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Assessment of coral-reef ecosystem services in West Buleleng Conservation Zone, Bali, Indonesia

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Abstract

Bali provides many potential coral-reef ecosystems as part of the coral triangle, such as the one in the Buleleng Regency. Coral reefs are essential ecosystems for the development of both regions and countries. However, without appropriate conservation efforts, their economic value will be decreased. This paper aims to assess coral-reef ecosystem services in the West Buleleng Conservation Zone (WBCZ), Bali, Indonesia. This research employs the travel cost method, effects on production, replacement cost, benefit transfer methods, and the contingency valuation method. The result of the study is the estimation of the total economic value of the coral-reef ecosystem services in WBCZ that consist of use values (direct, indirect, option) and non-use values (existence, bequest) with a total estimate of approximately US$ 12,114,408/year for the reef area or US$ 18,602/ha/year. This study can raise awareness and encourage people to sustainably manage and conserve coral-reef ecosystems.

Keywords Assessment · Coral reefs · Reef total value · Tourism · Buleleng · Indonesia

Compliance with ethical standards.

Conflict of interest: The authors declare that they have no conflict of interest.

Research involving human participants and/or animals There is no humans or animals were used in this research.

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Introduction

Since the 1990s, the interest in the economic valuation of coral-reef ecosystem services has increased considerably (Cesar 1996; Ahmed et al. 2003; Laurans et al. 2013). Accordingly, the number of studies about the economic valuation of coral reefs has significantly increased by the mid 2000s, and these studies are mainly concentrated on Southeast Asian countries such as the Philippines, Thailand, and Indonesia (Cesar et al. 2003; Brander et al. 2007). Ecosystem valuations are necessary since they help the community

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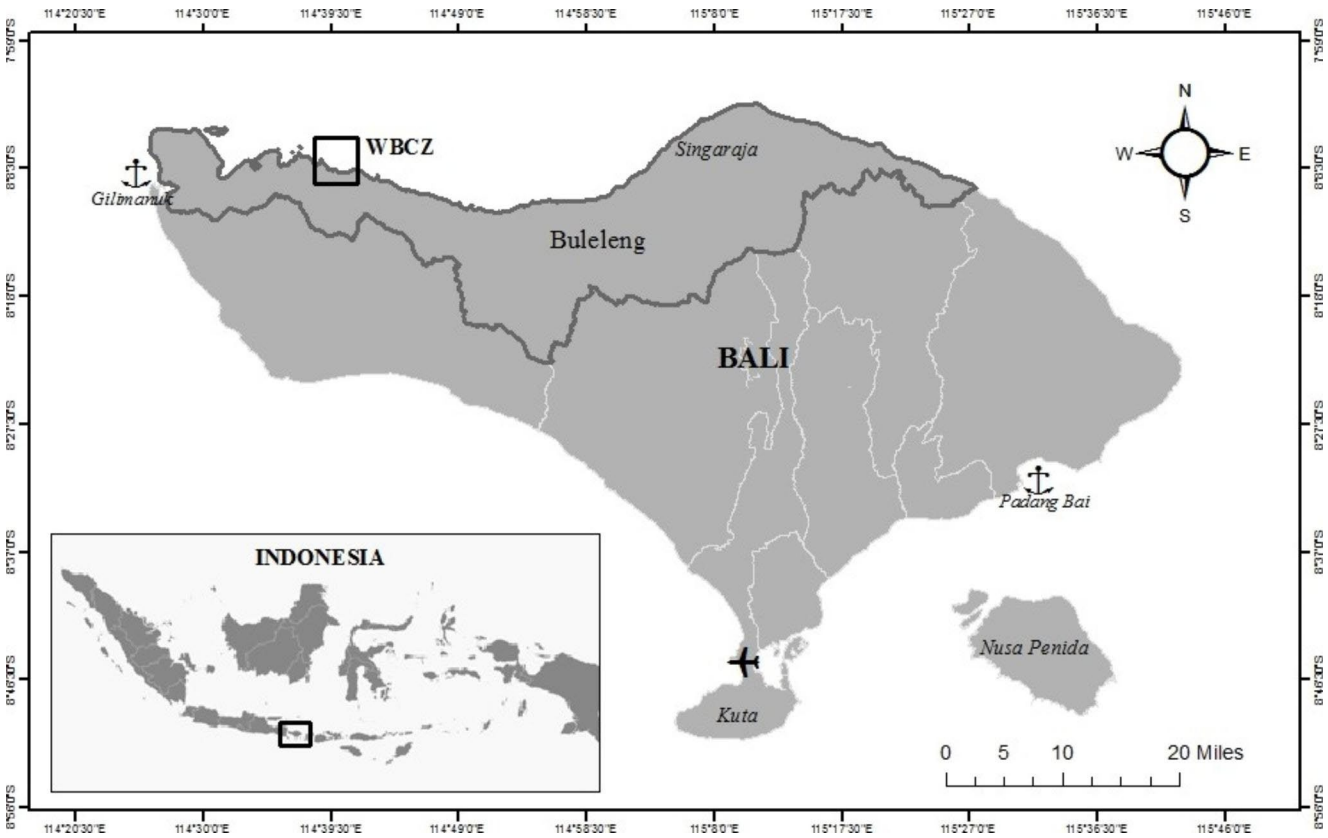

Fig. 1 West Buleleng Conservation Zone, Buleleng Regency, Bali Province, Indonesia

analyze the benefits that ecosystems offer and determine which action is economically beneficial. Moreover, ecosystem valuations are beneficial to analyze how and to whom the expenses and benefits are given, which sector should take action, and if it is done well, they help make sustainable conservation financially feasible (Pagiola et al. 2004). In the economic assessment of coral reefs worldwide, the essence of this type of research differs significantly in terms of both the methods employed and the advantages discussed (Brander et al. 2007). In Indonesia, the economic valuation of coral reefs is still rare since the government directly focuses on policies, community empowerment, applying a green economy, or environmental impacts on coastal ecosystems (Cannon and Surjadi 2004; Sutawa 2012; Law et al. 2016; Allemand and Osborn 2019; Gerungan and Chia 2020; Mutaqin 2020; Lazuardi et al. 2021; Marfai et al. 2020, 2022; Adalya and Mutaqin 2022).

Bali is one of the islands in Indonesia, and it has abundant natural resources (Suprayogi et al. 2020; Mutaqin et al. 2020a; Marfai et al. 2020, 2022; Lazuardi et al. 2021). Bali is located in the Coral Triangle region and has a high potential for housing coral-reef ecosystems. Coral reefs are a source of food, are a marine mega biodiversity habitat and they provide coastal erosion protection, as well as support for tourism activities (UNDP 2013; Mutaqin 2020; Adalya and Mutaqin 2022). Based on a report from the Intergovernmental Panel on Climate Change (IPCC 2019), coral reefs are one of the most endangered ecosystems in the world and are currently affected by ocean acidification and extreme temperatures. Various initiatives and strategies to conserve coral reefs have been attempted by various governments, private sectors, local communities, and NGOs (Cinner et al. 2014; Mutaqin et al. 2020b; Lazuardi et al. 2021; Adalya and Mutaqin 2022).

To maintain and preserve natural resources and also prevent damage or degradation, some areas should be allocated to conservation zones, such as a marine protected area (MPA). There are 25 priority areas of MPA in Indonesia, one of them being the remote area of Pemuteran Village in Buleleng Regency, which was subsequently planned following Regent Decree number 523/630/HK/2011 related to the MPA in Buleleng Regency, later called the West Buleleng Conservation Zone (WBCZ) (see Fig. 1).

The condition of the coral reefs nowadays in Pemuteran is very different from that a few years ago (Lazuardi et al. 2021); Pemuteran was the poorest village in Bali until 1990 (Dunning 2015). In 2000, the rehabilitation of coral reefs began by creating artificial reefs using Biorock. Thus, the formation of WBCZ was also performed to restore the coral-reef ecosystem that had been facing negative pressure,

such as destructive fishing using dynamite and cyanide. This effort has a chain effect on the sustainability of ecosystems, thereby benefitting the tourism industry and increasing the income of local communities in this area (Marfai et al. 2020; Lazuardi et al. 2021).

However, the high level of tourism activities in WBCZ poses questions about the ecosystem's carrying capacity for supporting tourism activities. As a result, to develop and effectively maintain coral-reef ecosystems, this paper aims to assess their benefits. This article contains economic assessments, which can be related to the dynamic of the coral-reef ecosystem's socio-economic and ecological components. The economic assessment of the ecosystem can estimate the economic value, to validate the huge benefit provided by the ecosystem, so we can optimally protect it. Ideally, economic valuation also provides a tool for policymakers and conservationists to evaluate tourism activity management and their impact on the coral-reef ecosystem (Pagiola et al. 2004). The results can be used to strengthen the capacity of socio-economic and ecological elements, as basic data for conservation zone policy, to know the needs of both coastal communities and tourists, and to facilitate ecotourism activities in order to reduce the risks of ecosystem damage in the future.

Methods

The data were collected in August 2019 in WBCZ, Pemuteran Village, Gerokgak District, Buleleng Regency, Bali Province, Indonesia. This location was chosen based on a purposive sampling method with several considerations, such as marine resources (especially coral reefs) in this area representing the practical management challenge to achieve sustainable development (Lazuardi et al. 2021). Before determining the research location, the researcher made observations using the literature review from previously conducted research works, articles on the internet, and several sources who provided information about this area.

The primary data in this study were obtained directly in the field by employing direct observation, questionnaires, and in-depth interviews with the respondents. Furthermore, the secondary data were obtained from the written documents belonging to the regional and national governments, the local stakeholders and authorities, Yayasan Karang Lestari (NGO), and the managers of local hotels and diving resorts. The sampling method employed accidental sampling for tourist respondents and purposive sampling for the local community respondents and stakeholders. The total number of respondents was 92 consisting of 51 local respondents and 41 tourist respondents.

Table 1 Value of benefits, formulas, and economic valuation methods

No.	Value of benefits	Formulas	Methods
1	DUV a) Tourism b) Fisheries production	a) Number of visits = f(travel expenses, others factor x_1, x_2…) b) Fish cost/kg x total of production/year (kg)	*a) Travel cost method* *b) Effect on production*
2.	IUV a) Coastal protection b) Fish habitat	a) Length of the coastline (m) x Cost of breakwater making per meter b) Percentage of coral cover x Total area of coral reefs (ha) x Cost of making a pond	*Replacement cost method*
3	OV	The value of selected coral reefs (IDR) x Total area of coral reefs (ha)	*Benefit transfer method*
4.	EV Tourists and local communities	Existence benefit of respondent x The number of the population	*Contingency valuation method*
5.	BV	Bequest benefit of the respondent (local communities) x The number of the population	*Contingency valuation method*
6.	TEV	DUV + IUV + OV + EV + BV	*Total economic value*

The benefits of coral reefs and ecosystem services were assessed by adding the following parameters: (1) direct use-value (DUV), (2) indirect use value (IUV), (3) option value (OV), (4) existence value (EV), and (5) bequest value (BV), all of which will then be obtained to estimate the total economic value (TEV). Table 1 presents the value of benefits, the formulas, and the economic valuation methods.

Results

Direct use-value (DUV)

Tourism.

The tourism activity in WBCZ provides huge benefits to the economic value of both Pemuteran and the Buleleng Regency. In this study, approximately 41 tourist respondents were interviewed. The benefits from tourism activities in the region were estimated using the travel cost method to know how much the average individual spends when traveling to WBCZ, which is calculated using the result from the regression model between the number of visits (V) per individual per year as an independent variable with the cost of travel (X_1), income (X_2), education (X_3), distance (X_4), age (X_5), gender (X_6), and length of visit (X_7) as independent variables as mentioned in Eq. 1.

$$V = 1.367 - 0.000000125 \times_1 + 0.138 \times_2 - 0.055 \times_3 - 0.423 \times_4 + 0.179 \times_5 - 0.159 \times_6 + 0.061 \times_7 \text{ (Eq. 1).}$$

Table 2 Estimated DUV of Coral-Reef Ecosystems for Fisheries Production

DUV	Fisheries production (kg/year)	Cost (IDR/kg)	Total DUV
Fisheries production	75,000*	21,500	IDR 1,612,500,000
The total amount of fisheries production per year (US$)			115,179

Source: *Statistics Indonesia (2018)

The DUV of the tourism activities can be calculated by knowing the consumer surplus from the coefficient of each variable. The average travel cost was obtained at US$ 337 per individual. Subsequently, the average value of the travel costs per individual was multiplied by the number of tourists visiting each year—as many as 27,018 tourists. Finally, the value of the benefits of tourism activities at WBCZ was estimated to be US$ 9,096,391/year.

Fisheries Production.

The coral-reef ecosystem performs many ecological functions by acting as a place of spawning, a nursery, and a feeding ground to provide nutrients for various biota, and especially provides a direct benefit for many species of fish. Based on interviews with some fishermen involved in capture fisheries production, there are several types of fish such as snapper fish (Lutjanus sp.), little tuna (Euthynus sp.), flathead grey mullet (Mugil sp.), rabbitfishes (Siganus sp.), Indian mackerel (Rastreligger sp.), and coral grouper (Plectopromus sp.). Furthermore, the total amount of fisheries production per year in Pemuteran was approximately 75 tons/year, from the secondary data of Statistics Indonesia in Gerokgak District for the year 2018 (see Table 2), with the average value of local selling of IDR 21,500/kg fish (US$ 1 = IDR 14,000). Subsequently, the magnitude of the potential of coral-reef ecosystems in fisheries production was estimated to be US$ 115,179 /year.

Indirect Use Value (IUV)

Coastal Protection.

One of the IUVs obtained from the benefits of coral-reef ecosystems is protecting terrestrial areas from coastal abrasion or storm surges. In the absence of coral-reef protection, the beachfront should be protected by constructing barrier structures to reduce and manage disaster risk (Marfai 2008; Mutaqin 2017; Mutaqin 2020; Marfai et al. 2022; Alwi and Mutaqin 2022). The replacement cost method was used to estimate the value of the ecosystem-related benefits such as a coastal-abrasion barrier, where the replacement used the cost required to build a breakwater structure using the shadow price approach as the standard from the Indonesian Ministry of Public Works for retaining wave construction.

Table 3 Estimated IUV of the Coral-Reef Ecosystems for Coastal Protection

IUV	Length of coastline (m)	Cost (IDR /m)	Total IUV
Breakwater	6,000	19,474,313*	IDR 116,845,879,800
Breakwater durability for five years (US$)			8,405,573
Breakwater durability per year (US$)			1,681,114
Breakwater durability per year with an inflation rate (US$)			1,737,431

Source: * Indonesian Ministry of Public Works and Housing (2016)

Fish Habitat

The indirect benefit value of the coral-reef ecosystem acting as a fish habitat was calculated using the replacement cost method. This calculation is based on the cost of replacing the pond for fish development, as well as the breeding and nursery grounds for fish. Suparmoko et al. (2003) state that the cost of creating fish ponds is IDR 40,000,000/ha. In addition, it took five years to preserve and maintain the ponds, costing approximately IDR 40,000,000 (see Table 4). Subsequently, the value of constructing fish ponds per year and the replacement costs are estimated at US$ 256,406/year. However, the inflation rate from 2003 to 2019 increased by about 6.25% (Bank Indonesia 2019). Based on that amount, the total estimated IUV as fish ponds of the coral-reef ecosystem was US$ 272,431/year

Table 4 Estimated IUV of the Coral-Reef Ecosystems for Fish Habitat

IUV	The total area of coral reefs (ha)	Cost of constructing pond (IDR/ha)	Total IUV
Fish habitat	448.71	40,000,000*	IDR 17,948,400,000
Maintaining fish ponds (5 years) (US$)			1,282,029
Maintaining fish ponds per year (US$)			256,406
Maintaining fish ponds per year with an inflation rate (US$)			272,431

Source: *Suparmoko et al. (2003)

The shadow price approach is implementable if no data are available in the study area (Bunce et al. 1999; Murty 2001; Sato et al. 2015).

Furthermore, the cost of building a breakwater of size 150 m x 20 m x 5 m with a durability of 5 years requires IDR 2,921,147,000 or approximately IDR 19,474,313 per meter (Indonesian Ministry of Public Works and Housing 2016). The length of the coastline in Pemuteran is 6 km (6,000 m). It can then be calculated that the IUV approach to coral-reef ecosystems as coastal protection is US$ 8,405,573/five years (see Table 3). Therefore, the benefits are divided into 5 years, and the IUV is US$ 1,681,114/year. However, the inflation rate from 2016 to 2019 increased by about 3.35% (Bank Indonesia 2019). Based on that amount, the total estimated IUV as a breakwater of the coral-reef ecosystem was US$ 1,737,431/year.

Table 5 Estimated OV of the Coral-Reef Ecosystems

OV	The coverage area of coral reefs (ha)	Estimation value (US$/ha/year)	Total OV
Biodiversity	448.71	1,131*	507,491
Total OV (US$)			507,491
Total OV with an inflation rate (US$)			524,491

Source: * Mansyur and Lawelle (2016)

Characteristics	Local Communities			Chanceristics	Tourists		
	Category	Total	Percentage (%)		Category	Total	Percentage (%)
Age	15-19	2	4	Age	15-19	0	0
	20-24	7	14		20-24	15	37
	25-29	10	20		25-29	23	56
	29-34	7	14		29-34	1	2
	35-39	9	18		35-39	1	2
	40-44	6	12		40-44	1	2
	45-49	6	12		45-49	0	0
	>50	4	8		>50	0	0
Education	No Education	1	2	Education	No Education	0	0
	Elementary School	5	10		Elementary School	0	0
	Junior High School	12	24		Junior High School	0	0
	Senior High School	28	55		Senior High School	6	15
	Undergraduate	5	10		Undergraduate	33	80
	Graduate	0	0		Graduate	2	5
Occupation	Self-employment	13	25	Occupation	Self-employment	6	15
	Pulic Servant	0	0		Pulic Servant	9	22
	Security	2	4		Security	0	0
	Employee	23	45		Employee	12	29
	Student	0	0		Student	8	20
	Freelancer	2	4		Freelancer	5	12
	Village officials	2	4		Village officials	0	0
	NGO	2	4		NGO	1	2
	Fisherman	3	6		Fisherman	0	0
	Diver	4	8		Diver	0	0
Income (IDR)	<1,000,000	2	4	Income (IDR)	<1,000,000	1	2
	1,000,000 - 2,000,000	26	51		1,000,000 - 2,000,000	14	34
	2,000,000 - 3,000,000	9	18		2,000,000 - 3,000,000	10	24
	3,000,000 - 4,000,000	6	12		3,000,000 - 4,000,000	8	20
	4,000,000 - 5,000,000	7	14		4,000,000 - 5,000,000	6	15
	>5,000,000	1	2		>5,000,000	2	5
	No Answer	0	0		No Answer	0	0

Table 6 Characteristics of Respondents

Option value (OV)

The benefit of choice is the value that represents the future use of coral-reef ecosystems, both directly and indirectly. The value of choice can be estimated based on the value of biodiversity by using the benefits transfer method. The value of choice in this study was estimated by referring to the research results of Mansyur and Lawelle (2016). They estimated that the value of the choice of coral-reef ecosystems was US$ 1,131/ha/year. With the coral-reef conservation area of 448.71 ha in WBCZ, the estimated OV of coral-reef ecosystems was US$ 507,491/year (Table 5). However, the inflation rate from 2016 to 2019 increased by about 3.35% (Bank Indonesia 2019). Based on that amount, the total estimated OV of the coral-reef ecosystem was US$ 524,491/year.

Existence value (EV)

Characteristics of Respondents.

The total number of respondents was 92 people consisting of 51 local people and 41 tourists. Each respondent had different characteristics. The characteristics can be divided based on age, educational level, type of work, and income per month (see Table 6). The EV of the coral-reef ecosystems in WBCZ was calculated using the willingness to pay (WTP) approach.

Table 7 WTP of Local Communities and Tourists

	Local communities	Tourists
Number of respondents	51	41
Population	8,621	27,018
Mean WTP	150,000.00	161,428.57
Median WTP	60,000.00	100,000.00
Standard deviation	15,545.00	17,136.42
Total WTP (IDR)	517,260,000.00	2,701,800,000.00
Total WTP (US$)	36,947	192,986

The WTP approach is the willingness of a person to pay someone for services and goods produced by natural resources or the measurement of the value of goods and services for the ecological value of ecosystems (Fauzi 2014), which aims to pay for quality improvements in the protection of environmental services, based on a potential damage scenario. The contingency valuation method generates awareness and participation of both local communities and tourists to maintain the existence and sustainability of coral-reef ecosystems with all its benefits.

Before asking questions regarding WTP, the respondents were given a scenario about the existence and function of coral-reef ecosystems. The following is an initial scenario created to help the respondents understand all the questions about WTP; *"According to the information from the* Indonesian Ministry of Marine Affairs and Fisheries (2013*), the condition of the coral reefs in Indonesia is in an alarming condition with only 30% in good condition, 37% in moderate conditions, and the remaining 33% severely damaged. Therefore, now coral reefs are one of the most endangered ecosystems in the world. If coral-reef ecosystems are preserved by performing conservation activities, then are you willing to pay to sustain coral-reef ecosystems? (IDR/year)."*

According to the scenario discussed above, the respondents were asked to contribute to the coral-reef conservation program. The program required a high level of funding, and the respondents were given the option of whether they wanted to contribute to the program. This interview about WTP was conducted using the payment card method (Fauzi 2014), wherein the respondents were offered the cards; these cards contained, in writing, the value of money starting from the lowest to the limit that the respondents refused to pay. The card consisted of amounts ranging from IDR 10,000, IDR 20,000, IDR 30,000, IDR 50,000, IDR 75,000 to IDR 100,000. The amount of money considered the minimum wage of the community in the Buleleng Regency; this wage is one of the lowest in Bali province. Based on this question, all the respondents were willing to participate and pay for the coral-reef conservation program at WBCZ (Table 7). This shows that both local communities and tourists are concerned about the sustainability of coral-reef ecosystems.

Table 8 WTP of BV

Number of respondents	51
Population	8,621
Mean WTP	199,285.71
Median WTP	225,000.00
Standard deviation	17,786.31
Total WTP (IDR)	1,939,725,000.00
Total WTP (US$)	138,552

Table 9 Estimated Total Economic Value in 2019 (present value) in WBCZ

No.	Value of benefits	Economic value per year (US$)
1	DUV	9,096,391
	a) Tourism	115,179
	b) Fisheries production	
2.	IUV	1,737,431
	a) Coastal protection	272,431
	b) Fish habitat	
3	OV	524,491
4.	EV	229,933
	Tourists and local communities	
5.	BV	138,552
TEV		12,114,408

The average WTP value of the local-community respondents is IDR 20,500, with the economic value of WTP being US$ 36,947. In contrast, the average WTP value of the tourist respondents is IDR 27,500, with the economic value of WTP being US$ 192,986 (see Table 7).

Bequest value (BV)

Cesar and van Beukering (2004) stated that the value of a coral–reef ecosystem heritage is based on its future use. These uses or benefits can be attributed to "the way of life" of coastal communities. The BV of a coral-reef ecosystem is calculated using the contingent valuation method approach, thereby using the value of WTP of the local communities. The estimated value of the benefits of inheritance of coral-reef ecosystems in WBCZ is US$ 138,552/year (Table 8).

Total economic value (TEV)

The TEV of the coral-reef ecosystem in WBCZ was calculated based on the benefits, both direct and indirect, of the coral-reef ecosystems; these benefits include direct use from fisheries production that relates to fish consumption, indirect use from the replacement costs of the breakwater as a means to achieve coastal protection and fish ponds as fish habitat, OV from the chosen value of coral reefs in other location, and EV and BV as measured by the awareness or WTP for the scenario of the conservation program in WBCZ (see Table 9).

Based on the values in Table 9, the economic value of the coral-reef ecosystem in WBCZ is approximately US$ 12,114,408/year for 651.24 ha of the total area of WBCZ; this value can also be represented as US$ 18,602/ha/year. By knowing the TEV, it is expected that the natural resources from the coral-reef ecosystem in Pemuteran can be used wisely and efficiently according to need. This value can also be used as the minimum value that stakeholders in Pemuteran village must be borne, where the coral-reef ecosystems have been subjected to damages; these damages have negatively affected all sectors, especially tourism activities which generate the most significant share of income for this area.

Discussion

Why are coral reefs in Buleleng essential to preserve and be evaluated? The coral reef is a most majestic marine ecosystem and an important attraction for tourism in Buleleng, and we must ensure that our grandchildren benefit from it as well (Cesar and Chong 2004). Coral reefs are magnificent and have important ecological roles, such as providing a habitat and a nursery for various fish and invertebrates. As the first barrier among coastal ecosystems, the coral reef can reduce the energy of waves hitting the shore (Allemand and Osborn 2019; Mutaqin 2020; Lazuardi et al. 2021; Adalya and Mutaqin 2022). Coral reefs will also alleviate coastal erosion acting as a coastal defense, significantly lowering coastal risks for the world's more than 600 million inhabitants who live in those regions (United Nations 2017; Mutaqin and Lavigne 2019; Mutaqin 2020; Marfai et al. 2022; Adalya and Mutaqin 2022; Alwi and Mutaqin 2022). The coral reef ecosystem is one of the tropical ecosystems with a high level of fertility, biodiversity, and aesthetic value but is also one of the most vulnerable ecosystems related to changes in environmental quality (Cesar 2000; Burke et al. 2002; Samonte-Tan and Armedilla 2004; Allemand and Osborn 2019; Mutaqin et al. 2020b; Lazuardi et al. 2021; Adalya and Mutaqin 2022).

Great coral-reef management in Buleleng will effectively balance and improve the ecological quality and species richness of biodiversity (Lazuardi et al. 2021) and also benefits the net economy for all sectors (Kittinger 2013). The economic analysis of coral reefs goes beyond their pure monetary valuation (Cesar 2000). It addresses the following issues: (1) poverty and decline in the income standard because of the degradation of coral reefs, (2) destructive activities generating other incomes around reef areas such as blast fishing, terrestrial sand-mining induced sedimentation, and coral destruction, which are recognized as the largest pressures on the ecosystem (Haya and Fujii 2020;

Mutaqin 2020), and (3) the extent to which the local communities depend on the fisheries in the reef's ecosystem.

The study presents the current assessment of coral-reef ecosystem services, which is not all research valuing it by focusing on the creation of MPA to protect coastal biodiversity, then the valuation can serve to indicate benefits from their sustainable management (Laurans et al. 2013). MPA includes marine conservation zones, marine parks, marine reserves, and marine sanctuaries, all of which support rich biological communities that hold extensive conservation and protection, ecological, research-oriented, recreational, historical, education, commercial, and aesthetic values (Park et al. 2002; Mutaqin et al. 2020a; Marfai et al. 2020; Adalya and Mutaqin 2022).

A previously conducted study in Indonesia showed that two marine parks were able to benefit from their global value of biological diversity by obtaining an average of US$ 1,000,000/ha/year (Cesar 2000). Only 3% of Indonesia's reefs were identified to have a high potential for tourism (Burke et al. 2002). The study presents that tourism activities were assumed to have annual net benefits of US$ 56,000 for areas having good tourism potential, and also that US$ 330 reflects the lowest tourism returns.

The most popular recreational activities related to coral reefs are diving and snorkeling, which enhance the state economy by adding millions of dollars per year to it (Cesar and van Beukering 2004). Tourism activities such as snorkeling and diving are the largest contributors and major dollar earners in WBCZ, with more than 80% from TEV. WBCZ attracts tourists year-round, with about 1,003,810 tourists in 2018, and it multiplied by more than 1,600% from 2005 (56,523 tourists) (Statistics Indonesia 2019). Possible reasons are: (1) WBCZ has the famous underwater park on Bali Island, (2) the easy accessibility to visit Pemuteran village, which is less than 30 min from Gilimanuk harbor and about 2.5 h from the airport (see Fig. 1), and (3) the adequate facilities, wherein 2017, there are about 44 hotel and dive resort facilities with 1,158 individuals engaged in tourism to serve 27,018 visitors (Statistics Indonesia 2018; Marfai et al. 2020).

The result of the economic assessment in WBCZ is US$ 12,114,408/year with US$ 18,602/ha/year is quite different if compared to the valuation of West Lombok in the West Nusa Tenggara Province in Indonesia performed by Riopelle (1995), who estimated the total valuation of coral reefs to be US$ 58,200,000, which corresponds to more than US$ 100,000/ha of the reef. Many factors affect the valuation to varying extents, such as the time (year) of data collection, the abundance of biodiversity which can track the condition of the environment and reflect its ecological processes, the impact of climate change and other natural phenomena, and ultimately the anthropogenic activities including coastal pollution and the effect of overexploitation in the loss of biological diversity and also their habitat. The total economic valuation can be utilized as the minimum value that must be borne by the coastal communities, government, or related stakeholders if there is damage to the coral-reef ecosystem, which harms all sectors, especially tourism activities as the leading sector in the West Buleleng Conservation Zone.

Conclusion

We assessed the estimated TEV of the coral-reef ecosystem to be US$ 12,114,408/year for 651.24 ha of the total area of WBCZ or US$ 18,602/ha/year. From this study, we also expected that there would be some dynamic economics measured by WTP estimates. The WTP was affected by reef quality, which has an essential role in tourism and conservation activities. In conclusion, the presented economic valuation can be used to raise awareness and encourage people to protect and sustainably manage coral-reef ecosystems to ensure both the sustainable use of coral-reef resources and the conservation of threatened species, as well as the ecosystem.

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