



# Total Economic Valuation of Coral Reef Ecosystems and Ecotourism Carrying Capacity for Sustainable Management of the Gita Nada Marine Protected Area, West Lombok

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**Abstract:** Economic valuation alone is insufficient if it is not complemented by an analysis of environmental carrying capacity, particularly in areas designated for ecotourism development. This study aims to estimate the total economic value (TEV) of coral reef ecosystems and to assess the ecotourism carrying capacity within the Gita Nada Marine Protected Area (MPA) in West Lombok Regency. A descriptive research approach was employed using survey techniques involving three respondent groups: ecosystem service users (fishermen,  $n = 24$ ), tourists ( $n = 40$ ), and stakeholders ( $n = 11$ ), totaling 75 respondents. Direct and indirect use values were estimated using market price, surrogate market, and replacement cost methods, while non-use values were derived through willingness-to-pay (WTP) surveys and benefit transfer. The findings indicate that the total economic value of coral reefs in the Gita Nada MPA reaches IDR 74,961,205,060.00 per year, with the largest component being existence value (IDR 28,782,000,000.00 per year). The ecotourism carrying capacity based on Government Regulation No. 18 of 1994 (10% of utilization zone) is estimated at 275 visitors per day for diving and 137 visitors per day for snorkeling, and 137 visitors per day for beach-based recreation. These values underscore the importance of sustainable conservation management to preserve the long-term ecological and economic benefits of the Gita Nada MPA.

**Keywords:** Carrying capacity; Coral reef ecosystems; Ecotourism; Total economic value

## Introduction

Coastal and marine resources deliver ecosystem services that are vital to human well-being, including food provision, shoreline protection, recreational opportunities, and a wide range of cultural values (Haya & Fujii, 2019; Warningsih et al., 2026). The concept of Total Economic Value (TEV) is widely applied in environmental economics to quantify the direct use, indirect use, and a non-use-benefits derived from these ecosystems, encompassing existence values and bequest values for future (Wahyudin et al., 2019). TEV serves as an important analytical framework for converting non-market ecosystem services into money terms, thereby

enabling their integration into economic decision-making process and natural resource policy formulation (Suparyana et al., 2023). The Marine Protected Area (MPA) encompassing Gili Tangkong, Gili Nanggus, Gili Sudak, and the surrounding waters in West Nusa Tenggara Province was formally designated under the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia NO. 93/Kepmen-KP/2018. The total area of the Gita Nada MPA covers 21,132.82 ha (Figure 1), consisting of a core zone of 593.41 ha, and utilization zone of 1,800 ha, a sustainable fisheries zone of 18,663.40 ha, and other designated zones, including a mooring sub-zone covering 174.01 ha (Keputusan Menteri Kelautan Dan Perikanan, 2018).

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Administratively, this marine conservation area falls within Sekotong Sub-district, which is generally located on the largest peninsula of Lombok Island extending westward. The marine waters of the Gita Nada MPA include bay waters on the northern side of the peninsula that are connected to the Lombok Strait, a key component of the Indonesian Throughflow, as well as the southwestern waters of the peninsula that are directly influenced by the Indian Ocean (Anas et al., 2023).

Marine Protected Areas (MPAs) represent a key instrument for ensuring the long-term sustainability of marine ecosystems, particularly coral reefs, which are characterized by high biological productivity and substantial economic value (Santos et al., 2025). Coral reefs function as essential habitats for marine organisms, support fisheries production, provide natural coastal protection, and serve as major attractions for marine-based tourism (Rizki, 2024; Rusandi et al., 2021). In West Lombok Regency, West Nusa Tenggara Province (NTB), the Gita Nada Marine Protected Area possesses considerable coral reef potential that underpins both fisheries and ecotourism activities. Nevertheless, increasing anthropogenic pressures including overfishing, unregulated tourism activities, coastal development, and marine pollution pose significant threats to coral reef condition and jeopardize the sustainability of the associated economic benefits (Burke et al., 2012; Husni et al., 2025; Karnan, 2022).

Within the framework of conservation area management, economic valuation has emerged as an important approach for comprehensively quantifying the benefits generated by marine ecosystems. Previous studies demonstrate that estimates of coral reef economic value can inform marine spatial planning, guide conservation priority setting, and support the justification of investments in protected area management (Brander et al., 2007; Cesar & Beukering, 2004). However, economic valuation alone is inadequate when not accompanied by carrying capacity analysis, particularly in areas designated for ecotourism development. Ecotourism carrying capacity reflects the maximum level of use that an ecosystem can sustain without compromising its ecological integrity or diminishing the quality of ecosystem services it provides (Bencardino et al., 2025; Castro-Barrantes, 2020; Sitompul, 2024).

Numerous studies in Indonesia have examined the economic value of coral reefs and the carrying capacity of ecotourism independently. Research on coral reef economic valuation indicates that effective management can enhance the livelihoods of coastal communities and generate long-term economic benefits (Ramadhan et al., 2017). Conversely, studies on ecotourism carrying capacity highlight the importance of regulating visitor

numbers to prevent ecosystem degradation resulting from excessive tourism pressure (Ayuningrum et al., 2024; Muharam & Rusli, 2025). Despite these contributions, studies that simultaneously integrate total economic value (TEV) estimation with ecotourism carrying capacity analysis within a single Marine Protected Area framework remain limited in Indonesia, particularly in West Nusa Tenggara Province. The Gita Nada MPA presents a unique research opportunity due to its distinct multi-island configuration (nine clusters of small islands), its formal designation under Ministerial Decree No. 93/Kepmen-KP/2018, the documented overlap between conservation zoning and active ecotourism, and the absence of an updated economic valuation since (Hilyana et al., 2021). Unlike previous single-focus studies, this research provides a simultaneous assessment of both TEV and tourism pressure through carrying capacity, offering a more integrated foundation for conservation-based management decisions.

Accordingly, this study aims to estimate the total economic value of coral reef ecosystems and to analyze ecotourism carrying capacity in the Gita Nada Marine Protected Area, West Lombok Regency.

## Method

This study employed a descriptive research design using survey techniques. Three categories of respondents were involved, namely ecosystem service users represented by fishermen, tourists, and parties engaged in the management of the Gita Nada Marine Tourism Park, including relevant stakeholders.

The fisherman sample size was determined using the Slovin formula with a 10 percent margin of error, resulting in a sample of 24 fishermen. The tourist sample comprised 40 respondents and was determined using the Zonal Travel Cost Method analysis. As the total number of tourists was not precisely known, the sample size was estimated using the Linear Time Function approach (Sari, 1993). Furthermore, stakeholder respondents were selected through a combination of quota sampling and proportional random sampling, involving community leaders, officials from the Marine and Fisheries Agency, and non-governmental organizations, with a total of 11 respondents.

$$n = \frac{T - t_0}{t_1} \quad (1)$$

In this equation,  $n$  represents the number of respondents,  $T$  denotes the total research duration (minutes),  $t_0$  refers to the available daily time period (minutes), and  $t_1$  indicates the time required to complete the questionnaire (minutes). The ratio  $(T - t_0) / t_1$  is used

to estimate the effective number of respondents that can be surveyed within the available research time.

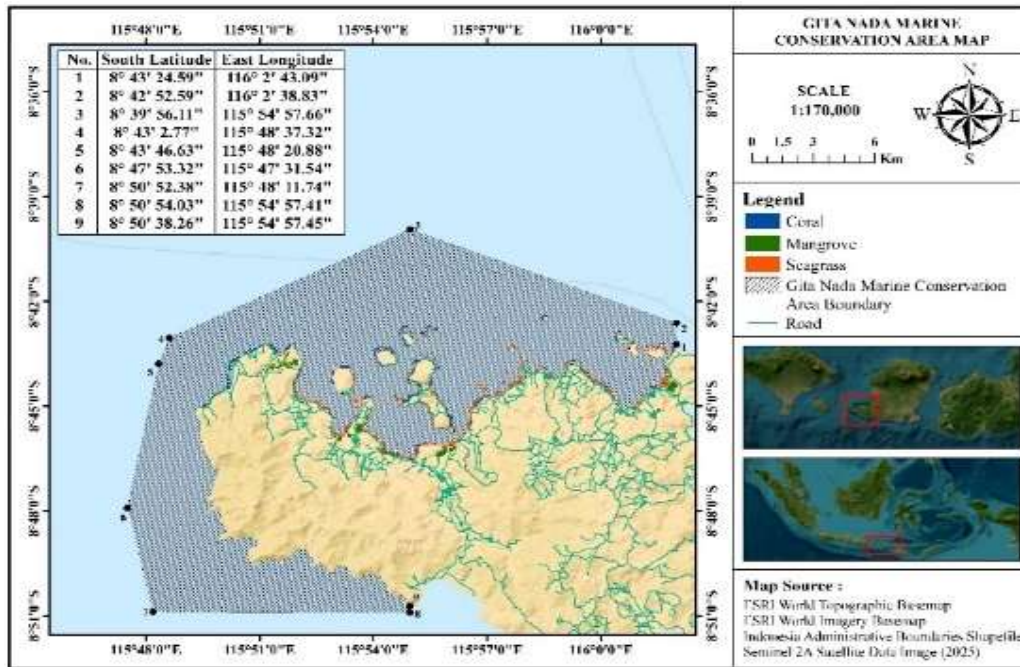


Figure 1. Map of the Gita Nada Marine Conservation Area (DKP NTB)

Table 1. Respondent categories and sample sizes

Category	Type of Respondents	Sample Size (persons)
Non-ecotourism ecosystem service users	Fishers	24
Ecotourism ecosystem service users	Tourist	40
Stakeholders	Community leaders, government agencies, and NGOs	11
<b>Total</b>		<b>75</b>

Economic valuation analysis was conducted by quantifying the various benefit components in order to derive the total economic value of coral reef ecosystems (Hilyana et al., 2021; Warningsih et al., 2026). The TEV framework decomposes ecosystem benefits into use and non-use components, as expressed by the following equation.

$$TEV = UV + NUV \tag{2}$$

Where TEV represents the Total Economic Value, UV denotes Use Value, and NUV refers to Non-Use Value.

$$UV = DUV + IUV + OV \tag{3}$$

In this equation, DUV refers to Direct Use Value, IUV to Indirect Use Value, and OV to Option Value.

$$NUV = BV + EV + QOV \tag{4}$$

Where BV is Bequest Value, EV is Existence Value, and QOV is Quasi Option Value. Each TEV component was quantified using a specific method commensurate with the type of value and available data: Direct Use Value from capture fisheries was estimated using the market price method based on fish landing data from 24 fishermen respondents; Direct Use Value from ecotourism was estimated using the surrogate market price method based on tourist expenditure data from 40 respondents and secondary visitation data; Direct Use Value from education and research was estimated using the benefit transfer method, adopting published per-hectare values from Cesar (2000) and Spurgeon (1992); Indirect Use Value from coastal protection was estimated using the replacement cost (avoided cost) approach based on per-hectare protective values from Barbier et al. (2013); Indirect Use Value from carbon sequestration was estimated using replacement cost based on carbon productivity and carbon market price; Option Value was estimated using the benefit transfer method from Cesar et al. (2003); Bequest Value was estimated using the compensation cost approach based on MPA management cost data from Balmford et al. (2009) and Existence Value was estimated using the willingness-to-pay (WTP) contingent valuation method based on interviews with 75 respondents residing around the Gita Nada MPA.

The estimation of marine tourism carrying capacity in this study follows the provisions of Government

Regulation of the Republic of Indonesia No. 18 of 1994 concerning the management of nature-based tourism within utilization zones of national parks and nature tourism parks, which allows a maximum use of 10 percent of the designated utilization area. Based on this principle, Hutabarat et al. (2009) developed a formulation to calculate the carrying capacity of conservation areas for marine tourism activities. This formulation considers the maximum number of visitors that can be accommodated per unit area, the extent of space available for tourism activities, and the temporal dimensions of visitor use and site availability (Costa et al., 2022). Accordingly, the carrying capacity for marine ecotourism is calculated using the following variables.

$$DDW = 0.1 \left[ K \frac{L_p W_t}{L_t W_p} \right] \tag{5}$$

DDW represents the carrying capacity of the area for ecotourism activities. K denotes the maximum number of visitors permitted per unit area.  $L_p$  refers to the total area or length of space that can be utilized for tourism purposes, while  $L_t$  represents the standard unit area assigned to a specific activity category.  $W_t$  indicates the total time available for tourism activities within the area per day, and  $W_p$  refers to the average time spent by visitors on a particular activity.

Table 2 presents the maximum number of visitors (K) permitted per unit area ( $L_t$ ) for each type of marine tourism activity.

**Table 2.** Maximum number of visitors per unit area for marine tourism activities (Yulianda, 2022).

Type of Activity	K (persons)	Unit Area ( $L_t$ )	Description
Diving Tourism	2	1,000 m <sup>2</sup>	Two persons per area of 100 m x 10 m
Snorkeling Tourism	1	500 m <sup>2</sup>	One person per area of 100 m x 5 m
Beach Tourism	1	25 m <sup>2</sup>	One person per area of 5 m x 5 m

The daily time constant represents the amount of time required by each visitor to engage in marine tourism activities. This value was derived from interviews conducted with all tourists within each tourism activity category.

**Table 3.** Time allocation for marine tourism activities (Yulianda, 2022)

Activity	Time Required ( $W_p$ ) (hours)	Total Available Time per Day ( $W_t$ ) (hours)
Diving	2	8
Snorkeling	3	6
Beach Tourism	3	6

## Result and Discussion

### *Total Economic Value of Coral Reefs*

Ecosystem services are defined as the benefits that humans derive from ecosystems. Natural ecosystems provide a wide range of environmental goods and services that contribute to ecosystem valuation, commonly classified into provisioning, regulating, supporting, and cultural services (Groot et al., 2010; Tan et al., 2020).

In many cases, ecosystem services are overlooked in planning and decision-making processes because their values are not directly observable or reflected in conventional market mechanisms. As a result, the importance of ecosystem conservation is often underestimated. In the absence of a clear understanding of the economic value associated with ecosystem services, many coastal and marine areas have experienced degradation due to human activities such as overfishing, pollution, and land use conversion. Effective resource management therefore requires reliable information on the economic benefits generated by ecosystem services to ensure that natural resources are utilized in a sustainable manner.

Coral reef ecosystems represent one of the most biologically productive and structurally complex tropical marine ecosystems in the world, providing essential ecosystem services that support human well-being and environmental sustainability. Coral reefs generate a wide range of ecological goods and services, including food provision through fisheries, opportunities for tourism, and coastal protection against waves and erosion, in addition to their high aesthetic and cultural values (Isdianto et al., 2024). A seminal study by Moberg & Folke (1999) highlighted that coral reefs supply renewable resources as well as structural and biotic services that underpin ecological stability and the socio-economic functioning of coastal communities. Degradation of these systems can substantially reduce their capacity to deliver such ecosystem services.

### *Direct Use*

#### *Coral Reef Fisheries*

The direct use value of coral reefs in the Gita Nada Marine Protected Area comprises utilization for capture fisheries, ecotourism, and educational and research activities. The economic value of capture fisheries was quantified using the market price method based on the value of fish landings. In contrast, the values of ecotourism and education or research activities were estimated using a surrogate market approach, which reflects improvements in environmental quality.

Fishermen's income represents net earnings obtained by subtracting total production costs from gross revenue. In the Gita Nada MPA, fishermen sell

their catches primarily to local collectors. Fish with export quality, such as snapper and grouper, are marketed to Bali using ferry transportation from Lembar to Padang Bai, while fish intended for local consumption are sold at Sweta Market and Kebon Roek Market in Ampenan, Mataram (Marzuki et al., 2023). The total annual income generated from capture fisheries is estimated at IDR 27,326,400.00 as presented in Table 4.

Given that the total number of fishermen operating within the Gita Nada Marine Protected Area is 812 individuals, the economic benefit of coral reef ecosystems from capture fisheries is estimated at IDR 22,189,036,800.00 per year, based on a coral reef area of 2.294 ha.

**Table 4.** Fishermen’s income in the Gita Nada Marine Protected Area, West Lombok Regency, 2025

Description (IDR)	Lean Season	West Monsoon	East Monsoon	Total (IDR/Year)
Revenue	4,102,421.00	14,757,631.00	39,786,980.00	58,647,032.00
Production Costs	3,311,102.00	9,030,278.00	18,979,252.00	31,320,632.00
Net Income	791,319.00	5,727,353.00	20,807,728.00	27,326,400.00

*Ecotourism*

Within the framework of coastal resource economic valuation, coral reefs are classified as direct use values, specifically as non-extractive use values, because they are utilized without removing or physically degrading the resource (Cesar, 2000; Fauzi, 2006). This non extractive utilization includes marine tourism activities such as snorkeling, diving, and beach recreation, which rely on visual appeal, coral reef biodiversity, and water clarity (Fikri et al., 2024). In the Gita Nada Marine Protected Area, coral reef ecosystems serve as a primary asset for the development of conservation-based ecotourism.

Tourist visitation to the Gita Nada MPA in 2025 reached 4,930 visitors (Global FM Lombok, 2025), indicating active use of coral reef ecosystem services by tourists. With an average tourist expenditure of IDR 787,500.00 per day covering transportation, boat rental, diving and snorkeling equipment, and consumption costs, the non-extractive direct use value of coral reefs derived from ecotourism activities in the Gita Nada MPA is estimated at IDR 3,882,375,000.00 per year. This value reflects a tangible economic contribution generated without physical exploitation of the resource, aligning with the principles of sustainable use (Cesar et al., 2003; Fauzi, 2005). Consequently, coral reefs possess not only ecological importance but also strategic economic value as a source of income for local communities and regional development (Ali et al., 2026), emphasizing the need to prioritize non extractive ecotourism and ecosystem protection in management strategies.

*Education and Research*

The coral reef ecosystem of the Gita Nada Marine Protected Area, covering an area of 2,294 ha, has considerable potential as a medium for education and research services with measurable economic value. Within the Total Economic Value framework, these benefits are classified as direct non extractive use values,

as they are generated through field learning activities, practical training, scientific research, and environmental awareness programs without extracting or physically damaging the resource (Yao & Wallace, 2024; Yunus et al., 2024). The extensive reef area enables the site to function as an open natural laboratory for students, researchers, and educational institutions.

The economic value of education and research services is reflected in expenditures associated with field activities, including transportation, boat rental, guide services, and snorkeling or diving equipment. Previous studies have reported that the value of educational and research services provided by coral reef ecosystems ranges from USD 50 to 150 per hectare per year, depending on the intensity of use (Cesar, 2000; Moberg & Folke, 1999; Spurgeon, 1992). Applying a conservative estimate of USD 75 per hectare per year, the potential economic value of education and research services in the Gita Nada MPA is estimated at USD 172,050 annually, equivalent to approximately IDR 2,666,775,000.00 per year. This estimate represents the economic contribution generated by educational and research activities within the area.

Beyond direct economic benefits, educational use of coral reef ecosystems provides long term value through improvements in human capital and environmental awareness. The use of coral reef ecosystems as sites for education and outreach can enhance community participation in conservation efforts, which in turn reduces ecosystem rehabilitation costs through avoided damage (Hadiprayitno et al., 2023). In line with the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No. 47/PERMEN KP/2016 concerning the utilization of marine protected areas, which emphasizes education and research functions, the coral reef ecosystems of the Gita Nada MPA are shown to possess not only ecological importance but also strategic economic value through non extractive education and research services.

*Indirect Use Value**Wave Attention*

Coral reef ecosystems in the Gita Nada Marine Protected Area perform a critically important ecological function as natural breakwaters that protect coastal areas from wave action, strong currents, and storm energy. Within the Total Economic Value framework, this function is classified as an indirect use value, as the benefits are realized through physical coastal protection without direct utilization or extraction of resource (Moberg & Folke, 1999; Spurgeon, 1992). The rigid and complex structure of coral reefs is effective in dissipating wave energy before it reaches the shoreline, thereby reducing coastal abrasion, erosion, and the risk of damage to coastal ecosystems.

Scientific evidence has consistently demonstrated the effectiveness of coral reefs in attenuating wave energy. Ferrario et al. (2014) reported that coral reefs can reduce incoming wave energy by up to 97 percent before it reaches the coast, highlighting their role as natural barriers in coastal hazard mitigation. With a total reef area of 2,294 ha, the coral reefs of the Gita Nada MPA make a substantial contribution to protecting shorelines, coastal settlements, productive land, and infrastructure from wave and storm related impacts. This protective function is increasingly significant in the context of climate change and the rising frequency of extreme weather events affecting coastal regions (Barbier et al., 2013).

From an economic perspective, the protective role of coral reefs as natural breakwaters can be valued using the avoided cost approach, which estimates the costs of coastal repair, infrastructure damage, and environmental rehabilitation that are prevented due to the presence of coral reefs (Barbier et al., 2013; Spurgeon, 1992). Applying a conservative value of USD 200 per hectare per year, the indirect economic benefit of the 2,294 ha coral reef ecosystem in the Gita Nada MPA is estimated at USD 458,800 annually, equivalent to approximately IDR 7,111,400,000.00 per year. This finding demonstrates that, although not directly exploited, coral reef ecosystems generate substantial and strategic economic benefits by maintaining coastal stability, reducing environmental losses, and supporting the long-term-socio-economic sustainability of coastal communities.

*Carbon Sequestration*

Coral reef ecosystems are an integral component of coastal systems that contribute to climate regulation through carbon cycling, and therefore fall under the category of indirect use value within the Total Economic Value framework (Mardiati et al., 2025). Although the carbon sequestration capacity of coral reefs is lower than that of mangroves or seagrass meadows, reefs still play

a role in carbon storage through the biomass of reef organisms, primary productivity, and complex biological interactions within the reef structure. Moberg & Folke (1999) identified coral reefs as providers of climate regulation services, while Howard et al. (2014) emphasized that shallow marine ecosystems, including coral reefs, are part of the blue carbon system that contributes to global climate change mitigation.

From an economic valuation perspective, the carbon sequestration and storage services provided by coral reefs can be estimated based on carbon productivity per unit area and converted into monetary values using carbon market prices. Several studies on tropical coastal ecosystems indicate that carbon productivity in shallow marine ecosystems ranges from 10 to 30 tons of carbon per hectare per year (Alongi, 2014). To ensure a precautionary approach and avoid overestimation, this study applies a conservative value of 25 tons of carbon per hectare per year in estimating the carbon sequestration service of coral reefs.

Based on a coral reef area of 2,294 ha in the Gita Nada Marine Protected Area, the total potential carbon sequestration is estimated at approximately 57,350 tons of carbon per year. Using a conservative carbon price of IDR 100,000.00 per ton, the indirect economic value of coral reefs as carbon sinks in the Gita Nada MPA is estimated at IDR 5,735,000,000.00 per year. This value demonstrates that, in addition to functioning as marine habitats and coastal protection systems, coral reefs also provide strategically important economic benefits in climate change mitigation. Consequently, the sustainable management of coral reef ecosystems is essential within the broader context of sustainable development and carbon emission control.

*Option Value*

Option value is a component of the TEV that reflects the value of coral reef biodiversity as an "option" for future use. This value represents potential benefits that are not currently utilized but may generate economic returns in the future through tourism development, scientific research, biotechnology, pharmaceuticals, and other ecosystem services. In coral reef ecosystems, option value is closely linked to biodiversity richness, as higher biodiversity increases the likelihood of future uses that are not yet fully known or realized (Cesar et al., 2003). Therefore, option value constitutes an important economic justification for coral reef conservation.

The estimation of coral reef option value in the Gita Nada Marine Protected Area was conducted using the benefit transfer method, by adopting values from relevant previous studies (Mazaya et al., 2019). Cesar et al. (2003), in their economic valuation of coral reefs in Asia, estimated coral reef biodiversity option value at approximately USD 100 per hectare per year. This value

represents the potential future benefits of coral reef biodiversity that have not been directly utilized but hold strategic importance for future generations. The benefit transfer approach is commonly applied in coastal resource economics when primary data are limited, assuming comparable ecosystem characteristics.

Based on a coral reef area of 2,294 ha in the Gita Nada MPA, the total option value is estimated at USD 229,400 per year (2,294 ha × USD 100/ha/year). When converted using an exchange rate of IDR 15,500.00 per USD, this corresponds to an option value of IDR 3,555,700,000.00 per year. This result indicates that although these benefits have not yet been directly realized, the existence of coral reefs in the Gita Nada MPA provides a tangible economic value as a reserve of biodiversity and future development opportunities. Consequently, the degradation or loss of coral reefs would not only reduce current benefits but also eliminate significant long-term economic potential.

#### *Bequest Value*

Bequest value is a component of non-use value within the TEV framework that reflects society's willingness to preserve coral reef ecosystems so they can be inherited by future generations. This value is not associated with current direct use, but rather with moral, ethical, and intergenerational responsibility to maintain natural resources for long-term sustainability. In the context of coral reefs, bequest value is particularly important due to their complex ecological functions, high biodiversity, and strategic role in supporting future coastal livelihoods (Cesar et al., 2003; Fauzi, 2005).

Bequest value represents the economic benefit derived from conserving ecosystem resources for the benefit of future generations. This value is closely linked to protection efforts that ensure the continued existence and functionality of coral reef ecosystems. The economic valuation of bequest value is estimated using the compensation cost approach, which reflects the costs required to maintain ecosystem integrity through effective management of marine protected areas.

Several studies provide reference values for estimating management costs of marine conservation areas. Balmford et al. (2009) report that the annual management cost required for small marine protected areas (< 10,000 ha) is USD 65.70 per hectare, medium-sized areas (10,000–120,000 ha) require USD 14.46 per hectare, large areas (120,000–1,000,000 ha) require USD 7.86 per hectare, and very large areas (> 1,000,000 ha) require USD 1.54 per hectare. The Gita Nada Marine Protected Area covers 21,132.82 ha and is therefore classified as a medium-sized conservation area. Accordingly, the estimated management cost is USD 14.46 per hectare per year, equivalent to IDR

224,130.00.00 per hectare per year using an exchange rate of IDR 15,500.00 per USD.

Based on this estimate, the total bequest value of the Gita Nada Marine Protected Area is calculated at IDR 4,736,418,260.00 per year. This value highlights the economic importance of conserving coral reef ecosystems not only for present benefits but also to ensure their availability and functionality for future generations. Consequently, investment in conservation and effective management represents a rational and necessary strategy to safeguard long-term ecological and socio-economic sustainability.

#### *Existence Value*

Existence value is a component of the non-use value within the TEV framework and reflects the value that people assign to coral reefs simply because they exist, regardless of whether they have used or will use the ecosystem directly. This value is intrinsic in nature and is closely related to psychological satisfaction, ethical considerations, and moral responsibility associated with the preservation of ecosystems with high biodiversity. In the context of coral reefs, existence value is particularly important because coral reefs are among the most biodiverse marine ecosystems in the world, giving them strong ecological, social, and symbolic significance (Cesar, 2000; Fauzi, 2005).

The estimation of coral reef existence value is commonly conducted using the willingness to pay (WTP) approach through the contingent valuation method (Adriani et al., 2025), which measures the amount individuals are willing to pay to ensure the continued existence of the ecosystem. When primary data are limited, this approach may also be supported by benefit transfer techniques. In this study, the existence value was estimated based on interviews with respondents living around the Gita Nada Marine Protected Area, which indicated a median WTP of IDR 1,000,000.00 per individual.

By multiplying the median WTP value by the total population residing around the Gita Nada Marine Protected Area, estimated at 28,782 people in 2023 (BPS Kabupaten Lombok Barat, 2024), the existence value of coral reefs in the Gita Nada Marine Protected Area is estimated at IDR 28,782,000,000.00 per year. This result demonstrates that the local community places a high economic value on the mere existence of coral reef ecosystems, even without direct utilization, thereby reinforcing the importance of coral reef conservation as a strategic ecological and socio-economic asset (Nurhayu et al., 2025).

#### *Total Economic Value of Coral Reef Ecosystems*

Based on Table 5, the Total Economic Value (TEV) of the coral reef ecosystem demonstrates a very high

economic contribution derived from multiple benefit categories, encompassing both direct and indirect uses. Direct use values consist of capture fisheries, tourism, and education and research, with a combined value of IDR 28,738,186,800.00 per year. Capture fisheries contribute IDR 22,189,036,800.00 per year, estimated using the market price method, reflecting the critical role

of coral reefs as primary habitats for commercially valuable fish species. Meanwhile, tourism and education/research activities generate IDR 3,882,375,000.00 and IDR 2,666,775,000.00 per year, respectively, indicating that coral reefs also function as non-extractive income sources and as natural laboratories for scientific and educational activities.

**Table 5.** Estimated total economic value of coral reefs in the Gita Nada MPA, 2025

Coral Reef Ecosystem Component	Function and Benefits	Valuation Method	Net Benefit Valur (IDR/year)
Direct Use Values	Capture fisheries	Market Price	22,189,036,800.00
	Tourism	Surrogate Market Price	3,882,375,000.00
	Education and research	Surrogate Market Price	2,666,775,000.00
Indirect Use Values	Coastal protection (natural breakwater)	Replacement Cost	7,111,400,000.00
	Carbon sequestration	Replacement Cost	5,735,000,000.00
Option Value	Biodiversity conservation	Benefit Transfer	3,555,700,000.00
Bequest Value	Ecosystem preservation for future generations	Compensation Cost	4,736,418,260.00
Existence Value	Public perception and appreciation	Willingness to Pay (WTP)	28,782,000,000.00
Total Economic Value (TEV)			74,961,205,060.00

The largest contribution to the TEV comes from the existence value, amounting to IDR 28,782,000,000.00 per year, estimated using the willingness to pay (WTP) method. This result highlights the strong appreciation and concern of the community for the existence of coral reefs, even in the absence of direct use. Overall, the Total Economic Value of coral reefs in the study area reaches IDR 74,961,205,060.00 per year.

This substantial value underscores that coral reefs play a strategic role not only from an ecological perspective but also from an economic standpoint. Therefore, effective conservation and sustainable management efforts are essential to ensure the continuity of these diverse and significant benefits.

*Ecotourism Carrying Capacity*

The Gita Nada Marine Protected Area (MPA) comprises nine clusters of small islands within the utilization zone that are suitable for diving and snorkeling activities. This zone covers an area of 1,923 ha, with coral reefs occupying approximately 9,264,572 m<sup>2</sup>. According to Tarigan et al. (2019) hard coral cover within the utilization zone reaches 37.23%. Following Yulianda (2022), only reef areas with coral cover classified as good (>50%) are considered appropriate for marine ecotourism activities. Based on this criterion, the area of coral reefs suitable for diving and snorkeling in the Gita Nada MPA is estimated at 3,324,873 m<sup>2</sup>, as presented in Table 6.

**Table 6.** Carrying capacity of diving and snorkeling tourism in the Gita Nada MPA, 2025 (\*Witomo, 2021)

Small Island	Area (m <sup>2</sup> )*	Carrying Capacity (persons/day)	
		Diving	Snorkeling
Gili Poh	124,305	99	49
West Gili Tangkong	36,849	29	14
West Gili Rengit	256,337	205	102
East Gili Tangkong	168,012	134	67
East Gili Rengit	316,158	253	126
Gili Lontar	162,234	130	65
Gili Sudak	238,087	190	95
Gili Nanggu	231,198	185	92
Gili Layar	383,964	307	154
Gili Asahan	450,859	361	180
Gili Gede	1,081,174	865	433
Total	3,324,873	2,753	1,374
Government Regulation No. 18/1994 (Allowable Use Capacity)	332,487.3	275	137

As shown in Table 6, the carrying capacity for diving and snorkeling tourism in the Gita Nada MPA is

strongly influenced by the extent of coral reef areas available for use. Islands with extensive reef coverage,

such as Gili Gede (1,081,174 m<sup>2</sup>) and Gili Asahan (450,859 m<sup>2</sup>), exhibit the highest carrying capacities, at 865 and 361 visitors per day for diving (and 433 and 180 visitors per day for snorkeling), respectively. In contrast, islands with relatively limited reef areas, such as West Gili Tangkong (36,849 m<sup>2</sup>), support a much lower carrying capacity of only 29 visitors per day for diving and 14 visitors per day for snorkeling. This pattern indicates that larger coral reef habitats substantially enhance the ability of ecosystems to accommodate tourism pressure without compromising ecological integrity (Yulianda & Mazaya, 2021).

These findings are consistent with the carrying capacity framework proposed by Cifuentes (1992) and further developed by Salm & Clark (2000) which emphasizes that marine tourism capacity should be determined by both physical and ecological constraints. In aggregate, the total carrying capacity for diving and snorkeling activities in the Gita Nada MPA reaches 2,753 visitors per day and 1,374 visitors per day, respectively. These figures are considerably higher than the allowable utilization capacity (DDP) stipulated under Government Regulation No. 18 of 1994, which limits use to 275 visitors per day for diving and 137 visitors per day for snorkeling.

The discrepancy highlights that carrying capacity estimates derived from site-specific biophysical characteristics of coral reefs provide a more accurate and adaptive assessment than generalized normative-based approaches. This result aligns with the findings of (Hawkins & Roberts, 1997; Tratalos & Austin, 2001), who argue that diving tourism capacity must be determined according to reef-specific conditions, including reef area, structural complexity, and susceptibility to physical disturbance. Without effective visitor management, diving and snorkeling activities may lead to coral reef degradation through direct physical contact, increased water turbidity, and physiological stress on coral organisms.

Referring to Government Regulation No. 18 of 1994 on the management of ecotourism activities within utilization zones of national parks and nature tourism parks, only 10% of the utilization zone is permitted for tourism use. Based on this regulation, the allowable carrying capacity for diving tourism in the Gita Nada Marine Protected Area is 275 visitors per day, and for snorkeling is 137 visitors per day. It should be noted that visitor arrivals to the Gita Nada MPA specifically reached 4,930 visitors in 2025 (approximately 13-14 per day), while tourist arrivals in the wider Sekotong area reached approximately 40,307 visitors in 2025, equivalent to an average of 110 visitors per day (Global FM Lombok, 2025).

Furthermore, the findings of this study are consistent with previous research emphasizing that

visitor limitation based on carrying capacity is a critical instrument for sustainable marine tourism management. Zakai & Chadwick-Furman (2002), as well as Hasler & Ott (2008), demonstrated that diving intensity exceeding ecological thresholds leads to declines in live coral cover and alterations in coral reef community structure. Conversely, the appropriate application of carrying capacity not only safeguards ecosystem integrity but also supports the long-term economic viability of marine tourism (Diedrich, 2007; Spalding et al., 2017).

Accordingly, carrying capacity values provide a sound scientific basis for establishing daily visitor quotas, regulating diving and snorkeling zones, and formulating sustainable tourism management strategies in the Gita Nada Marine Protected Area (Wati et al., 2023).

**Table 7.** Carrying capacity of beach tourism areas in the Gita Nada Marine Protected Area, 2025 (\*Witomo, 2021)

Beach Tourism Site	Area (m <sup>2</sup> )*	Carrying Capacity (persons/day)
Elak-Elak Beach	22,250	890
Kemos Beach	9,600	384
White Sand Beach	2,450	94
Total	34,300	1,368
Government Regulation No. 18/1994 (Allowable Use Capacity)	3,430	137

Based on the carrying capacity assessment of beach-based ecotourism in the Gita Nada Marine Protected Area, the physical carrying capacity of coastal recreation areas is estimated at 1,368 visitors per day, while the allowable utilization capacity (DDP) is limited to 137 visitors per day. Based on field observations and interviews during the study period, average beach visitation was estimated at approximately 85 visitors per day (Witomo, 2021). These results indicate that existing tourism activities can be accommodated without exceeding the ecological limits of the area, thereby allowing coastal ecosystems to remain in a stable and well-preserved condition (Zhao & Jiao, 2019).

As presented in Table 7, the total recreational beach area in the Gita Nada MPA covers 34,300 m<sup>2</sup> and supports a carrying capacity of 1,368 visitors per day. Among the assessed sites, Elak-Elak Beach exhibits the highest carrying capacity at 890 visitors per day, attributable to its larger spatial extent compared to Kemos Beach (384 visitors per day) and White Sand Beach (94 visitors per day). This finding underscores the dominant role of physical space availability in determining beach tourism capacity, particularly for low-impact recreational activities such as swimming, shoreline walking, and passive enjoyment of coastal scenery. This pattern is consistent with the concept of

physical carrying capacity, which emphasizes spatial availability as a key determinant in beach tourism management (Cifuentes, 1992; Zacarias et al., 2011).

When compared with the allowable utilization capacity established under Government Regulation No. 18 of 1994, which restricts use to 137 visitors per day, the estimated physical carrying capacity appears substantially higher. This discrepancy reflects the conservative nature of national policy frameworks, which prioritize long-term environmental protection over short-term tourism expansion. Manning (2013) notes that conservative carrying capacity thresholds are essential to anticipate cumulative and often latent impacts, including sand compaction, disturbance to coastal vegetation, and declines in visual quality.

Empirical observations further support the sustainability of current tourism use. With average beach visitation remaining below both physical and policy-based capacity thresholds, beach tourism in the Gita Nada MPA has not yet exerted significant ecological pressure. Silva (2002) similarly reported that tourism intensity maintained below carrying capacity limits is unlikely to induce substantial changes in beach morphology or coastal environmental quality. Consequently, the present utilization level of beach recreation areas in the Gita Nada MPA can be classified as environmentally safe and well controlled.

The results of this study are consistent with findings from other coastal regions, which identify imbalances between visitor numbers and carrying capacity as a primary driver of beach ecosystem degradation. Micallef & Williams (2009) emphasized that beaches experiencing visitor loads beyond their capacity tend to suffer from environmental deterioration and declining visitor satisfaction. In the context of the Gita Nada MPA, the substantial gap between current visitation levels and estimated carrying capacity suggests that there remains potential for the controlled development of beach ecotourism, provided that visitor limits, activity zoning, and continuous environmental monitoring are rigorously implemented.

Overall, the carrying capacity values presented in Table 7 offer a robust scientific foundation for planning and managing sustainable beach ecotourism in the Gita Nada Marine Protected Area. A carrying capacity-based approach enables managers to balance economic utilization with coastal ecosystem conservation. In line with the findings of Zacarias et al., (2011) the integration of carrying capacity assessments with regular monitoring of beach bio-physical conditions represents an effective strategy for ensuring the long-term sustainability of coastal ecotourism.

## Conclusion

The total economic value of coral reefs in the Gita Nada Marine Protected Area is estimated at IDR 74,961,205,060.00 per year. This figure encompasses direct use values (capture fisheries, tourism, education and research), indirect use values (coastal protection, carbon sequestration), option value, bequest value, and existence value, reflecting the strategic ecological and economic role of coral reefs. It is important to note that a substantial portion of this value, particularly the existence value (IDR 28,782,000,000.00 per year), is derived from community willingness-to-pay estimates and benefit transfer methods rather than direct market transactions. Furthermore, the carrying capacity for diving tourism is estimated at 275 visitors per day, for snorkeling at 137 visitors per day, and for beach-based recreation at 137 visitors per day, based on the 10% utilization allowance under Government Regulation No. 18 of 1994. The total biophysical carrying capacity for diving and snorkeling reaches 2,753 and 1,374 visitors per day, respectively, indicating potential for carefully managed tourism expansion. Future research is recommended to update the regulatory framework to current legislation, increase sample sizes for more representative valuation, and conduct time-series monitoring of coral reef conditions and tourist impacts to ensure long-term sustainability of the Gita Nada MPA.

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## Author Contributions

Conceptualization, formal analysis, visualization, writing original draft preparation, S.H.; supervision, methodology, writing—review and editing, S.Hi., L.S., and M.J. All authors have approved the final manuscript.

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## Conflicts of Interest

The authors declare no conflict of interest.

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