| 46,562                          | 3,046,272,288                   |

Source: Researcher’s Analysis (2019)

Based on Table 1., the economic value obtained from the fisheries products in Gedangan Village is IDR 7,666,920,000.00 per year, in the Jatikontal village IDR 10,082,224,320.00. While the catches of fisheries products in Jatimalang Village have an economic value of IDR 3,046,272,288.00 per year. This calculation is based on the results of interviews with respondents by asking about the amount of average income obtained from fishing activities during the week. Income during the week is then calculated to obtain income for one year.

From the results of interviews conducted to the sample of community respondents, the average income of the community in Gedangan Village, which was obtained from the activities of fish, shrimp, and crab for one week, amounting to IDR 343,500.00. In Jatikontal Village, the average income of the community is IDR 214,333.00. As for Jatimalang Village, the average income of the community is smaller than that in the other two villages, which is IDR 46,562.00. This is due to the fact that the people in Jatimalang are mostly busy farming in the fields and doing activities in the ponds. Besides that the condition of the river in this village is narrower than the other two villages.

3.2. Indirect Use Value

The calculation of the value of indirect benefits from the existence of mangrove ecosystems in this study is based on two parameters, namely seawater intrusion prevention services and carbon sink services. Seawater intrusion prevention services are calculated using the replacement cost approach, which uses the calculation of the cost of providing clean water for daily needs purposes. Provision of clean water for daily needs is calculated based on PDAM fees. The carbon sink service is calculated from the ability of the mangrove ecosystem to carry out carbon absorption of 200 tons in one hectare of land [17]. Then, the total carbon absorbed is calculated by the value of the rupiah with a value of USD 20 per ton of CO₂ [18].

The economic value of seawater intrusion prevention services in the three villages of Purwodadi Sub-district differs depending on how much the population is (Table 2). In Gedangan Village, the economic value of seawater intrusion prevention services is IDR 39,952,800.00 per year, in Jatikontal Village reaches IDR 84,201,600.00, while in Jatimalang Village reaches IDR 117,108,960.00.

Table 2. The economic value of seawater intrusion prevention services.

| Village   | Total population | Average water requirements per month (m³) | PDAM fees (per m³) | Total in a year (IDR) |
|-----------|------------------|------------------------------------------|--------------------|-----------------------|
| Gedangan  | 465              | 4                                        | 1,790              | 39,952,800            |
| Jatikontal| 980              | 4                                        | 1,790              | 84,201,600            |
| Jatimalang| 1,363            | 4                                        | 1,790              | 117,108,960           |

Source: Researcher’s Analysis (2019)

The economic value of carbon sink services in the Purwodadi Sub-district can be seen in Table 3. Economic value in Gedangan Village is IDR 57,283,200.00 with an area of 1.02 ha of mangroves. In Jatikontal Village, which has a mangrove area of 4.72 ha, it has an economic value of mangrove absorbing services amounting to IDR 265,075,200.00. The Jatimalang village has the largest carbon...
sink economic value of IDR 419,515,200.00. This is due to the largest area of mangrove in Jatimalang village, which is 7.47 ha, so the ability to absorb carbon is even greater.

Table 3. The economic value of carbon sink services.

| Village   | Mangrove Area | Carbon Value (IDR) |
|-----------|---------------|--------------------|
| Gedangan  | 1.02 ha       | 57,283,200         |
| Jatikontal| 4.72 ha       | 265,075,200        |
| Jatimalang| 7.47 ha       | 419,515,200        |

Source: Researcher’s Analysis (2019)

3.3. Option Value
Option values in this study were calculated from the value of mangrove biodiversity using the benefits transfer approach which refers to the results of Ruitenbeek (1992). Based on Table 4., the biodiversity value of the mangrove ecosystem in Gedangan Village is IDR 214,812.00 per year. In Jatikontal Village the value of biodiversity is higher at IDR 994,032.00. Whereas in Jatimalang Village the value of biodiversity has the highest value compared to the other two villages, namely IDR 1,573,182.00. Differences in the value of biodiversity in each village are due to the wide differences in mangrove ecosystems. The larger the area of the mangrove ecosystem, the greater the biodiversity value.

Table 4. The economic value of mangrove biodiversity.

| Village   | Mangrove Area | Biodiversity Value (IDR) |
|-----------|---------------|--------------------------|
| Gedangan  | 1.02 ha       | 214,812                  |
| Jatikontal| 4.72 ha       | 994,032                  |
| Jatimalang| 7.47 ha       | 1,573,182                |

Source: Researcher’s Analysis (2019)

3.4. Existence Value
The existence value is obtained from the willingness of respondents to pay with the benefits they feel from the existence of mangrove ecosystem. Before knowing the willingness of the respondent to pay, the respondent is given a hypothetical market scenario to give an overview of the community. After that, respondents were given an offer whether they were willing to participate in contributions for mangrove conservation activities. For respondents who are willing, they are given an offer with a value of IDR 2,000.00, IDR 5,000.00, IDR 10,000.00, IDR 15,000.00, IDR 20,000.00, IDR 25,000.00, IDR 50,000.00, up to the voluntary value that the respondent wants to give.

Based on the results of the survey (Fig. 3), 87% of the Gedangan community are willing to pay for the conservation of mangrove ecosystems, the remaining 13% are unwilling. In Jatikontal Village, 92% of the people were willing, while 8% were not willing. As for Jatimalang Village, 73% of the community is willing to pay and the remaining 27% of the community is not willing to pay.

|        | Will | Not Will |
|--------|------|----------|
| Gedangan | 87   | 13       |
| Jatikontal | 92   | 8        |
| Jatimalang | 73   | 27       |
Figure 3. Willingness Community To Pay in Purwodadi Sub-district.

In the Gedangan Village, the WTP value that majority of the people choose is IDR 5,000.00 (57.6%). Furthermore, the value of the WTP chosen by the community is IDR 2,000.00 (12.1%), IDR 10,000.00 (6.1%), and the value of IDR 15,000.00, IDR 20,000.00, and IDR 50,000.00 (3%). In Jatikontal Village, the highest number of WTP chosen by the community is IDR 2,000.00 and IDR 10,000.00 (30.6%). Furthermore, at the value of IDR 5,000.00, 28.6% of respondents were selected. The WTP value of IDR 20,000.00 was chosen by as many as 6.1% of respondents, while IDR 25,000.00, and IDR 50,000.00 were chosen by respondents as much as 2.3%.

As for Jatimalang Village, the majority of respondents (55.6%) chose the WTP value of IDR 2,000.00; 25.9% chose the WTP value of IDR 5,000.00; 11.1% of respondents chose the WTP value amounting to IDR 10,000.00, and as many as 7.4% of respondents chose the WTP value of IDR 3,000.00.

The mean WTP value of the Gedangan Village is IDR 9,394.00 and mean WTP value of Jatikontal Village is IDR 7,857.00. While the mean WTP value of Jatimalang Village is IDR 3,741.00. Each mean WTP value is then multiplied by the total population of each village within a period of one year so that the total WTP value per year is obtained. From the calculation results, the total WTP value per year for Gedangan Village is IDR 52,418,182.00, for Jatikontal Village is IDR 92,400,000.00, and for Jatimalang Village is IDR 61,183,556.00 (Table 5).

Table 5. WTP Value in Purwodadi Sub-district.

| WTP Value (IDR) | Frequency of Respondents | WTP Value (IDR/month) |
|-----------------|---------------------------|------------------------|
| Gedangan        | Jatikontal                | Jatimalang             |
| 2,000           | 5                         | 15                     | 15                     | 10,000  | 30,000  | 30,000  |
| 3,000           | 0                         | 0                      | 2                      | 0       | 0       | 6,000   |
| 5,000           | 19                        | 14                     | 7                      | 95,000  | 70,000  | 35,000  |
| 10,000          | 2                         | 15                     | 3                      | 20,000  | 150,000 | 30,000  |
| 15,000          | 1                         | 0                      | 0                      | 15,000  | 0       | 0       |
| 20,000          | 1                         | 3                      | 0                      | 20,000  | 60,000  | 0       |
| 25,000          | 4                         | 1                      | 0                      | 100,000 | 25,000  | 0       |
| 50,000          | 1                         | 1                      | 0                      | 50,000  | 50,000  | 0       |
| Total           | 33                        | 49                     | 37                     | 310,000 | 385,000 | 101,000 |

Mean WTP: 9,394.00 7,857.00 3,741.00
Total population: 465 980 1,363
Total WTP per year: 52,418,182.00 92,400,000.00 61,183,556.00

Source: Researcher’s Analysis (2019)

3.5. Total Economic Value

The total economic value is obtained from the sum of direct use value, indirect use value, option value and the existence value of the mangrove ecosystem found in Purwodadi Sub-district (Table 6). The total economic value of mangroves in Gedangan Village is IDR 7,816,788,994.00; in Jatikontal Village in the amount of IDR 10,524,895,152.00; and in Jatimalang Village in the amount of IDR 3,645,653,186.00. Of the three villages when compared, Jatikontal Village has the highest value because Jatimalang Village has the largest mangrove area compared to the other two villages. As for Jatikontal Village, carbon sequestration services and seawater intrusion services have great value because Jatimalang Village has the largest mangrove area compared to the other two villages.
Table 6. Total Economic Value of Mangrove Ecosystems.

| Economic Value                        | Gedangan Village | Jatikontal Village | Jatimalang Village |
|---------------------------------------|------------------|--------------------|--------------------|
| Use Value                             |                  |                    |                    |
| Fish, shrimp, and crab catch          | 7,666,920,000    | 10,082,224,320     | 3,046,272,288      |
| Indirect use value                    |                  |                    |                    |
| Seawater intrusion prevention services| 39,952,800       | 84,201,600         | 117,108,960        |
| Carbon sink services                  | 57,283,200       | 265,075,200        | 419,515,200        |
| Option value                          |                  |                    |                    |
| Biodiversity value                    | 214,812          | 994,032            | 1,573,182          |
| Existence value                       | 52,418,182       | 92,400,000         | 61,183,556         |
| Total economic value                  | 7,816,788,994    | 10,524,895,152     | 3,645,653,186      |

Source: Researcher’s Analysis (2019)

When compared with the total economic value of mangroves in Bedono village, Demak [19] amounting to IDR 2,037,005,895.00 per year, the three villages in Purwodadi District had a greater total economic value. Then when compared with the total economic value of mangroves in Pasar Banggi Village, Rembang Sub-district, Rembang Regency [20] which has a total economic value of IDR 19,610,846,229.00 per year, the three villages in Purwodadi Sub-district have lower total economic values. The total economic value of mangrove ecosystems has a greater value than the economic benefits obtained from the conversion of mangroves into shrimp ponds. The net profit from the black tiger shrimp farm business is 5.57 Lakh/ha/crop, equivalent to IDR 112,694,437/ha/crop, while the white legged shrimp business gains 19.63 Lakh/ha/crop or equivalent to IDR 397,161,902 [21]. The benefits obtained from shrimp farms are not always positive. This is based on experience in Iran, the value of the benefits of shrimp farms being negative after 5 years of operation [22]. Shrimp productivity has been observed to decline at rates between 3% -8% per production cycle [23].

4. Conclusion

The total economic value of mangroves is obtained from the sum of direct use values, indirect use values, choice values, and values of existence. Use value is directly calculated from the production of fish, shrimp, and crabs that are captured by the surrounding community. The indirect use value is calculated from seawater intrusion prevention services and carbon sink services. The option value is calculated from the value of mangrove biodiversity, while the existence value is calculated from the willingness of the community to pay (WTP) from the presence of mangrove forests and the benefits generated. Once calculated, the total economic value of mangroves in Gedangan Village is IDR 7,816,788,994.00; in Jatikontal Village in the amount of IDR 10,524,895,152.00; and in Jatimalang Village in the amount of IDR 3,645,653,186.00. Jatikontal Village has the highest total economic value. The direct use-value has the highest contribution to the total economic value.

Acknowledgments.
The authors would like to thank the Universitas Gadjah Mada’s Grant for the support and funding. We thank for Dr. Rika Harini, M.P and Dr. Niken Wirasanti, M.Si for their support and supervision of this study, and also Rizki Setiawan as our field assistant. We are also grateful to the respondents contributing to the study.
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