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An assessment of the coastal ecosystem services of Jayapura City, Papua Province, Indonesia

Basa T. Rumahorbo[1], Baigo Hamuna[1]*, Henderina J. Keiluhu[2]

[1]Department of Marine Science and Fisheries, Cenderawasih University, Kamp Wolker Street, Jayapura City 99351, Papua Province, Indonesia
[2]Department of Biology, Cenderawasih University, Kamp Wolker Street, Jayapura City 99351, Papua Province, Indonesia
*E–mail address (*corresponding author): bhamuna@yahoo.com.sg*
ORCID iD: Basa T. Rumahorbo: https://orcid.org/0000-0002-0189-3619; Baigo Hamuna: https://orcid.org/0000-0002-0706-2496; Henderina J. Keiluhu: https://orcid.org/0000-0003-1957-2191

ABSTRACT

This study aims to assess and quantify the economic value of coastal ecosystem services (CES) in the coastal areas of Jayapura City based on the perceptions of Papuan indigenous peoples. Data collection was conducted from March to April 2018 using the direct interview method based on questionnaires to 228 respondents in Enggros, Tobati, and Nafri villages. The CES value in Jayapura City is estimated to be around USD 5,427,212.34/year, which consists of service values of mangrove, coral reef, and seagrass ecosystems that are USD 4,447,802.85/year or USD 19,079.46/ha/year, USD 424,333.06/year or USD 11,303.49/ha/year, and USD 555,076.43/year or 5,008.36/ha/year, respectively. The value of CES as a provider of fishery products is quite high because of the high desire of the community to exploit and utilize natural resources such as fish, crabs, shrimp, and shellfish in coastal ecosystems to as a food resource. Therefore, with the description of the CES value in this study, good coastal ecosystem management and integrated coastal area development policies are needed to maintain the quality of the environment and the sustainability of coastal ecosystems, as well as efforts to increase public awareness of the importance of coastal ecosystems and the important role that they play in improving the welfare of the Papuan indigenous people.

KEY WORDS: ecosystem services, economic values, direct and indirect services, Papuan indigenous peoples

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1. Introduction

Generally, coastal areas in the tropics consist of three main types of ecosystems, namely mangrove, coral reef, and seagrass. These three ecosystems have various benefits, both from ecological aspects and to support the economic life of the surrounding population, especially those in coastal areas. About 85% of tropical marine biota depends on coastal ecosystems (BERWICK, 1983) and 90% of the world's total fish catch comes from coastal waters (FAO, 2000). In particular, there are various benefits that humans can obtain from coastal ecosystems. Mangrove ecosystems are very useful from an ecological aspect as natural habitats and provide various types of biota and from an economic perspective as sources of fuel, aquaculture, salt production, building materials, also offer coastal protection (VALIELA ET AL., 2001; DAHDOUH-GUEBAS ET AL., 2005; CONSERVATION INTERNATIONAL, 2008; MALIK ET AL., 2015) and various other functions. Coral reef ecosystems can function in the fisheries sector as a producer of fish resources, tourist areas, coastal protection (CONSERVATION INTERNATIONAL, 2008; STOECKL ET AL., 2011) and various other functions. Likewise, seagrass ecosystems have high primary productivity in shallow waters which greatly contributes to fish abundance and diversity (JACKSON ET AL., 2015), seagrass is a food for marine animals (GIAKOUMI ET AL., 2015) and various other functions.

People who live in coastal areas have a very high level of dependence on coastal ecosystems, so their condition determines the level of economic income (MEHVAR ET AL., 2018). Ecosystems provide many services for humans as part of the ecosystem function. Given the high potential benefits and level of utilization of coastal ecosystems, it is necessary to make efforts to manage coastal ecosystems sustainably, including the calculation of the value of economic benefits from the functions and services of coastal ecosystems (BARBIER ET AL., 2011; ATKINSON ET AL., 2016; DEWSBURY ET AL., 2016; MEHVAR ET AL., 2018). The economic value of an ecosystem function, or service, is closely related to its contribution to human welfare (BOCKSTAEL ET AL., 2000). Coastal ecosystem services (CES) are defined as benefits obtained by humans in the form of goods and services from coastal ecosystems, namely mangrove, coral reefs, and seagrass ecosystems. These three ecosystems provide ecosystem services in the form of support services, regulatory services, inventory services, and cultural services (MILLENNIUM ECOSYSTEM ASSESSMENT, 2005). CES assessments can be an important instrument for increasing public appreciation and awareness of the benefits and services of coastal ecosystems (GARROD & WILLIS, 1999). The results that can be obtained from calculating the economic value of CES determine the priority of coastal ecosystem conservation that is related to the level of utilization of the ecosystem (RAO ET AL., 2015).

The classification of ecosystem services used must refer to important ecosystem characteristics and the context of decisions about how ecosystem services will be used (FISHER ET AL., 2009). Understanding service rules and ecosystem functions (provision) for human well-being is also important in obtaining identification and targets for seeking natural capital from a system and in completing sustainable development requirements (DE JONGE ET AL., 2012). The classification of ecosystem services is useful for clarifying the identification of services in accordance with the ecosystem under study. The use of classification needs to be adjusted according to the objectives of the study, especially if it is related to economic valuation to avoid recurring calculations (ELLIFF & KIKUCHI, 2015). A good understanding of ecosystem services will assist in gaining a picture of the relationship of ecosystems to the welfare of the community (SOFIAN ET AL., 2019).

Various studies to quantify the value of CES in Indonesia have been carried out. However, most of these studies only assess CES from one coastal ecosystem, such as the CES assessment of mangrove ecosystems (MALIK ET AL., 2015; RIZAL ET AL., 2018), CES seagrass ecosystems (WAWO ET AL., 2014; OKTAWATI ET AL., 2018), and CES coral reef ecosystems (ROMADHON, 2014; MIRA ET AL., 2017). Especially for coastal ecosystems in Jayapura City, RUMAHORBO ET AL. (2019) have quantified the service value of mangrove ecosystems such as direct use value, indirect use value, option value, and existence value.

To encourage the sustainable use of coastal ecosystems, a comprehensive CES assessment needs to be carried out. This study aims to assess and quantify the economic value of CES in Jayapura City, Papua Province, Indonesia. CES information in this study is obtained based on the perceptions of indigenous Papuans living in coastal areas. The results of this study are expected to help decision-makers to predict economic efficiency from various possible uses of ecosystems in coastal areas and can assist in the determination of sustainable coastal ecosystem management.

2. Methodology

2.1. Study area

This study was carried out in the coastal area of Jayapura City, Papua Province, Indonesia. The study area is presented in Fig. 1. Administratively, Jayapura City has an area of 940 km^2. The coastal area of Jayapura City was formed by two bays namely Yos Sudarso bay and Youtefa bay. The indigenous people of Jayapura City live in the coastal area of Jayapura City, which has local wisdom (customary law) that applies in the community and have certain rules for the utilization of natural resources, including coastal resources. There are three important ecosystems in the coastal area of Jayapura City, namely mangrove ecosystems, coral reefs, and seagrass with an area of about 233.12 ha, 37.54 ha, and 110.83 ha, respectively (TEBAIY ET AL., 2014; HAMUNA & TANJUNG, 2018). Enggros, Tobati, and Nafri villages are indigenous villages in the city of Jayapura, where the majority of the population has its main livelihood as traditional fishermen. In addition, the community in the three villages is the owner of customary rights to the use of the area and its natural resources.

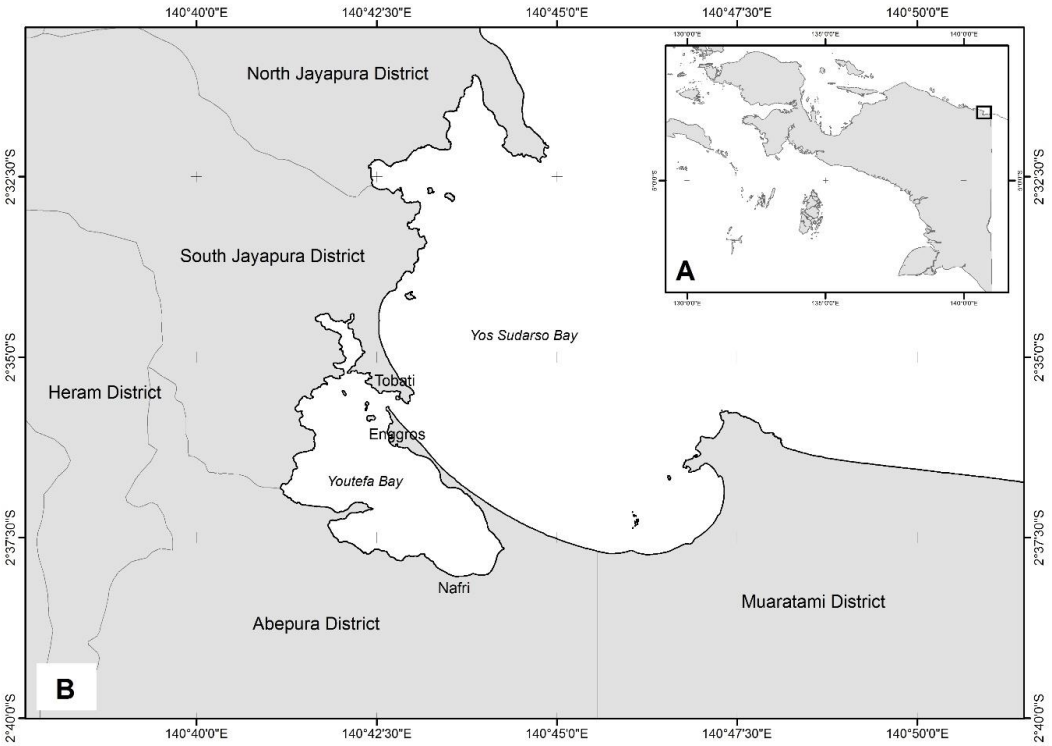

Fig. 1. Map of study site; (A) Papua Island, and (B) Jayapura City, Papua Province, Indonesia

2.2. Data collection

Data collection was conducted in March to April 2018 located in three villages located in the Teluk Youtefa region, Jayapura City namely Enggros, Tobati, and Nafri villages. The number of households in the three villages are 514 households. Data collection was by conducting interviews directly with respondents who were guided by questionnaires (list of questions). The categories of people that were used as respondents were beneficiaries of coastal ecosystems or communities living in coastal areas with livelihoods as fishermen (both men and women).

Data collection was carried out by two methods, namely (1) gathering people in the village hall, and (2) direct interviews with visits to community houses. The number of respondents obtained in this study was 228 consisting of 150 men and 78 women, and 3 people from the diving tourism businesses in the city of Jayapura. After the interview, we continued with direct observations in the field with regard to the utilization of coastal ecosystems.

2.3. Data analysis

Identification of CES based on the type of utilization of the current coastal ecosystems by the indigenous peoples in Enggros, Tobati, and Nafri villages, which consists of services that are direct, indirect, and those that are of non-use value. The concept used to estimate the economic value of CES in Kota Jayapura is the concept of Total Economic Value (TEV). The CES value from the calculation results in IDR (Indonesian Rupiah) which is then converted to USD (USD 1 = IDR 14,156.00 on May 18, 2018).

For the mangrove ecosystem, some CES values were obtained which refer to the results of the study by RUMAHORBO ET AL. (2019). While for the CES value of coral reef and seagrass ecosystems, data processing and analysis were carried out. To estimate the value of CES that is directly utilized by humans in the form of goods (fishery and firewood products), a market price approach was used (MALIK ET AL., 2015). The equation for obtaining the CES value as a provider of fishery and firewood products is as follows:

CES = Production (kg/year) x Selling price (USD/kg) – Production cost (USD/year) (1)

The replacement cost method was used to determine CES values that do not provide direct benefits to humans such as CES of coastal protection and prevention of seawater intrusion, while the benefit transfer method was used to determine CES values of such things as carbon sequestration and storage, and fish habitats. The benefit transfer method can also be used to determine the value of ecosystem biodiversity and to determine the inheritance value of ecosystem conservation for future generations.

The existence value of ecosystems is the economic value obtained from the perception that the existence of an ecosystem exists and without considering whether the ecosystem is utilized or not utilized. The Willingness to Pay (WTP) method can be used to determine the value of the existence of an ecosystem. WTP value collection techniques are carried out using the Contingent Valuation Method (CVM). CVM can be done by asking respondents directly how much they would pay to get better conditions (LIGUS, 2018). After getting the WTP value from each respondent, it is used to estimate the average WTP using the equation (RAKTHAI, 2018):

$$EWTP = WTP\ total/N \quad (2)$$

where:
EWTP – Average of WTP
WTP total – The total willingness to pay of all respondents
N – Number of respondents

The next step was to convert the results of the EWTP into the population WTP by multiplying the EWTP value by the total number of households (BUNDAL ET AL., 2018).

3. Results and discussion

3.1. Provision of fishery products

One of the main benefits of various coastal ecosystems is as a provider of fishery products that can be utilized directly by humans. In this study, the economic value of the type of fishery product quantified as CES is the fishery product that is predominantly utilized by respondents. The people of Jayapura City who live around the Youtefa bay area (Tobati, Enggros, and Nafri villages) carry out activities to obtain fish, crabs, shrimps, and shells in the coastal ecosystem almost every day (except Sundays). The type and amount of fishery products provided by each coastal ecosystem utilized by the community are presented in Table 1. The average production costs (costs of obtaining fishery products and costs for the sale of fishery products) were spent at USD 423.19/year for fish products and USD 338.55/year for other products. So that CES as a provider of fishery products can be obtained for mangrove, coral reefs and seagrass ecosystems are USD 1,992,034.16/year, USD 162,150.11/year, and USD 352,565.01/year, respectively (Table 2).

Table 1. Type and number of fishery products from CES in the coastal area of Jayapura City, Papua Province, Indonesia

Ecosystems type	Type of fishery products	Production total (kg/year and crab/year)	Average the selling price (USD/kg and USD/crab)
Mangroves	Fish	302,150.48	1.77
	Crabs	415,574.47	1.41
	Shrimp	169,910.94	3.53
	Shells	195,133.09	1.41
Coral reef	Fish	91,285.71	1.77
Seagrass	Fish	111,840.00	1.77
	Crabs	44,373.33	1.41
	Shells	66,560.00	1.41

Table 2. The value of CES as the provision of fishery products in the coastal area of Jayapura City, Papua Province, Indonesia

Ecosystems type	Type of fisheries products	Value of ecosystem services (USD/year)
Mangroves	Fish	533,184.66
	Crabs	586,796.37
	Shrimp	599,798.47
	Shells	275,350.51
Coral reef	Fish	162,150.11
Seagrass	Fish	196,783.75
	Crabs	62,256.08
	Shells	93,525.18

The value of CES as a provider of fishery products is quite high. The high value of CES can be caused by the high desire of the community to exploit and utilize the natural resources (fish, crabs, shrimp, and shellfish) that live in mangrove, coral reef, and seagrass ecosystems as a food resource and to improve people's welfare. This can also be caused by the majority of indigenous Papuans who are respondents having jobs as main fishermen and part-time fishermen.

3.2. Provision of firewood

Only the mangrove ecosystem provides CES of the provision of firewood. Almost all respondents stated that they often utilize damaged mangrove wood as firewood and this is only for household use. According to the results of the study conducted by RUMAHORBO ET AL. (2019) the mangrove ecosystem services in Jayapura City for the supply of firewood amounted to USD 54,289.16/year.

3.3. Provision of tourism areas

Coral reef ecosystems can provide services like the provision of tourism areas. The assessment of coral reef ecosystem services for the provision of tourism areas was carried out by using the results of interviews with diving tour guides. Diving activities are usually carried out once a week (usually on Saturdays) with 5 to 10 domestic tourists (an average of 7.5 tourists) with the cost of a diving activity being USD 35.27. Based on these data, it was calculated that the services of coral reef ecosystems for the provision of tourism areas were USD 12,679.20/year.

3.4. Fish habitat

Coastal ecosystems such as mangrove, coral reef, and seagrass can be used as habitats by various species of fish (HONDA ET AL., 2013). The value of CES as a fish habitat can be obtained using the benefits transfer method for the value of the coastal ecosystem as a nursery ground. Based on the results of several studies in Indonesia, the ecosystem service value of mangrove and seagrass ecosystems as a nursery ground is USD 2,292.00/ha (MALIK ET AL., 2015) and USD 1,309.00/ha (OKTAWATI ET AL., 2018), respectively. While the service of the coral reef ecosystem as a nursery ground from work by SNEDAKER & GETTER (1985) who said that that a coral reef ecosystem with an area of 1 km^2 has the potential to become a nursery ground for 5 tons of reef fish or 50 kg/ha. The average selling price for reef fish in Jayapura City is USD 1.78/kg so the coral reef ecosystem service as a nursery can be calculated as USD 89.00/ha. So, it can be estimated that the service value of mangrove, coral reef, and seagrass ecosystems in Jayapura City as fish habitat is USD 534,311.04/year, USD 3,341.06/year, and USD 154,076/year, respectively.

3.5. Coastal protection

CES as coastal protection is its function to block waves or to reduce the wave energy that reaches the coastal area. CES as coastal protection is an indirect benefit of mangrove and coral reef ecosystems where the value can be obtained by using a replacement cost from the cost of making waves and erosion resistant embankments that refer to the standard costs issued by the Ministry of Public Works of the Republic of Indonesia. The cost of making an embankment of the size of 50 m x 1.5 m x 2.5 m with estimated durability of up to 5 years reached USD 20,594,87 or USD 411.90/m (KEMENTERIAN PEKERJAAN UMUM, 2014). Based on this cost, it can be seen that the services of mangrove and coral reef ecosystems as coastal protectors are USD 1,395,925.74/year and USD 224,789.90/year, respectively.

3.6. Carbon sequestration and storage

CES as carbon sequestration and storage is an indirect service for mangrove and seagrass ecosystems. Coastal ecosystems that are rich in carbon stocks are those of mangrove (HONG ET AL., 2017) and seagrass (PENDLETON ET AL., 2012; LAVERY ET AL., 2013). CES as carbon sequestration and storage can be obtained using the benefits transfer method. Based on the results of the study by RUMAHORBO ET AL. (2019), mangrove ecosystem services in Youtefa bay as carbon sequestration and storage amounted to USD 192,324.00/year. The value of seagrass ecosystem services as carbon sequestration and storage can be estimated using the potential value of carbon sequestration by seagrass ecosystems in Indonesia is USD 18.77 tons/ha/year (AL-HADAD, 2012). Seagrass ecosystem services as carbon sequestration and storage are obtained by multiplying the value of the potential carbon sequestration with the carbon price which refers to DIAZ ET AL. (2011) as USD 5.50/tons, so the value of seagrass ecosystem services in Jayapura City as carbon sequestration and storage is USD 11,441.54/year.

3.7. Prevention of seawater intrusion

CES as the prevention of seawater intrusion is one of the indirect benefits of mangrove ecosystems. The value of mangrove ecosystem services in the prevention of seawater intrusion can be approached by using a replacement cost from the cost of consuming clean water. Based on the results of the study by RUMAHORBO ET AL. (2019), mangrove ecosystem services in Youtefa bay in the prevention of seawater intrusion is USD 65,663.50/year.

3.8. Biodiversity services

The biodiversity value of CES can be approached using the benefits transfer method, which is by assessing the estimates of the benefits of the same ecosystem biodiversity from other places. Indonesian mangrove forests have a biodiversity value of USD 15.00/ha/year (RUITENBEEK, 1992), while coral reef ecosystems have a biodiversity value of USD 2,400.00 to 8,000.00/km^2/year (BURKE ET AL., 2002). Both biodiversity values can be used in all mangrove and coral reef ecosystems which are ecologically important and remain naturally preserved. The biodiversity value of coral reefs used is the median value which is USD 5,200.00/km^2/year or USD 52.00/ha/year.

Based on the biodiversity value of mangrove and coral reef ecosystems, it can be seen that the service value of mangrove and coral reef ecosystems is USD 3,496.80/year and USD 1,952.08/year, respectively. Both of these values are obtained from the results of the multiplication of the biodiversity values and the area of the ecosystem. The biodiversity value of mangrove and coral reef ecosystems obtained in this study is expected to continue to decrease due to the high level of utilization of coastal areas for other purposes, destructive fishing, and the increasing size of the population of Jayapura City which can threaten the biodiversity of coastal ecosystems.

3.9. Existence services

One of the CES values in calculating the economic value of a natural resource is its existence value. The service value of the existence of coastal ecosystems can be obtained based on the value of the Willingness to Pay (WTP) of the community for the existence of coastal ecosystems. WTP is a potential useful value generated by natural resources and environmental services (HANLEY & SPASH, 1993). Therefore, the WTP referred to in this study is the willingness of the community to contribute, or pay, to maintain the condition of sustainable coastal resources or for a rehabilitation program to preserve coastal ecosystems. The average value of respondents' WTP for mangrove and seagrass ecosystems was USD 3.95/year (HAMUNA ET AL., 2018b) and USD 3.77/year (HAMUNA ET AL., 2018a), respectively. While the calculation results that the average WTP for coral reef ecosystems is USD 3.38/year. Based on the average WTP, the CES values for mangrove, coral reef, seagrass ecosystems were obtained at USD 2,030.30/year, USD 1,937.78/year, and USD 1,737.38/year, respectively. The high value of the WTP obtained shows that the people of Tobati, Enggros, and Nafri villages greatly appreciate the existence of coastal ecosystems in Jayapura City, Papua Province, Indonesia.

3.10. Bequest services

The inheritance value of coastal ecosystems is one of the CES that can be useful for future generations. According to RUITENBEEK (1992), the bequest value of an ecosystem is not more than 10% of the total direct benefit value. Based on the assumptions, it can be estimated that the bequest value of mangrove, coral reef, and seagrass ecosystems are USD 204,632.3/year, USD 17,482.93/year, and USD 35,256.5/year, respectively.

3.11. The total value of CES

Ecosystems are unique and specific ecological systems that require specific management to provide maximum benefit for the welfare of the community. Based on the results of CES calculations, it can be concluded that the coastal area of Jayapura City has a high potential for natural resources to support the welfare of the people who have a high level of dependence on coastal ecosystems. The CES value in Jayapura City is estimated to be around USD 5,424,116.49/year, where the service value of mangrove, coral reef, and seagrass ecosystems is USD 4,444,707.00/year, USD 424,333.06/year, and USD 555,076.43/year, respectively (Table 3).

The service value of mangrove ecosystems is higher than that of coral reefs and seagrass ecosystems, especially for the value of direct benefits (fishery products) to the community. The high service value of the mangrove ecosystem is especially felt by Papuan women, where the mangrove ecosystem is a food store and a place for social and cultural interaction for Papuan women when searching for shells, shrimps, and firewood in the mangrove ecosystem, so it is

often referred to as a 'woman's forest' (HANDONO ET AL., 2014). Seagrass ecosystems are also used as a place for social interaction by Papuan women when searching for shells in the Youtefa bay area (HAMUNA ET AL., 2018a). The various activities carried out in the mangrove and seagrass ecosystem areas were predominantly carried out by women.

The condition of coastal ecosystems is very important for human welfare, if there is a degradation of coastal ecosystems and a change in the function of the area, or land use, for other purposes it will have an impact on the loss of functioning of coastal ecosystems (CONSERVATION INTERNATIONAL, 2008; BARBIER ET AL., 2011) and will affect the reduction in the value of CES (WANG ET AL., 2014; SHAO ET AL., 2017). High population growth and high development activities in coastal areas will certainly increase pressure on coastal ecosystems and cause coastal areas and their ecosystems to be more vulnerable. Various human activities can directly reduce the functions and services of coastal ecosystems, such as the disposal of anthropogenic waste (PUSPITASARI ET AL., 2013) and destructive fishing (BURKE ET AL., 2002). In addition, natural factors such as tsunami disasters can damage coastal ecosystems with greater impacts (RÖMER ET AL., 2012; KAISER ET AL., 2013; HAMUNA ET AL., 2019). Therefore, if there is a change in the condition of the coastal ecosystem, it will cause a change in the functioning of the coastal ecosystem. The results in this study, of the value of CES of mangrove, coral reef, and seagrass ecosystems were USD 19,079.46/ha, USD 11,303.49/ha, and USD 5,008.36/ha, respectively. So, if there is damage to coastal ecosystems of 1 ha, then there will be a loss in the economic value of CES of mangrove, coral reefs, and seagrass ecosystems of USD 19,079.46, USD 11,303.49, and USD 5,008.36, respectively. Changes that occur in these ecosystems will certainly affect the existence of ecosystem services and ultimately human welfare (MILLENNIUM ECOSYSTEM ASSESSMENT, 2003).

Table 3. The total value of CES in Jayapura City, Papua Province, Indonesia

Type of CES	Typology	Value of ecosystem services (USD/year)		
		Mangroves	Coral reef	Seagrass
Fishery products	DUV	1,995,130.01	162,150.11	352,565.01
Firewood product	DUV	54,289.16	-	-
Tourism areas	DUV	-	12,679.20	-
Fish habitat (nursery ground)	IUV	534,311.04	3,341.06	154,076.00
Coastal protection	IUV	1,395,925.74	224,789.90	-
Carbon sequestration and storage	IUV	192,324.00	-	11,441.54
Prevention of seawater instruction	IUV	65,663.50	-	-
Biodiversity	OV	3,496.80	1,952.08	-
Existence	EV	2,030.30	1,937.78	1,737.38
Bequest	BV	204,632.30	17,482.93	35,256.50
Total value of CES		4,447,802.85	424,333.06	555,076.43

DUV = Direct Use Values; IUV = Indirect Use Values; OV = Option Value; EV = Existence Value; BV = Bequest Value

The CES value is strongly influenced by the number of identified and quantified ecosystem services, as well as the condition and extent of coastal ecosystems. The CES value will increase if more CESs are identified. Some economic value CESs that have not been quantified in this study include the potential of CES as feeding and spawning grounds (SALEM & MERCER, 2012; MALIK ET AL., 2015), wild plant and animal resources, raw materials, genetic material, storm protection, flood control, pollution control, spiritual and religious values (BARBIER, 2017), scientific and educational opportunities (NORDLUND ET AL., 2014; BARBIER, 2017), seagrass potential as sediment stabilization (CHRISTIANEN ET AL., 2013), and the potential of mangroves and seagrasses as pharmaceutical ingredients (KANNAN ET AL., 2013; MALIK ET AL., 2015).

4. Conclusions

The results of this study present the value of CES from three important ecosystems in coastal areas in Jayapura City, Papua Province, Indonesia, namely those of mangrove, coral reef, and seagrass ecosystems. The CES value in Jayapura City is estimated at around USD 5,427,212.34/year,

where the service value of mangrove, coral reef, and seagrass ecosystems are USD 4,447,802.85/year, USD 424,333.06/year, and USD 555,076.43/year, respectively. The CES value is expected to increase if all CESs can be identified and quantified. CES contributes greatly to the welfare of society, especially to the Papuans who live in the coastal areas of Jayapura City through the direct benefits of coastal ecosystems as providers of fishery products.

An implication of the results of this study is that the high CES value must be balanced with efforts to manage coastal ecosystems, through conservation activities to preserve these coastal ecosystems. Decreasing the area and condition of coastal ecosystems will result in a decline in their function, threaten the food sources of the Papuan people and decrease economic income due to a decrease in the catch of fisheries' products. Furthermore, there needs to be a special policy in development planning in coastal areas so that it does not threaten the sustainability of coastal ecosystems. Good management of coastal ecosystems and integrated coastal area development policies will have an impact on improving the quality of the environment and on the preservation of coastal ecosystems which will certainly have a major impact on retaining the economic income and the welfare of the Papuan people. Therefore, the sustainable development of the coastal area of Jayapura City must provide optimal economic benefits for the community and must maintain the ecosystem conditions that do not conflict with the socio-economic and cultural conditions of the Jayapura City community.

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