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The application of economic-valuation in the calculation of damage to coral reefs ecosystems in Indonesia

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The application of economic-valuation in the calculation of damage to coral reefs ecosystems in Indonesia

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Abstract. Natural resources and environment are very vulnerable to damage that caused by natural disasters or human. To determine the monetary value of the damage, an approach is needed that can help policymakers. This paper indicates that to determine the damage value from natural resources and the environment, which in this paper we get an example coral reef ecosystem in the waters of Kapoposang, Sarappo Keke, and Saugi Island. This assessment can be done with an economic-valuation approach, where economic-valuation can determine the monetary value of the coral reef ecosystem that is the object of calculation. The monetary value of the economic-valuation becomes a basis for determining that any damage to the ecosystem will eliminate a number of benefits from the ecosystem. If occur 1 Ha damage to the coral reef ecosystem in Kapoposang then will lose benefits (losses) amounting to IDR 1,047,788,387,- per hectare per year; Sarappo Keke amounting to IDR 583,688,686,- per hectare per year; Suagi amounting to IDR 940,772,682,- per hectare per year.

1. Introduction

Damage to natural resources and the environment is a major problem throughout the world, both it caused by earthquake and human. The damage requires a lot of time, energy, and funds to be able to return to its original state. The main problem faced by almost all countries in the world is not knowing the value of natural resources and the environment so that if occur a natural disaster or damage caused by human activities, we are not able to justify the loss.

Human-caused damage can be anticipated if each country has a strong commitment to protecting it. In Indonesia, many damage natural resources and the environment due to human activities but the government cannot give a deterrent effect to the destroyers. They were arrested and then given a sentence according to the existing rules but what about the damage? Such damage ultimately becomes the government' responsibility, because the government finances it, indirectly the damage is borne by all citizens who pay taxes.

Looking this situation, it will result in at least 2 (two) things, namely: *the first*, the destroyers of natural resources and the environment do not get a deterrent effect so that it is feared that they will repeat it. *The second*, the State does not have a basis for determining the monetary value of every

natural resource and environment owned, so that it is difficult to establish additional penalties for destroyers of natural resources and the environment in Indonesia.

A country should be able to provide additional penalties, for example, if damage one hectare of natural and environmental resources, the destroyer must pay as much as a few rupiahs plus a punishment according to the law. Therefore, it is necessary to calculate the monetary value of natural resources and environmental owned. A method that can be used in calculating losses for damage to natural resources and the environment is economic-valuation. Economic-valuation is an attempt to provide a quantitative value for goods and services produced by natural resources and the environment, both on the market and non-market value [1,2]

2. Coral Reef Damage

One of the natural resources and environment owned by Indonesia is a vast coral reef ecosystem. According to Greenpeace, the area of coral reefs in Indonesia reaches 50.875 square kilometers which account for 18% of the total area of the world's coral reefs and 65% of the total area in the coral triangle. The status of coral reefs in Indonesia, namely those experience coral cover 0-25% in bad or damaged category, 26-50% in the moderate category, 51-75% in good category, and 75-100% in the very good category. Based on these categories, there were 6.39% in the very good category, 23.40% in good category, 35.06% in the moderate category, and 35.15% in bad category [3].

Damage to coral reefs or other resources can be caused because *the first* is human factor, such as coral reef mining as material for making betel lime and coral damage by fishing poisons; *the second* is natural factor such as wave-caused impact [4, 5]. The observation of coral reef conditions for four years indicates that the percentage of live coral cover in Pangkajene Island tends to increase. The average percentage of live coral cover in 2006 (31.30 ± 5.75%), 2007 (30.37 ± 4.83%), 2009 (37.43 ± 5.33%) and 2010 (40,58 ± 4.95%), [6] While, the particular coral cover in Kapoposang Island is generally in a moderate category (48.53%) [7].

3. Method of Economic-Valuation and Data Analysis

Method of economic-valuation comes from a study on the relationship between well-being and ecology in a concept of ecosystem services. In 1977, Westman proposed a social value of the ecosystem-benefit and it is likely to be calculated so that the public gets information about policy decisions and its management [8]. However, there are 2 (two) important things related to the absence of a market for environmental resources, namely a) a difficulty of defining and determining ownership rights; b) a high cost of creating and operating the market [9], in addition there is a concept of public goods on natural resources and the environment [10].

As development, the concept of *Willingness to Pay* and *Willingness to Accept* become a basis of economic-valuation [11,12] Based on this concept, it becomes a parameter in economic-valuation. If damage to natural resources and the environment increases from Q^0 to Q^1, then a value (price) of natural resources and the environment will decrease from P^0 to P^1. *Willingness to Pay* (WTP) shows how much consumers are willing to pay if the P^0 price decrease to P^1 with the level of well-being still similar as the P^0 price. Furthermore, *Willingness to Accept* (WTA) shows how much that want to accept as compensation so that the price does not decrease to P^1 with a similar level of well-being [2].

This paper will describe several approaches used by adjusting the benefits derived from the existence of coral reef ecosystems in the research site. Data is analyzed based on the benefits that can be derived from the existence of coral reef ecosystems in the research site, namely direct, indirect, option, existence, and bequest as in figure 1.

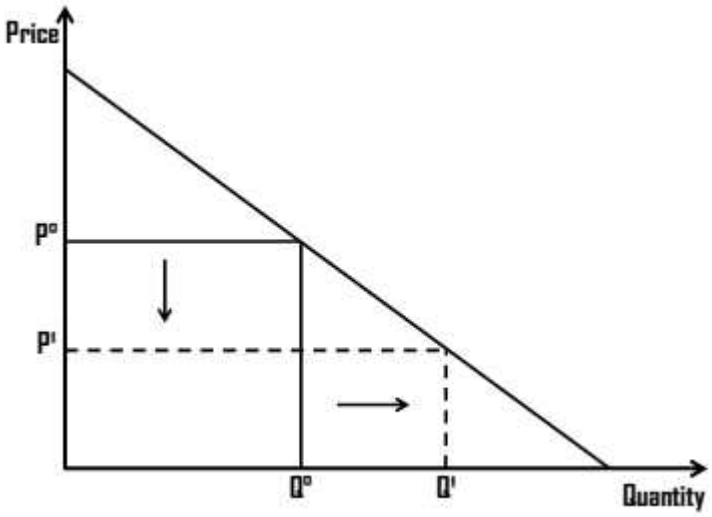

Figure 1. Benefits that can be derived from the existence of coral reef ecosystems in the research site. Source: Modified from (Soemarno, 2010) [13]

Table 1. Benefits of Coral Reef Ecosystem and Analysis Method Approach

No	Benefit Value	Calculation	Approach (Source)
1	Direct		
	a. Fishery	It was calculated by the approach to the amount of catch production obtained from the research site multiplied by the market price	Market value [14]
	b. Tourism	It was calculated by the approach of the number of tourists visiting a year multiplied by the amount of round-trip expenditure.	Travel cost method [14]
	c. Reef	It was calculated by the approach of the number of coral volumes used by the community to make houses multiplied by the price of corals if imported from outside.	Replacement cost method [1,14]
	d. Research	It was calculated by the approach of the number of researchers who came to the research site multiplied by the amount of round-trip expenditure.	Travel cost method [14]
2	Indirect (breakwater)	It was calculated by the approach as a substitute for breakwater in the research site, so the area of coral reefs multiplied by the cost of making break water per m^2	Replacement cost method [14]
3	Option (biodiversity)	It was calculated by *Willingness to Pay* (WTP) approach, a value of the desire to pay for the beauty and sustainability of the coral reef ecosystem.	Contingent valuation method [14]
4	Existence	It was calculated by *Willingness to Pay* (WTP) approach, a value of the desire to pay for the existence of the coral reef ecosystem.	Contingent valuation method [14]
5	Bequest	It was calculated with the *Willingness to Accept* (WTA) approach, a desire to be paid for the loss of the coral reef ecosystem.	Contingent valuation method [1]

For all these benefits, it can be determined the number of benefits of coral reef ecosystems in the waters of Kapoposang, Sarappo Keke, and Saugi by summing up all the existing benefit values with a formula [15]:

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

Where:

TEV = *Total Economic Value*
UV = *Use Value*
NUV = *Non Use Value*
DUV = *Direct Use Value*
IUV = *Indirect Use Value*
OV = *Option Value*
XV = *Existence Value*
BV = *Bequest Value*

4. Results and Discussion

Coral reef ecosystems in the waters of Kapoposang, Sarappo Keke, and Saugi provide services in the form of direct-benefits (fisheries, tourism, coral reefs, and research), indirect (breakwater), option (biodiversity), existence and bequest [13,1]. Thus, to calculate the number of economic value, we first calculate the economic value of each benefit. The three of Island has been calculated namely Kapoposang Island [13,1], while Sarappo Keke and Saugi [1]

In this paper, such calculation becomes references so that it can be shown how much damage caused in each hectare of coral reef ecosystems in Kapoposang, Sarappo Keke, and Saugi. The results of the calculation of the economic valuation of coral reef ecosystems in Kapoposang, Sarappo Keke, and Saugi, Pangkep district can be seen in table 2.

Table 2. Economic-Valuation of Coral Reef Ecosystems in Kapoposang, Sarappo Keke, and Saugi

No	Benefit Value	Kapoposang (Total IDR / year)	Sarappo Keke (Total IDR / year)	Saugi (Total IDR / year)
1	Direct			
	a. Fishery	21,385,172,597	148,135,110	37,463,921
	b. Tourism	562,000,000	9,050,000	5,430,000
	c. Coral Reef	3,475,400,000	99,232,000	8,470,000
	d. Research	62,570,000	71,775,000	21,532,500
2	Indirect (break water)	16,796,037,641	81,726,430	36,387,313
3	Option (biodiversity)	570,712,576	813,181	362,055
4	Existence	9,393,688,833	469,227,273	538,086,957
5	Bequest	2,568,544,260	32,819,211	7,289,642
	Total	**25,685,442,597**	**912,778,205**	**655,022,388**
		[13]	[1]	[1]

Source: Calculation result [13, 1].

Based on table 2, Kapoposang island with an area of 24.51396 Ha, gained economic-value of coral reef ecosystems of IDR 1,047,788,387,-/Ha/year, Sarappo Keke with an area of 1.56381 Ha gained economic-value of IDR 583,688,686,-/Ha/year, then Saugi with an area of 0.69626 Ha gained economic-value of IDR 940,772,682,-/Ha/year. Value per hectare per year can be used as a reference in determining the value of losses that occur when there is damage to the coral reef ecosystem in the three islands.

In table 2 show that the economic value of the coral reef ecosystem on these three islands varies based on the services provided to the people around the island, another thing that can distinguish is the time of calculation and the approach used in the calculation. Several calculation approaches have a value that will increase with the development of time, for example, the market price approach, the replacement cost method, and the travel cost method on the economic value of direct benefits. The case of a changed value as stated above can be anticipated by adjusting the price at the time of the damage by referring to the previous calculation.

The main priority in this paper is to show that the results of the calculation of the economic value of natural resources and the environment can be used to determine how much damage caused by earthquakes and human to these natural and environmental resources [16,5] Furthermore, damage can be calculated by a *contingent valuation method* [17].

5. Conclusion

This paper provides an illustration that to determine the damage value of natural resources and environment is exemplified by coral reef ecosystems in the waters of Kapoposang, Sarappo Keke, and Saugi can be done with an economic valuation approach. With an economic-valuation approach, we can know the monetary value of the coral reef ecosystem that is the object of calculation. The monetary value of the economic-valuation become a basis for determining that any damage to the ecosystem will eliminate some benefits from the ecosystem. If occur 1 Ha damage to the coral reef ecosystem in Kapoposang then benefits lost will be amounting to IDR 1,047,788,387,- per hectare per year; Sarappo Keke amounting to IDR 583,688,686,- per hectare per year; Suagi amounting to IDR 940,772,682,- per hectare per year.

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