Identifying and Quantifying the Economic Value of Coastal Ecosystem Services According to the Perceptions of Papuan Indigenous Peoples in Jayapura City, Papua Province, Indonesia

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Abstract: - Coastal ecosystem services (CES) are benefits obtained by humans in the form of goods and services from coastal ecosystems. CES assessment is an important instrument for increasing appreciation and awareness public of the benefits and services produced by coastal ecosystems. This study aims to identify and quantify the economic value of CES (mangrove, coral reefs, and seagrass ecosystems) in the coastal areas of Jayapura City based on the perceptions of Papuan indigenous peoples. Data collection was conducted in March to April 2018 using the direct interview method based on the questionnaire to 228 respondents in Enggros, Tobati, and Nafri Villages, as well as 3 dive tourism businesses in Jayapura City. The CES value in Jayapura City is estimated to be around USD 5,424,116.49/year, which consists of service values of mangrove, coral reefs, and seagrasses ecosystems that are USD 4,444,707.00/year or USD 19,066.18/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 service value of mangrove ecosystems is higher than that of coral reefs and seagrass ecosystems, especially in the value of direct benefits (fishery products) felt by the community. 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 improve community welfare. 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 that play an important role in improving welfare Papuan people.

Key-Words: ecosystem services, economic values, direct and indirect services, mangrove, coral reefs, seagrass, Papuan indigenous peoples

1 Introduction

Generally, ecosystems in coastal areas consist of three main types of ecosystems, namely mangrove ecosystems, coral reef, and seagrass. The three coastal 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 depend on coastal ecosystems [1] and 90% of the world's total fish catch comes from coastal waters [2]. In particular, various benefits that humans can obtain from coastal ecosystems. Mangrove ecosystems are very useful in ecological aspects as natural habitats and provide various types of biota and on economic aspects like sources of fuel, aquaculture, salt production, building materials, coastal protection [3-6] and various other functions. Coral reef ecosystems can function in the field of fisheries as a producer of fish resources, tourist areas, coastal protection [5,7] and various other functions. Likewise, seagrass ecosystems have high

primary productivity in shallow waters which greatly contributes to fish abundance and diversity [8,9], seagrasses as food for marine animals [10] and various other functions.

Basically, people who are in coastal areas have a very high level of dependence on coastal ecosystems, so the condition of coastal ecosystems determines the level of economic income [11]. Ecosystems provide many services for humans as part of the ecosystem itself. Given the high potential benefits and level of utilization of coastal ecosystems, it is necessary to make efforts to manage sustainable coastal ecosystems. One effort that can be done is to calculate the value of economic benefits from the functions and services of coastal ecosystems [11-14]. The economic value of an ecosystem function or service is closely related to its contribution to human welfare [15]. The 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 [16]. CES assessments can be an important instrument for increasing public appreciation and awareness of the benefits and services of coastal ecosystems [17]. The results that can be obtained from calculating the economic value of CES are determining the priority of coastal ecosystem conservation that is related to the level of utilization of the ecosystem [18].

The classification of ecosystem services used must refer to important ecosystem characteristics and in the context of decisions about how ecosystem services will be used [19]. Understanding service rules and ecosystem functions for human well-being is also important in obtaining identification and targets for seeking natural capital from a system and completing sustainable development requirements [20]. The classification of ecosystem services is useful for clarifying understanding of 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 [21]. A good understanding of ecosystem services will help in getting a picture of the relationship of ecosystems to the welfare of the community.

To encourage sustainable use of coastal ecosystems, a comprehensive CES assessment needs to be carried out. This study aims to identify and quantify the economic value of CES in Jayapura City, Papua Province, Indonesia. CES information is obtained based on 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 Material and Method

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 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 seagrasses with an area of about 233.12 ha, 37.54 ha, and 110.83 ha, respectively [22,23]. Enggros, Tobati, and Nafri Villages are indigenous villages in the city of Jayapura, where the majority of the population has a 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 natural resources.

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 is 514 households. Data collection techniques by conducting interviews directly with respondents who are guided by questionnaires (list of questions). The categories of peoples that are used as respondents are beneficiaries of coastal ecosystems or communities living in coastal areas with livelihoods as the main and secondary as fishermen, both men, and women.

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

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

2.3 Data Analysis

Data 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 services that are of no use value. The concept used to estimate the economic value of CES in Kota Jayapura is the concept of Total Economic Value (TEV). TEV is obtained by summing all identified CES values [24]. The CES value from the calculation results in IDR is then converted to USD (USD 1 = IDR 14,178 at Mei 18, 2018) [https://www.bi.go.id/id/moneter/imformasi-kurs/transaksi-bi/Default.aspx].

For the mangrove ecosystem, some CES values were obtained which refer to the results of the study by Rumahorbo et al. [25]. While for the CES value of coral reef and seagrasses ecosystems, data processing and analysis must still be 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 is used [6]. The equation for obtaining the CES value as a provider of fishery and firewood products as follows:

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

The replacement cost method is used to determine CES values that do not provide direct benefits to humans such as CES as coastal protection and prevention of seawater instruction, while the benefit transfer method is used to determine CES values such as carbon sequestration and storage, and fish habitats. The benefit transfer method can also be used to determine the value of CES as a provider of biodiversity and bequest services.

The existence value of ecosystems is one of CES that does not have a market price, then the Willingness to Pay (WTP) method is used. WTP value collection techniques are carried out using the Contingent Valuation Method (CVM). CVM can be done by asking respondents directly how much they will pay to get better conditions [26]. After getting the WTP value from each respondent, it is calculated to estimate the average WTP using equations [27]:

$$EWTP = WTP\ total/N$$

where:
EWTP : Average of WTP
WTP total : The total WTP of all respondents
N : Number of respondents

The next step is to convert the results of the EWTP into the population WTP by multiplying the EWTP value by the total number of households [28].

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 dominantly utilized by respondents. The people of Jayapura City who live around the Youtefa bay area (Tobati, Enggros, and Nafri Villages) almost every day (except Sundays) carry out activities to obtain fish, crabs, shrimps, and shells in the coastal ecosystem. 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 seagrasses ecosystems are USD 1,992,034.16/year, USD 162,150.11/year, and USD 352,565.01/year, respectively (Table 2).

The value of CES as a provider of fishery products is quite high. The high value of CES can be caused due to the high desire of the community to exploit and utilize natural resources (fish, crabs, shrimp, and shellfish) that live in mangrove ecosystems, coral reefs, and seagrasses 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.

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 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	532,357.32
	Crabs	585,885.83
	Shrimp	598,867.76
	Shells	274,923.25
Coral reef	Fish	162,150.11
Seagrass	Fish	196,783.75
	Crabs	62,256.08
	Shells	93,525.18

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3.2 Provision of Firewood

Only the mangrove ecosystem provides CES as the provision of firewood. Almost all respondents stated that they often use damaged mangrove wood to be used as firewood and only used for household use. According to the results of a study conducted by Rumahorbo et al. [25] that mangrove ecosystem services in Jayapura City as 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 as the provision of tourism areas is carried out by using the results of interviews with dive tour guides. Diving activities are usually carried out once a week (usually on Saturdays) with a number of domestic tourists around 5–10 tourists (an average of 7.5 tourists) with the cost of a diving activity are USD 35.27. Based on these data, it can be obtained that the services of coral reef ecosystems as the provision of tourism areas are USD 12,679.20/year.

3.4 Fish Habitat

Coastal ecosystems such as mangroves, coral reefs, and seagrass can be used as habitats by various species of fish [29]. The value of CES as a fish habitat can be obtained using the benefits transfer method from the value of the coastal ecosystem as a nursery ground. Based on the results of several studies in Indonesia that the service value of mangrove and seagrass ecosystems as a nursery ground is USD 2,292.00/ha [6] and USD 1,309.00/ha [30], respectively. While the service of the coral reef ecosystem as a nursery ground refers to Snedaker and Getter [31] that the coral reef ecosystem with an area of 1 km^2 has the potential to become a nursery ground of 5 tons of reef fish or 50 kg/ha. The average selling price of reef fish in Jayapura City is USD 1.78/kg (IDR 25,250.00/kg) so that the coral reef ecosystem service as a nursery can be obtained is USD 89.00/ha. So that it can be estimated the service value of mangrove ecosystems, coral reefs and seagrasses in Jayapura City as fish habitat is USD 534,311.04/year, USD 3,341.06/year, and USD 154,076/year, respectively.

3.4 Coastal Protection

CES as coastal protection is its function to block waves or reduce wave energy that reaches the coastal area. CES as coastal protection is an indirect benefit of mangrove ecosystems and coral reefs where the value can be obtained by using a replacement cost from the cost of making waves and erosion resistant embankments. Data on the making embankment retaining the abrasion using standards issued by the Ministry of Public Works of the Republic of Indonesia. The cost of making the embankment with the size of 50 m x 1.5 m x 2.5 m which can be strength until 5 years reached USD 20,594,87 or USD 411.90/meters [32]. Based on this cost, it can be seen that the services of mangrove ecosystems and coral reefs as coastal protection are USD 1,395,925.74/year and USD 224,789.90/year, respectively.

3.5 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 mangroves [33,34]; Hong et al., 2017] and seagrass [35-37]. 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. [25], mangrove ecosystem services in Youtefa bay, Jayapura City 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 [35]. 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. [38] for 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.

3.6 Prevention of Seawater Instruction

CES as the prevention of seawater instruction is one of the indirect benefits of mangrove ecosystems. The value of mangrove ecosystem services as the prevention of seawater instruction can be approached by using a replacement cost from the cost of consuming clean water. Every household in Enggros, Tobati, and Nafri Villages was consuming 1 gallon of clean water every day at a price of USD 0.35 for 1 gallon. Based on this cost, it can be obtained that in one year (365 days), the expenditure of each household is USD 127.75/year, so that the mangrove ecosystem service as the prevention of seawater instruction is obtained at USD 65,663.50/year.

3.7 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 biodiversity values of USD 15.00/ha/year [39], while coral reef ecosystems have biodiversity values of USD 2,400.00 to 8,000.00/km^2/year [40]. Both biodiversity values can be used in all mangrove ecosystems and coral reefs 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 ecosystems and coral reefs, it can be seen that the service value of mangrove ecosystems and coral reefs is USD 3,496.80/year and USD 1,952.08/year, respectively. Both of these values are obtained from the results of multiplication between biodiversity values and ecosystem area. The biodiversity value of mangrove ecosystems and coral reefs obtained in this study is expected to continue to decrease along with the high level of utilization of coastal areas for other purposes, destructive fishing, and the increasing population of Jayapura City which can threaten the biodiversity of coastal ecosystems.

3.8 Existence Services

One of the CES values in calculating the economic value of a natural resource is the 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 [41]. 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 [42] and USD 3.77/year [43], respectively. While the calculation results that the average WTP for coral reef ecosystems is USD 3.38/year. Based on the average WTP, CES values such as 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 can show that the peoples of Tobati, Enggros, and Nafri Villages give great appreciation for the existence of coastal ecosystems in Jayapura City, Papua Province, Indonesia.

3.9 Bequest Services

The inheritance value of coastal ecosystems is one of the CES that can be useful for future generations. According to Ruitenbeek [39] that 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 reefs, and seagrass ecosystems is USD 204,632.3/year, USD 17,482.93/year, and USD 35,256.5/year, respectively.

3.10 The Total Value of CES

Ecosystems are unique and specific ecological systems and require specific management in order to provide the 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 of 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 ecosystems, coral reefs, and seagrasses 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 in the value of direct benefits (fishery products) felt by the community. The high service of the mangrove ecosystem is especially felt for Papuan women, where the mangrove ecosystem is a food barn and a place for social and cultural interaction for Papuan women when searching for shells, shrimp and firewood in the mangrove ecosystem, so it is often referred to as ‘women forests’ [44]. Seagrass ecosystems are also used as a place for social interaction by Papuan women when searching for shells in the Youtefa bay area [43]. 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 function of coastal ecosystems [5,12] and will affect the reduction in the value of CES [45,46]. High population growth and high development activities in coastal areas will certainly increase ecological 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 [47] and destructive fishing [40]. In addition, natural factors such as tsunami disasters can damage coastal ecosystems with greater impacts [48-50]. 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, CES of mangrove, coral reefs, and seagrass ecosystem values were USD 19,066.18/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 of CES economic value of mangrove, coral reefs, and seagrass ecosystems of USD 19,066.18, USD 11,303.49, and USD 5,008.36, respectively. Changes that occur in ecosystems will certainly affect the existence of ecosystem services and ultimately on human welfare [16].

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 CES are identified. Some economic value CES that have not been quantified in this study include the potential of CES as feeding and spawning grounds [6,51], wild plant and animal resources, raw materials, genetic material, storm protection, flood control, pollution control, spiritual and religious values [52], scientific and educational opportunities [52,53], seagrass potential as sediment stabilization [54], and the potential of mangroves and seagrasses as pharmaceutical ingredients [6,55].

Table 3. The total value of coastal ecosystems services in Jayapura City, Papua Province, Indonesia

Type of ecosystem services	Typology*	Value of ecosystem services (USD/year)		
		Mangroves	Coral reef	Seagrass
Fishery products	DUV	1,992,034.16	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		4,444,707.00	424,333.06	555,076.43

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

4 Conclusion

The results of this study present the value of CES from three important ecosystems in coastal areas in Jayapura City, Papua Province, Indonesia, namely mangrove ecosystems, coral reefs, and seagrasses. The CES value in Jayapura City is estimated to be around USD 5,424,116.49/year, where the service value of mangrove ecosystems, coral reefs, and seagrasses is USD 4,444,707.00/year, USD 424,333.06/year, and USD 555,076.43/year, respectively. If there is damage to coastal ecosystems of 1 ha, then there will be a loss of CES economic value of mangrove, coral reefs, and seagrass ecosystems of USD 19,066.18, USD 11,303.49, and USD 5,008.36, respectively. The CES value is expected to increase if all CES can be identified and quantified. CES contributes greatly to the welfare of society, especially to Papuans who live in the coastal areas of Jayapura City through the direct benefits of coastal ecosystems as providers of fishery products.

As an implication of the results of this study that the high CES must be balanced with efforts to manage a good coastal ecosystem, one of which is through conservation activities to preserve coastal ecosystems. Decreasing the area and condition of coastal ecosystems will result in a decline in its function, threatening the food sources of the Papuan people and decreasing 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 increasing 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 maintain the ecosystem conditions that do not conflict with the socio-economic and cultural conditions of the Jayapura City community.

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