

# Economic valuation of Lansia Mangrove Forest, North Sulawesi, Indonesia

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**Abstract.** *Sondak CFA, Kaligis EY, Bara RA. 2019. Economic valuation of Lansia Mangrove Forest, North Sulawesi, Indonesia. Biodiversitas 20: 978-986.* Mangrove forest gives many benefits and services to human and environment. Even though it contributes many benefits and services, coastal ecosystems threatened as one of the most critical ecosystems in the world. The study aims to estimate the economic value of ecosystem services provided by Lansia mangrove forest, Wori Sub-district, North Minahasa District, North Sulawesi Province, Indonesia. Here, we describe the use value (direct and indirect value) and non-use value (option and existence value), and emphasize the components of ecosystem services fish resources, firewood, coastal protection, biodiversity, carbon (C) removal and mangrove sustainability because these directly influence human welfare. Their market price calculated fish and C removal value. Coastal barrier and firewood were approached using the replacement cost method. Biodiversity value was calculated using Indonesia mangrove forest biodiversity value. Contingent Valuation method was used to find out people willing to pay for the sustainability of mangrove forest. Lansia mangrove forest total economic value (TEV) was IDR 4,431,197,603 or equal to US\$ 305,600 (US\$ 1,959 ha<sup>-1</sup>). The success of this mangrove valuation has potentially large implications for future policy-making of its' ecosystem service values.

**Keywords:** Ecosystem service, mangrove forest, valuation

## INTRODUCTION

Mangrove forest is one of the coastal ecosystems that can be found mostly in tropical regions. Indonesia has the largest mangrove forest area in the world. Data of Indonesian mangroves area was varied. Giesen (1993) reported that the Indonesia mangrove forest area was about 2.5 million ha, while 4.5 million ha claimed by Spalding et al. (1997). Meanwhile, recent data shows, mangrove forest area from 2016-2016 were 4.4 million ha, 3.7 million ha, and 3.9 million ha respectively (BPS 2017; MMAF 2017). In Indonesia, mangrove forest appeared in all 34 provinces. The largest area was found in Papua Province about 1.1 million ha, while Yogyakarta Province was the smallest about 40.10 ha (BPS 2017).

Mangrove forest gives many benefits and services to human and environment, such as coastal protection, food resources, species biodiversity and conservation (Vo et al. 2012). Even though, it contributes many benefits and services, coastal ecosystems threatened as one of the most critical ecosystems in the world. This condition due to the fact that approximately 340,000-980,000 ha mangrove forests destroyed annually (Murray et al. 2011), while Indonesia mangrove forest lost approximately 5.6% (204,698 ha) annually (BPS 2017). Globally, mangrove, seagrass, and salt marsh area lost to about 67%, 35% and 29% respectively (Pendleton et al. 2012). If this phenomenon continue, mangrove can lose the services that it provides for human and adjacent ecosystems.

Ecosystem services (ES) sustain, strengthen, and

enrich various aspects of human life (Kumar and Muradian 2009). Natural ecosystems such as those associated with forest, freshwater, marine, or coastal environments interact with cultivated ecosystems (Wattage 2011). The term 'ecosystem services' is sometimes used interchangeably with 'environmental services' or 'ecological services' (FAO 2002). It has been defined as the array of processes and functions that benefit and support human welfare (Daily 1997; de Groot et al. 2002; MA 2005). These services have been classified as provisioning, regulating, supporting, cultural etc., which would otherwise remain hidden or unappreciated, can be revealed through estimates of value (Wilson et al. 2005). Only a few of these ecosystem services have been marketed, and integration has not been completed between the functions of ecological production and economic valuation within many key estuaries and coastal ecosystem services (Barbier et al. 2011).

Economic value is one way to define and measure worth based on a person's wants or preferences (King and Mazzota 2000). It is often considered the maximum amount an individual is willing to forego in other services and goods to obtain some services, products, or state of the world (Lipton et al. 1995). Economic valuation can also be described as an effort to allocate a quantitative value to the products and services provided by natural ecosystems (Costanza and Folke 1997; Daily et al. 1997). Recognizing the services and economic value of ecosystems is essential because of the great importance that humans place on their well-being, resource sustainability, and fairness in

distribution (Costanza and Farber 2002).

Lansa mangrove forest is located in Wori Sub-district, North Minahasa District, North Sulawesi Province covered an area of 156 ha. Mangrove forest provides ecosystem services that can be used by humans and animals. Where an ecosystem's services can be identified and measured, it will often be possible to assign values to them by employing existing economic valuation methods (NRC 2004). The study aims to estimate the value of services provided by Lansa mangrove forest, Wori Sub-district, North Minahasa District, North Sulawesi Province, Indonesia. Several factors formed the basis for our study concept, such as gaps in our knowledge about marine coastal ecosystems services. This paper present ecosystem services valuation of Lansa mangrove forest. Here, we chose to emphasize the components of food resources, fuel, coastal protection, biodiversity, carbon (C) removal and mangrove sustainability because they directly influence human welfare.

## MATERIALS AND METHODS

### Study site

Lansa mangrove forest is located in the coast of North Minahasa District, North Sulawesi Peninsula, Indonesia ( $124^{\circ}55'6''$ - $124^{\circ}56'3''$ E and  $1^{\circ}38'36''$ - $1^{\circ}39'30''$  N. The

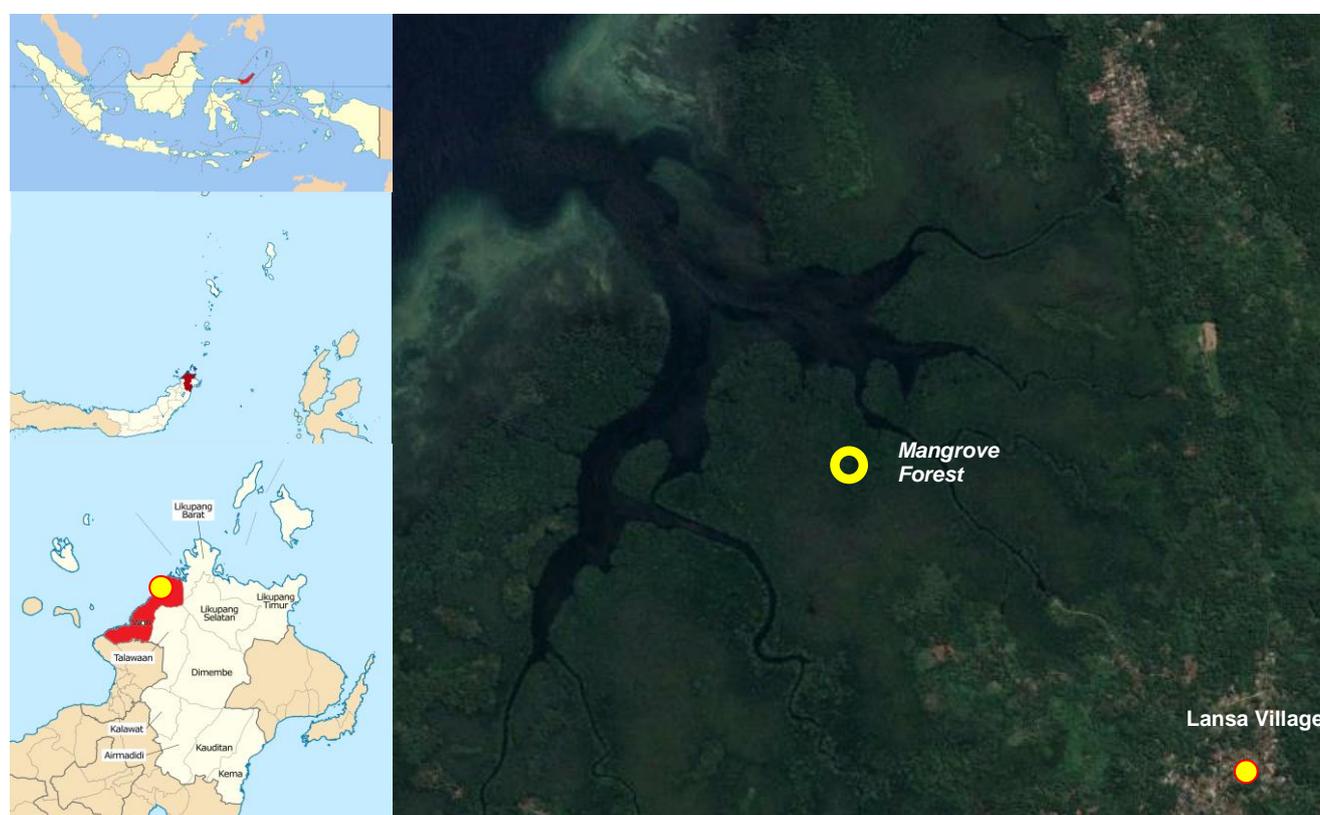
total area of mangrove forest is 156 ha. The map of study site is shown in Figure 1.

### Direct use value calculation

Direct use value (DUV) for fishery and fuel was calculated by multiplied their quantity with the market price. Fish market price data was based on an interview to 16 local fishermen, while for firewood was six collectors. Data was collected using purposive sampling method with assumption that the respondents are mangrove resources user. Based on the interview, there was no market price for firewood as this firewood only uses for household activities. If there is no market price or final price for the service, replacement cost was used (Dixon and Sherman 1991; Woodward and Wui 2001; Permen KLH 2012; Barbier 2016). In this study, firewood market price was replaced with a 3kg gas price. Fish and firewood value was based on Takarendehang et al. (2018).

### Indirect use value calculation

Coastal protection value was based on Takarendehang et al. (2018) while for C removal, was computed by multiplied carbon trading price with C total content. In 2011, relevant markets were paying \$3.90 per ton temporary Certified Emission Rate, or tCER for carbon trade (Peters-Stanley et al. 2012).



**Figure 1.** The study site of Lansa mangrove forest, North Sulawesi, Indonesia

*Option value*

Mangrove forest biodiversity value was calculated according to Ruitenbeek (1992) value for Indonesia mangrove biodiversity value (USD 15/ha = Rp. 14,500 in September 2018) multiplied by the total area of mangrove. For mangrove wood potency was calculated by multiplied mangrove basal area with tree height.

*Existence value*

Existence value was estimated using the contingent valuation method (CVM). This method was based on the respondent's willingness to pay (WTP) on mangrove forest sustainable in their village. Questioners were used to get their willing to pay. Forty-two respondents randomly selected among the villagers with different backgrounds. They were given bid value IDR 10,000, IDR 15,000, IDR 20,000 and IDR 25,000 then was asked to bid among these values. Existence value was calculated by multiplying average of respondents WTP by the number of households.

*Total economic value*

Recognizing the total economic value (TEV) of services from mangrove forest is essential to meeting demands for human well-being, sustainability, and fairness in resource distribution (Costanza and Farber 2002). The concept of TEV generally entails both use-and non-use values when calculating the economic benefits of mangrove forest. Here in this study, there is no bequest value.

$$TEV = UV (DUV + IUV) + N-UV (OV + XV + BV)$$

Where:

- UV : Use Value
- DUV : Direct Use Value
- IUV : Indirect Use Value
- N-UV : Non-Use Value
- OV : Option Value
- XV : Existence Value
- BV : Bequest Value

**Community structure study**

Mangrove community structure data was collected by stratified random sampling from six plots within mangrove forest. In each plot, a 10 x 10 quadrat were laid for trees sampling. Every tree within quadrat were counted, identified, and measured its diameter at breast high (dbh) at ≥ 1.3 m. Mangrove tree structural indices including relative density, relative frequency, relative dominance, and importance value index (IVI) were estimated (Soerianegara and Irawan 2002).

$$\text{Relative density} = \frac{\text{Density species -i}}{\text{Density of all species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency species-i}}{\text{Frequency all species}} \times 100$$

Dominance species-i

$$\text{Relative dominance} = \frac{\text{Dominance species-i}}{\text{Dominance value of all species}} \times 100$$

$$IVI = \text{relative density} + \text{relative frequency} + \text{dominance relative}$$

**Mangrove biomass**

Above ground biomass was calculated by multiplying wood density with allometric equation and tree dbh.

$$W_{top} = \rho * 0.251 dbh^{2.46} \text{ (Komiyama et al. 2005)}$$

Where:

- W<sub>top</sub> : is above-ground biomass
- ρ : is wood density
- dbh : is diameter at breast height at 1.3m

**Mangrove carbon and carbondioxide (CO<sub>2</sub>) content**

Carbon content in mangrove was estimated base on the tree biomass (above ground biomass) (IPPC 2006). C concentration in organic matter is 0.47 (47%). Carbon content in mangrove tree then estimated by multiplying 0.47 to above-ground biomass.

$$C_{con} = 0.47 \times B$$

Where:

- C<sub>con</sub> : C concentration
- 0.47 : percentage of organic matter
- B : Biomass

The potential amount of CO<sub>2</sub> that could be sequestered then was calculated by multiplying Carbon (C) by the amount of CO<sub>2</sub> measured in 1 gram of dry plant material which is 3.67 (Mudiyarso 1999).

$$WCO_2 = C \times 3.67$$

Where:

- WCO<sub>2</sub> : CO<sub>2</sub> potential sequestration
- C : Carbon concentration
- 3.67 : amount of CO<sub>2</sub> in 1 g of dry plant material

**RESULTS AND DISCUSSION**

**Use value**

According to TEEB (2010), Use Value can be associated with private of quasi-private good, for which market price usually exist and can be grouped into direct use value and indirect use value. This study found that mangrove forest use value (direct use and indirect use value) were fishes, firewood, carbon removal, and coastal barrier. Total direct use value was 1,789,629,000 while indirect use value was 2,586,190,270 (Table 3). Direct Use Value (DUV) represents services that are intended for immediate consumptive or non-consumptive purposes (e.g fishes, firewood) while the Indirect Use Value (IUV) indicates

the intermediate inputs associated with the manufacture of end products and services for human consumption (e.g. coastal barrier, carbon removal) (MA 2005).

Many Indonesia coastal inhabitants have used services from mangrove for a long time for firewood, charcoal, tannin, dyes, food, beverages, medicine, pole, and timber (Kusmana 2014). Similarly, some Lansia village inhabitants relies on their daily income from services offer by mangrove forest. Fishes and firewood were used for food, cooking, and sell to the market but mostly the community use for their daily use. Fishes mostly dominated by grouper (*Epinephelus* sp.), these fishes mostly sell to support family income and the rest consume as food for all family member. Firewood mainly used as fuel for their cooking activities and trade in the market. It was found that age level, income, and job are strongly affected by the dependency on mangrove (Mojiol et al. 2016). This was an assumed factor that affects the utilization of mangrove forest services by the villagers.

As the risk of natural disasters such as cyclones and tsunami increasing in North Sulawesi, mangrove forest can be a barrier to reduce the hazardous impact on many North Sulawesi coastal villages including Lansia village. With a total coverage area of 156 ha, Lansia mangrove can protect the coast line and the communities of this area. Mangrove provides coastal barrier and protection for the coastal community in terms of decrease the wave and wind power (Mazda et al. 1997; Kathiresan and Rajendran 2005; Spalding et al. 2014; Barbier 2016). Moreover, mangrove can reduce the impact of storm and tsunami that can save coastal communities from property damage and get injury even death (Koch et al. 2009; Barbier 2016). As an example, an area of *Rhizophora* sp. 400m wide with a density of 0.2 trees m<sup>-2</sup>, and a stem diameter of 15 cm can minimize the tsunami inundation depth by 30% when 3 m tsunami wave occur (Yanagisawa et al. 2009). Mangrove value as the coastal barrier was approached using replacement cost method where calculation was done by substitute mangrove forest value as the coastal barrier with construction of breakwater. Current estimation value was IDR 2,583,300,000 (Table 4) but with prediction that natural disaster events increase on its frequency and intensity in the future, this value could be higher.

Climate change and rising atmospheric CO<sub>2</sub> levels have become serious environmental issues. Present day the study on the role of coastal vegetation (i.e. seagrass, salt marsh, seaweed bed, mangrove) to combat climate change by carbon dioxide mitigation has been increasing (Chmura et al. 2003; Duarte et al. 2005; Donato et al. 2011; Sondak and Chung 2015; Sondak et al. 2017). Mangrove plays an important role in carbon fixation that can help improve the capacity to absorb atmospheric CO<sub>2</sub> by sequester through photosynthesis. Lansia mangrove forest can remove C and sequester CO<sub>2</sub> about 13.94 t C and 51.11 t CO<sub>2</sub> respectively. This result indicates that 55 t CO<sub>2</sub> have an economic value about IDR 2,890,270 or US\$ 199. By comparison, the economic value attributed to CO<sub>2</sub> sequestration within Philippine coral reefs is \$8.4 million over 464,090 ha, or \$18.10 ha<sup>-1</sup> (Samonte-Tan and Amedilla 2004).

**Table 1.** Biomass, total potential of Carbon (C) and Carbondioxide (CO<sub>2</sub>)

| Species                                  | Total biomass (ton h <sup>-1</sup> ) | Total karbon (ton h <sup>-1</sup> ) | Total CO <sub>2</sub> (ton h <sup>-1</sup> ) |
|--|--------------------------------------|-------------------------------------|--|
| <i>Avicennia marina</i> (Forssk.) Vierh. | 3.37                                 | 1.59                                | 5.83   |
| <i>Rhizophora</i> sp.                    | 20.48                                | 9.64                                | 35.34  |
| <i>Xylocarpus granatum</i> J.Koenig      | 4.49                                 | 2.12                                | 7.76   |
| <i>Sonneratia alba</i> Sm.               | 5.31                                 | 0.56                                | 2.06   |
| <i>Ceriops tagal</i> (Perr.) C.B.Rob.    | 0.07                                 | 0.03                                | 0.12   |
| Total                                    | 33.72                                | 13.94                               | 51.11  |

*Rhizophora* sp. has the highest total biomass (20.48 t ha<sup>-1</sup>) (Table 1) compare to other mangrove species (Table 1). C total and CO<sub>2</sub> total removal and sequestrate were dominated by *Rhizophora* sp., 9.64 t C and 35.34 t CO<sub>2</sub> correspondingly. *C. tagal* indicated to have the lowest biomass, C total and CO<sub>2</sub> total among these five species. Biomass and carbon stock affected by mangrove tree diameter and density (Eusop et al. 2018). Our data from the mangrove community structure support this statement as *Rhizophora* sp. has the highest density and basal area (Table 5). We found as biomass increase carbon stock in mangrove also increase. This condition could be explained why *Rhizophora* sp. has the highest potency of C removal it is because this species has the highest biomass among five species found.

#### Non use value

Non use value is value that do not involve direct and indirect uses of ecosystem services (TEEB 2010). These values can be categorized in option value, existence value, and bequest value.

#### Option value

The option value (OV) is the value that people place on having the possible opportunity to enjoy something in the future, such as biodiversity (King and Mazzota 2000). Mangrove option value was approached from its biodiversity value. Lansia mangrove forest biodiversity value was IDR 56,550,000 (Table 4). During the study, some terrestrial fauna, such as birds, butterflies, insects) as well as mangrove fauna, such as crabs, shrimps, mollusks, crustacean spotted in this area. This condition can be assumed that the area has high biodiversity.

Mangrove ecosystem is well known as one of most diverse flora and fauna that come from land and ocean as they provide foods, habitat, and shelter for them. The Indonesian mangrove consists of 202 species, (Kusmana 1993; Noor et al. 2006), while marine fauna, such as gastropods, bivalves, and crustaceans consist of 118 species (Kartawinata and Walujo 1977; Budiman and Darnaedi 1984; Pramudji 2001) and terrestrial fauna, such as mammals, reptiles, amphibians, and birds consist of 147 species (LPP Mangrove 2000). Fauna mangrove can be found in every part of mangrove ecosystem such as, in mangrove tree and canopy (birds, insects, mammals, and reptiles), roots (tunicates, sponges, algae, and bivalves), space between roots (prawns, crabs and fishes) (Nagelkerken et al. 2008). As mangrove provide high

biodiversity, it is urgent to protect from losing its value. According to de Groot et al. (2012), marine ecosystem services have sustained degradation and a loss of biodiversity. This condition has led to their decreased functioning and resilience, ultimately risking the continuity of flow in supplying both present and future generations. The diversity of flora and fauna and also economic values should be evaluated to reserve this resources loss.

#### Existence value

The existence value (XV) is the value people assign to knowing that something is available, even if they will never see or use it, such as mangrove sustainability (King and Mazzota 2000). Table 2 presents data analysis of respondents' willingness to pay for sustaining mangrove forest. All 42 respondents answered that they would contribute for the existence of mangrove forest. with WTP values ranging from IDR 10,000 to 25,000. The highest respondent bidding value was IDR 25,000 as 23 out of 42 willing to pay this amount of money for the sustainability of mangrove forest. The existence value for mangrove forest was IDR 7,828,333.

The concept of Willingness to Pay (WTP) offers a measure of how financially supportive humans would be toward implementing a given policy change to protect nature or environmental quality, with one goal being the improvement of their well-being (Goulder and Kennedy 2009). When both TEV and WTP are applied, ecological ecosystems can be translated into the language of economics to assess the monetary value of goods and services (monetization). In some cases, markets indicate individuals' true WTP as defined above, such as the market price of tomato might indicate what consumers are willing to pay for that product (Goulder and Kennedy 2009). The results of this study cannot be said to be represent respondents desire to pay WTP, but it is important to note that this WTP study is a preliminary study conducted to obtain feedback from the public on the value of the services provided by the mangrove forest services. The results are expected to be used as a reference for future studies such as used bid value for contingent valuation study in mangrove forest.

#### Total economic valuation (TEV)

Total economic value (TEV) is the sum of Use Value (Direct Value and Indirect Value) and Non-Use Value (Option Value, Existence Value, and Bequest Value). Mangrove forest TEV in this study was IDR 4,431,197,603. Non Use Value has the biggest contribution on TEV as it contributed 58.36% followed by use value (40.18%), optional value (1.28%) and existence value (0.18%) respectively (Table 3).

Total economic value (TEV) was calculated by sum of the direct, indirect, option and existence values. The economic valuation of coastal resources and marine ecosystems is a complementary tool for decision-making and implementation of public policies related to the conservation and sustainable exploitation of renewable resources and their ecosystems (Vasquez et al. 2014). Total economic value (TEV) represents the sum of all types of use and non-use values for a good or service (King and

Mazzota 2000). The ecosystem services value were grouped into direct value, indirect value, and option value Direct use value (DUV) focuses on services intended for immediate consumptive or non-consumptive purposes while indirect use value (IUV) comprises the intermediate inputs associated with the manufacture of end products and services for human consumption (MA 2005).

Lansa mangrove forest TEV was approximately IDR 4,431,197,603 or equal to US\$ 305,600 (US\$ 1,959 ha<sup>-1</sup> = 1 US\$ = IDR 14,500 in September 2018). Globally, the average annual revenues per hectare for other coastal ecosystems have been approximately \$2,287 to \$16,283 for seagrasses (Dirhamsyah 2007; Baldwin 2009), \$983 to \$51,000 for wetlands (Emerton and Kakulandala 2003; Brander et al. 2006; Tong et al. 2007; Costanza et al. 2008), \$15,000 to \$100,000 for coral reefs (Senprachawong 2004; Baldwin 2009), \$232 to \$91,000 for mangroves (Sathirathai and Barbier, 2001; Spurgeon, 2002; Gunawardena and Rowan 2005; Corps 2007; Aburto-Oropeza et al. 2008; Hussain and Badola 2008; Baldwin 2009), and \$8,565 for natural seaweed beds (Wahyudin 2007).

**Table 2.** Total WTP suggested by respondents to sustain mangrove forest

| Bidding value   | Frequency | Total WTP Y <sup>-1</sup> |
|-----------------|-----------|---------------------------|
| IDR 10,000      | 13        | 130,000                   |
| IDR 15,000      | 5         | 45,000                    |
| IDR 20,000      | 1         | 20,000                    |
| IDR 25,000      | 23        | 575,000                   |
| Total           | 42        | 770,000                   |
| Average         |           | 18,333.33                 |
| # of Household  |           | 427                       |
| Existence Value |           | 7,828,333                 |

**Table 3.** Mangrove forest total economic value, North Sulawesi, Indonesia

| Ecosystem service group | Value (IDR)   | Percentage (%) |
|-------------------------|---------------|----------------|
| Direct value            | 1,780,629,000 | 40.18          |
| Indirect value          | 2,586,190,270 | 58.36          |
| Optional value          | 56,550,000    | 1.28           |
| Existence value         | 2,890,270     | 0.18           |
| Total                   | 4,431,197,603 | 100            |

**Table 4.** Lansa mangrove forest economic valuation, North Sulawesi, Indonesia

| Ecosystem services | Use                                      | Economic value (IDR) |
|--------------------|--|----------------------|
| Coastal barrier    | Protection from abrasion, waves, tsunami | 2,583,300,000*       |
| Fire-wood          | Fuel for cooking                         | 259,200,000*         |
| Fish source        | Family income                            | 1,521,429,000*       |
| Biodiversity       | Flora and Fauna diversity                | 56,550,000           |
| Carbon removal     | Help to combat climate change            | 2,890,270            |
| Willingness to Pay | Mangrove sustainability                  | 7,828,333            |
| Total              |  | 4,431,197,603        |

Note: \*Based on Takarendehang et al. (2018)

**Table 5.** Lansa mangrove forest community structure

| Species                                  | Local name | Common name                 | Ni  | K (m <sup>2</sup> ) | BA (cm <sup>2</sup> ) | KR (%) | DR (%) | IVI    |
|--|------------|-----------------------------|-----|---------------------|-----------------------|--------|--------|--------|
| <i>Avicennia marina</i> (Forssk.) Vierh. | Api api    | Grey mangrove               | 36  | 0.06                | 1,411.91              | 13.95  | 27.15  | 66.10  |
| <i>Rhizophora</i> sp.                    | Lolaro     | Stilt mangrove              | 134 | 0.22                | 1,495.45              | 51.94  | 28.76  | 105.69 |
| <i>Xylocarpus granatum</i> J.Koenig      | Kira-kira  | Cannonball mangrove         | 65  | 0.11                | 1,356.31              | 25.19  | 26.08  | 76.27  |
| <i>Sonneratia alba</i> Sm.               | Posi-posi  | Apple mangrove              | 11  | 0.02                | 911.91                | 4.26   | 17.54  | 38.47  |
| <i>Ceriops tagal</i> (Perr.) C.B. Rob.   | Ting       | Rib-fruited yellow mangrove | 12  | 0.02                | 24.84                 | 4.65   | 0.48   | 13.46  |
| Total                                    |            |                             | 258 | 0.43                | 5,200.42              | 100    | 100    | 300    |

Note: Ni = #Mangrove Stand; K = Density; BA = Basal Area; Kr = Relative Density; DR = Relative Dominance; IVI = Important Value Index

There were some positive results obtained from this study, among others, the results obtained from this study at least can be said to have described the community's desire to provide value to the services provided by the mangrove forest. In addition, this study can also be said to succeed to inform the public about the services provided by the mangrove forest. Moreover, this study also increased public awareness for the conservation and sustainability of the mangrove forest in the future.

#### Ecosystem service

This study found that Lansa mangrove forest provides ecosystem services for human well-being. These services are mangrove forest as a coastal barrier, provide fishes, firewood, conserve biodiversity, and removing carbon to mitigate climate change. This study also can provide the monetary value of these services. The total monetary value for coastal barrier was IDR 2,583,300,000. Per-annum economic values for fire-wood were IDR 259,200,000 and IDR 1,521,429,000 for fish. An annual value for biodiversity was IDR 56,550,000 and potential C removal value was IDR 2,890,270. People willing to pay (WTP) for mangrove forest sustainability, was IDR 7,828,333. The annual TEV for mangrove forest was approximately IDR 4,431,197,603 (Table 4).

Ecosystems and species biodiversity provide a wide range of services that sustain, strengthen, and enrich various components of human well-being (Kumar and Muradian 2009). The services derived from marine plants such as seaweeds, kelps, seagrasses, and mangroves attract public attention because of their benefits to human life. The support services associated with ecosystems are often greatly undervalued by society because most are not traded in formal markets and are not easily quantified (Daily 1997; Vo et al. 2012). Only a few of these ecosystem services have been marketed to date, and integration has not been completed between the functions of ecological production and economic valuation within many key estuaries and coastal ecosystem services (Barbier et al. 2011).

Moreover, their unique characteristics mean that although humans might recognize them, they are generally discounted, have no assigned price, and therefore remain outside of market domains (Kumar and Muradian 2009).

This lack of valuation leads to treating these services as public policy issues when entering into collective decision-making (Robbins 2005). However, the valuation of ecosystem services (ES) is becoming an increasingly important contributor to policy and decision-making on scales that range from local to global (Fisher et al. 2011).

#### Mangrove forest ecosystem service economic valuation

Lansa mangrove forest offers services to the surrounding inhabitant. These services give not only ecological benefits, but also economic benefits to the village community. These services include coastal protection, biodiversity, firewood, fishes, C removal and sustainability. By knowing ecosystem services resource management can help the local government, stakeholders and decision makers to decide the best resource management action for mangrove (Kaplowitz 2001). Despite using these services, however, these services should be protected from loss. Protection can be done through the valuation of mangrove forest ecosystem services. The value of ecosystem service is the community willing to pay for keeping natural resources or products from being the loss (TEEB 2010). The value of a product can be defined and measured in many ways. For example, the results of economic analysis can be used to promote effective strategies for valuating ecosystem services already being rendered from mangrove but which have not yet been fully captured on commercial markets (Costanza et al. 1997; Beaumont et al. 2008). This approach provides a powerful tool for sustainable development because it can illustrate how dependent a particular economy is on that ecosystem and show what would be lost if that ecosystem were not protected (Lange and Jiddawi 2009). In the absence of such a valuation, those services risk being regarded as free and, thus might not receive adequate consideration as part of a management strategy (Beaumont et al. 2008).

#### Mangrove community structure

Five mangrove species were found within six plots, *Avicennia marina*, *Rhizophora* sp., *Sonneratia alba*, *Xylocarpus granatum*, and *Ceriops tagal* (Table 5). Total mangrove area was 156 ha and the distance from the sea to coastline approximately 1,500 m. The highest absolute

density and relative density was found in *Rhizophora* sp. (0.22 ind/m<sup>2</sup> and 51.94%) and the lowest was *S. alba* (0.02 ind/m<sup>2</sup> and 4.26%). Similarly, the highest relative dominance value (DR) was found in *Rhizophora* sp (28.76%) while the lowest was in *C. tagal* (0.48%). In addition, this study found that *Rhizophora* sp. have the highest IVI (105.69) while the lowest was *C. tagal* (13.46).

Mangrove tree density was 0.43 m<sup>2</sup> which is 4,300 trees ha<sup>-1</sup>. Based on the criteria of mangrove health status from the Ministry of Environmental (KLH) (2004), mangrove forest in this area was considered in good condition ( $\geq 1500$  tree ha<sup>-1</sup> = good). We found that the local wisdom plays the important role in local community perspective on mangrove sustainability. Together with the village government, the communities protect this forest. The local government established a village regulation to conserve and preserve their mangrove and socialized it to the communities. As a result, the communities have high awareness of mangrove conservation and sustainability. Local communities have a high contribution to mangrove conservation as they realize that mangrove are directly supporting their livelihood (Badola et al. 2012; Basyuni et al. 2016). Important value index (IVI) shows one species influence into the community. Density is the total amount of species within one particular area (Odum 1998). This study shows that *Rhizophora* sp has the highest IVI while *C. tagal* was the lowest. IVI shows the role of one species to its community, so it can be said that in Lansa village mangrove forest, *Rhizophora* sp has the highest role in the mangrove community compare to other species. The greater IVI of a species leads to the greater its role in the community (Soegianto 1994).

In conclusion, the success of mangrove valuation has potentially board implications for future policy-making. Monetary value is a currency that is universally understood by policy makers, economists, scientists and politicians alike. Considered together these estimates of mangrove forest economic values might help focus management priorities. For example, the estimates could suggest that managing ecosystem services to food production for food sustainability, more sensible management option toward potential CO<sub>2</sub> sequestration with the aim of mitigating climate change. Although some ecosystem attributes can be valued during this study, the current study does not value all the services of mangrove forest. Thus, an assessment of what can and cannot be valued, and what problems remain after existing methods are important in the future study.

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