Rapid economic valuation and sustainability analysis for managing ecotourism in Gili Matra Marine Conservation Area, West Nusa Tenggara Province

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Abstract. The Gili Matra Marine Conservation Area has dual functions as a center for marine conservation as well as an ecotourism destination. Although ecotourism contributes significantly to the economy, the area faces challenges in maintaining ecological and social sustainability owing to increased tourism activities. This study evaluated economic value using the Travel Cost Method (TCM). The status of sustainability was assessed using the multi-dimensional scaling (MDS) method by RAPFISH, with the support of leverage analysis to identify sensitive factors and Monte Carlo to validate the results. The results of the economic valuation analysis show that the average tourist expenditure varies based on the origin of the region, with the total economic contribution of the region being more than Rp 9.5 trillion per year. These findings indicate that marine ecotourism has great economic value and potential to continue to increase. The results for the sustainability level for the study area indicated that the institutional (63.83), infrastructure (58.32), and economic (56.53) aspects were moderately sustainable, whereas the ecological (44.91) and social (45.26) aspects were less sustainable. These findings confirm the need for integrative policies that emphasize strengthening ecological and social aspects, accompanied by infrastructure and institutional support.

Keywords: Gili Matra, Travel Cost Method (TCM), Eco tourism, sustainabilty, RAPFISH, MDS

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1 Introduction

As part of a marine conservation area, Gili Matra is now playing a strategic role in preserving marine and coastal ecosystems while encouraging the development of sustainable ecotourism. This area is not only popular for nature tourism destinations but also has important value for marine resource conservation. Its utilization and management have been regulated in the Decree of the Minister of Maritime Affairs and Fisheries Number 57 of 2014 concerning the Management and Zoning Plan of TWP Gili Ayer, Gili Meno, and Gili Trawangan 2014-2034, which emphasizes the protection of biodiversity, sustainable fisheries management, and optimization of economic potential through marine ecotourism.

The ecosystems in Gili Matra TWP, such as coral reefs, mangroves, and seagrasses, serve as important habitats for various marine species and are a major attraction for tourists interested in ecotourism activities, such as snorkeling and diving. Matra also has the potential to support the local economy through the tourism sector [1]. It has been proven that, at least in 2009-2014 tourists in Gili Matra increased by up to 695.30% [1]. It has a positive economic impact on the communities around the conservation area, especially those living around Gili Trawangan, Gili Meno, and Gili Air, who are mostly involved in tourism activities, both as accommodation service providers, restaurants, snorkeling and diving equipment rentals, and as tour guides [2, 3]. Therefore, effective and sustainable management of these areas is essential for maintaining a balance between spatial and natural resource utilization and marine conservation [4].

However, with an increasing number of tourists visiting the area, it is challenging to maintain the sustainability of existing ecosystems [5]. Overall, although public awareness of the importance of conserving marine resources is increasing, understanding of the benefits of maintaining natural ecosystems remains limited [6]. However, poorly managed tourism activities can cause damage to coral reefs and disrupt marine biodiversity [7]. This is because many people assume that protecting resources by not exploiting them or services such as coastal protection, biodiversity, and cultural values has little value and is often undervalued without serious economic assessment [1, 8, 9].

Economic value for ecotourism is important information that can provide a strong basis for policymakers and site managers in formulating decisions related to area management [10]. In addition, the results of economic valuation can help local communities understand the economic contributions of ecotourism, thus encouraging them to be more supportive and involved in conservation activities and sustainable area management. A clear economic valuation helps identify areas that have high revenue and can be the focus of further development while maintaining a balance with conservation efforts [11, 12]. Economic valuation serves as an important tool to manage and utilize the area for generating an economy based on sustainable ecotourism, supports the local economy, and makes a significant contribution to the country's economy. [13]

The management of the Gili Matra TMP requires an approach that prioritizes the principles of sustainability, so that negative impacts on the environment can be minimized and the economic benefits of the tourism sector can be maximally felt by the local community, including the use of economic valuation analysis. Economic valuation is an important aspect of the management of natural tourism destinations because it can provide a clear picture of the economic value generated by the area [14]. Nature tourism often has benefits that are difficult to measure directly, such as ecosystem, recreational, and educational. Through economic valuation, these values can be objectively calculated and valued. One commonly used method for the economic valuation of nature tourism is the *Travel Cost Method* (*TCM*), which measures how much tourists spend to visit the site from their home, including travel costs, time, and other related expenses.

To obtain optimal benefits, the management of Gili Matra for ecotourism must meet the criteria of sustainable development that accommodates economic, social, and ecological interests to obtain the principles of sustainable marine management [15]. Thus, the ecotourism management of Gili Matra requires an approach that prioritizes the principles of sustainability, so that negative impacts on the environment can be minimized and the economic benefits of the tourism sector can be maximally felt by the local community, among others, by using sustainability analysis with (muldimensional scaling MDS (*Multi Dimensional Scalling)*.

This study aims to provide recommendations for the development of sustainable Ecotourism in Gili Matra which includes 5 (five) aspects: ecological, economic, social, institutional, and infrastructural. Sustainable assessment can be done with *Impact Analysis, Cost Benefit Analysis, Economic Valuation, or Multi-Criteria Analysis techniques* [16]. This study uses the results of the identification of criteria that can be categorized into ecological, economic, social, technological, infrastructure, and institutional/policy aspects that are analyzed using the multidimensional scaling (MDS) technique. The MDS technique was conducted using a modified MDS ordination technique from RAPFISH - *Rural Appraisal for Fisheries* [17]. RAPFISH is based on the ordination technique of placing objects in the order of measurable criteria through perceptual mapping using MDS [1].

Sustainable Ecotourism development strategies in Gili Matra MPA were analyzed using the role of each criterion in each aspect (ecological, economic, social, technological, infrastructure, institutional, and policy), and then analyzed using RAPFISH, which performs multivariate statistical data processing with the MDS approach, with stages: 1) determination of criteria in each attribute, 2) assessment of criteria in sustainability scores/scales, 3) preparation of sustainability index, 4) ordination assessment, 5) leverage analysis, and 6) Monte Carlo analysis. RAPFISH is a tool developed by a team from the Fisheries Center University of British Columbia to determine the sustainability of fisheries [17, 18, 19, 20]. In this study, leverage analysis was used to detect dominant attributes, while Monte Carlo analysis was applied to detect sources of error from variability [21].

This research aims to evaluate the rapid economic valuation of ecotourism using the *Travel Cost Method (TCM)* and to analyze the level of sustainability of ecotourism development in the Gili Matra Marine Conservation Area. The outcome is expected to provide policy recommendations for the management of areas that are balanced between the utilization of natural resources for ecotourism and ecosystem conservation to increase understanding of the economic contribution of the tourism sector, encourage the implementation of sustainable tourism practices, and empower local communities. This study can also be used as a basis for developing policies that support sustainable tourism management, both at the local and national levels, to ensure the economic welfare of the community without damaging the environment.

2 Research methodology

This research was conducted from August to December 2024, including initial survey activities, socialization of research plans, and collection of secondary data from relevant agencies in the Gili Matra Marine Conservation Area, North Lombok Regency, and West Nusa Tenggara Province. This research focused on Gili Meno, Gili Trawangan, and Gili Air Island. The study area is shown in **Fig. 1**.

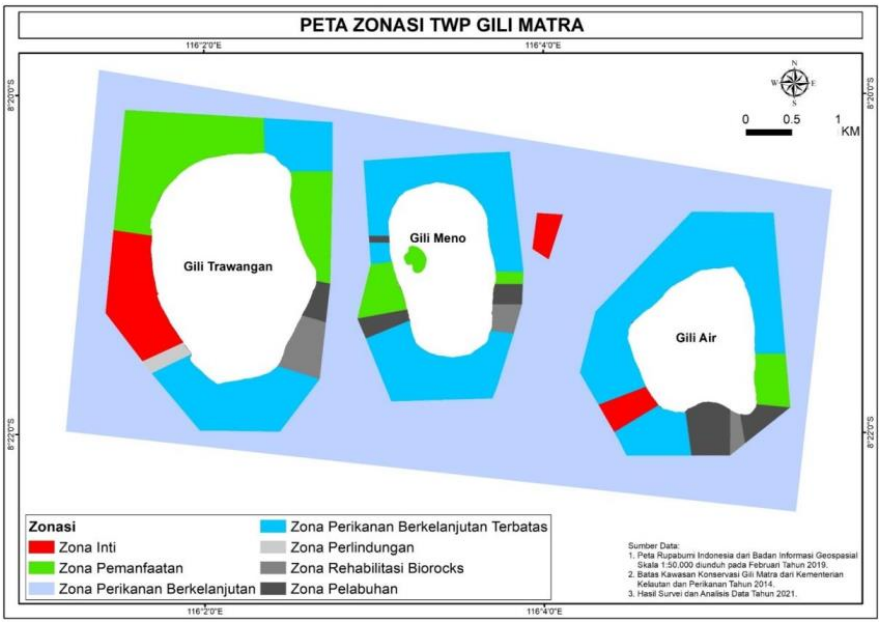

Fig. 1. Research study area.

Primary and secondary data were used in this study. Primary data were obtained through data collection techniques by interviews and group discussions or focus group discussions (FGDs) at the research location involving various regional agencies and other relevant ministries/institutions. According to [13], a survey is conducted to obtain facts from existing symptoms and seek factual information about social and economic institutions from a group business or an area. The data collected include spatial and non-spatial data, which include data from the ecological, economic, social, and cultural aspects of society and institutions. Primary data in this study were obtained through a groundcheck, questionnaire data collection, and discussion.

2.1 The economic analysis of ecotourism

The rapid economic assessment of ecotourism in this study applied the individual Travel Cost Method (TCM) to estimate the Direct Use Value (DUV) of marine tourism. This method operates under the assumption that travel-related expenses, including transportation, accommodation, entrance fees, and opportunity cost of time, represent their willingness to pay (WTP) for recreational benefits [3, 22, 23]. Primary data were obtained from survey activities, research plan socialization, and collection of secondary information from relevant agencies within the Gili Matra Marine Conservation Area, North Lombok Regency, West Nusa Tenggara Province (Gili Trawangan, Gili Meno, and Gili Air). The TCM Approach to Calculate Textual Data Processing Exercises, TCM calculations are formulated as equation 1.

$$Y = \beta 0 + \beta X \quad (1)$$

Explanation:
Y = visitation rate per 1,000 population as the dependent variable (Y),
X = average travel cost per zone as the independent variable (X), and
N = population.

2.2 The sustainability analysis of ecotourism

In this research, the criteria of each aspect, good and bad, were conducted through questionnaire assessments by government/local government officials, experts, academics, and relevant stakeholders. Table 1 lists the criteria for each aspect, as presented in **Table 3**.

Table 1. Sustainability aspects and criteria.

Number	Aspects	Sub Number	Criteria
1	Ecologycal	1.1	Small Island Landscape Change
		1.2	Water Quality Level
		1.3	Changes in the Extent and Condition of Seagrass and Coral Reef Ecosystems
		1.4	Condition of Fish Species and Abundance
		1.5	Increase in waste and potential pollution
		1.6	Physical degradation of coastal/coastal environment
		1.7	Conservation and disaster/climate change mitigation activities
		1.8	Frequency of natural disaster events
2	Economy	2.1	Increase in central/local government revenue
		2.2	Increased community/business income
		2.3	Labor absorption
		2.4	Increased number and variety of local products
		2.5	Improvement of public infrastructure
		2.6	Involvement of communities and SMEs in the development of superior commodities and new businesses
3	Social	3.1	Social conflicts between communities and migrants/tourists
		3.2	Utilization conflicts in Marine space
		3.3	Shifting/loss of customs and cultural systems of localcommunities
		3.4	Influence of traditional leaders
		3.5	Circulation of dangerous drugs/products
		3.6	Involvement of surrounding communities in tourism activities
4	Institutional	4.1	Adherence to RTR/RPZ in the utilization of Marine Spaces
		4.2	Regulatory/policy conflicts between central/local/regional/local

Number	Aspects	Sub Number	Criteria
4	Institutional	4.3	Management of the number of visitors so that space utilization is in accordance with the carrying capacity / capacity
		4.4	Ease of licensing services
		4.5	Organization/Tourism Awareness Groups, Supervision and Law Enforcement
		4.6	Sustainable tourism management strategy and coordination among stakeholders/community
5	Infrastructures	5.1	Road infrastructure and environmentally friendly modes of transportation
		5.2	Electricity and green energy infrastructure
		5.3	Clean water and sanitation infrastructure
		5.4	Waste and emissions management infrastructure
		5.5	Eco-Port, and other sea transportation infrastructures
		5.6	Waste treatment facilities
		5.7	Supporting facilities for environmentally friendly tourism

To assess the criteria in each of these aspects, a questionnaire filling technique was used, with the provision of good conditions given a score of 2 (two), bad conditions given a score of 0 (zero), and between good and bad, given a value of 1 (one). For the MDS analysis test, the questionnaire results were collected and analyzed using the mode value, which reflects the assessment results (points that reflect the position of readiness relative to good and bad points using the MDS statistical ordination technique). The estimated score for each aspect was expressed on a scale of 0% worst (poor) to 100% best (good), which was grouped into 4 (four) categories, as shown in **Table 2**.

Table 2. Sustainability index assessment.

No	Index Values	Category
1	< 25	Unsustainable
2	> 25 – 50	Less Sustainable
3	> 50 – 75	Moderately Sustainable
4	> 75 – 100	Highly Sustainable

The role of the criteria for each aspect was assessed using a scoring method based on the RAPFISH results. Subsequently, an MDS analysis was conducted to determine the relative position against Good and Poor ordination. To determine the uncertainty and sensitivity aspects of the criteria analyzed, Monte Carlo and Leverage analyses (sensitivity analysis) were used as a follow-up analysis of the results of the MDS ordination measurement and the measurement of the score of each criterion from all aspects. The sensitivity values of the criteria indicate the degree of influence. Thus, the higher the

sensitivity, the greater the influence as a determining factor to assess the sustainability index. The improvement of the criteria is assumed to increase the sustainability of ecotourism development.

3 Results and discussion

3.1 Rapid economic valuation using travel cost method

In the context of the Travel Cost Method (TCM) analysis, the division of zones based on travel distance to the Gili Matra Marine Tourism Park serves to systematically identify and categorize the geographic origin of tourists. **Table 3** classifies the origin of visitors into five zones: Zone A for a distance of 0–200 km, Zone B for 200-1,000 km, Zone C for 1,000-1,500 km, Zone D for 1,500-2,000 km, and Zone E for a distance of more than 2,000 km.

Table 3. Zone division by distance.

Zone	Direct Range to Gili Matra
A	0 – 200 km
B	200 - 1000 km
C	1000 - 1500 km
D	1500 – 2.000 km
E	> 2.000 km

This grouping has analytical significance in the calculation of economic valuation because theoretically, the longer the distance traveled by tourists, the higher the travel costs. Therefore, zones with a greater range of distances (especially Zones D and E) represent a segment of tourists with higher economic commitment, both in terms of transportation and accommodation costs. In contrast, visitors in zones A and B generally come from nearby areas or within the same province, with lower travel costs and more seasonal numbers of domestic and foreign tourist visits that can be predicted.

These zoning divisions are not only important in estimating consumer surplus and the total economic value of tourism but also contribute to understanding tourists' spatial behavior, accessibility preferences, and the effectiveness of destination promotion strategies. From a policy perspective, this zoning approach enables the formulation of dynamic tariffs and the more targeted management of tourism services based on the geographic origin of visitors. Thus, the division of travel distance is an important indicator in supporting marine tourism management, which is data-based and oriented towards economic efficiency and sustainability.

In the next stage, the number of visitors from each zone was calculated, as shown in **Table 4**. The table presents data on the distribution of visitors to Gili Matra Marine Tourism Park based on distance zoning.

Table 4. Number of visitors from each zone.

Zone	Number of respondents per zone	Percentage	Number of visitors from each zone (person/year)
A	16	18.60	67,907
B	15	17.44	63,663
C	3	3.49	12,733

Zone	Number of respondents per zone	Percentage	Number of visitors from each zone (person/year)
D	11	12.79	46,686
E	41	47.67	174,012
Total	86	100.00	365,000

Based on the data obtained, Zone E was the largest contributor to the number of annual visits, with 41 respondents (48%) representing an estimated 174,012 people per year (47.7%). The dominance of this zone indicates that Gili Matra has a strong attraction for tourists from very far away, including Western Indonesia and foreign tourists. This also reflects the high interest in exotic marine destinations despite the relatively high cost and distance involved.

Zone A (0-200 km) and zone B (200-1,000 km) accounted for 16 (19%) and 15 (17%) respondents, respectively, representing an estimated annual visitation of 67,907 and 63,663 people, or accumulatively 36.2% of the total visitors. This shows that the surrounding and regional areas still contribute significantly to the number of visits, despite being below Zone E in terms of tourist volume.

Zone D (1,500-2,000 km) accounted for 11 respondents (13%), with an estimated 46,686 visits, while Zone C (1,000-1,500 km) accounted for only three respondents (3%), equivalent to 12,733 visitors per year. These two zones show a medium to low contribution to total visitors but are still relevant in spatial analysis and travel cost estimation.

The striking distribution between Zone E and other zones has important implications in the context of Travel Cost Method (TCM)-based economic valuation. The greater the proportion of visitors from distant zones, the higher the average value of travel costs, which can be calculated by estimating consumer surplus and total economic value. This also indicates the high financial commitment of tourists to this destination, which in turn strengthens the position of the Gili Matra Marine Tourism Park as a leading national and international marine tourism destination.

The visit rate was calculated by dividing the number of visitors to each zone by the total population (per 1000) of each zone, and the results are shown in **Table 5**. This indicator provides a more proportional picture of the level of tourist participation in the total population of each visitor's region of origin while reflecting the intensity of tourist involvement in the marine tourism activities of the zone.

Table 5. Visit rate per 1000 population.

Zone	Number of visitors form each zone (person/year)	Total population of each zone	Visitation Rate per 1000 population
A	67,907	9,000	7.55
B	63,663	19,000	3.35
C	12,733	17,000	0.75
D	46,686	52,000	0.90
E	174,012	330,000	0.53

Zone A (0-200 km) recorded the highest visitation rate, at 7.55 visits per 1,000 population, far exceeding the other zones. This shows that despite the relatively small absolute population (9,000 people), a very high proportion of people access the Gili Matra Marine Tourism Park. This high visitation rate is likely to be influenced by geographical proximity, easy access to transportation, and more effective local promotion.

Zone B (200-1,000 km) ranked second with 3.35 visits per 1,000 population, followed by zone D (1,500-2,000 km) with 0.90, and zone C (1,000-1,500 km) with 0.75. Zone E (>2,000 km), despite having the highest absolute number of visitors, recorded the lowest visitation rate of 0.53 per 1,000 people. This low value is due to the large base population of Zone E (330,000 inhabitants), resulting in a relatively smaller visitation rate.

This interpretation confirms the importance of considering the visitation-to-population ratio indicator in tourism demand analyses. Nearby zones tend to have a high visitation intensity, although the absolute number of visits is not always the largest. Conversely, distant zones have a large number of visitors in absolute terms, but a relatively low level of participation in the home population. In the context of Travel Cost Method (TCM)- based economic valuation, these data are important for calibrating the demand function and identifying zones with high market potential on a proportional basis, not just on the basis of visitation volume.

The average travel cost per individual in each zone (**Table 6**) shows that the components of travel costs for tourists to Gili Matra Marine Tourism Park are grouped based on the travel distance zone of origin. Each zone reflects different cost characteristics, including the main transportation costs (average cost of travel), consumption, accommodation, and other costs (such as tickets, activities, and additional expenses). These four components constitute the total average cost of a tourist trip per geographic zone.

Table 6. Per-zone travel costs (in IDR).

Zone	Average Cost of Travel Per zone	Consumption	Accommodation	Other Costs	Total Average Cost per zone
A	13,544,375.00	1,374,375.00	1,351,375.00	1,204,166.67	17,474,291.67
B	4,431,333.33	2,110,000.00	2,496,000.00	635,365.08	9,672,698.41
C	4,583,333.33	250,000.00	1,100,000.00	60,000.00	5,993,333.33
D	13,161,272.73	778,181.82	880,727.27	1,300,909.09	16,121,090.91
E	20,284,000.00	1,986,707.32	2,144,682.93	1,657,621.95	26,073,012.20

Zone E (>2,000 km), which represents travelers from the farthest regions, recorded the highest travel costs, with an average total of IDR 26,073,012.20. The largest component came from the main cost of travel (IDR 20,284,000), followed by consumption (IDR 1,986,707.32), accommodation (IDR 2,144,682.93), and other costs (IDR 1,657,621.95). These high costs indicate that tourists from Zone E are a segment with high purchasing power and strong economic commitment to marine tourism destinations such as Gili Matra.

Zone A (0-200 km) ranked second, with an average total cost of IDR 17,474,291.67, despite coming from a closer region. This suggests that tourist expenditure in this zone is more concentrated on tourism experiences and recreational facilities rather than solely on transportation costs. Travel costs mainly reached IDR 13,544,375, with significant expenditure on consumption, accommodation, and others.

Furthermore, Zone D (1,500-2,000 km) shows an average total cost of IDR 16,121,090.91, with a relatively even cost structure between main travel, accommodation, and additional expenses. Zones B and C show lower costs of IDR 9,672,698.41, and IDR 5,993,333.33, indicating that travelers from the middle zone tend to have more moderate expenses due to time constraints, visit duration, and purchasing power.

Overall, the data confirm that travel costs increase with geographic distance of origin but are also influenced by each segment's consumption preferences and travel style. This finding is in line with the basic principles of the Travel Cost Method (TCM), where distance and cost are proxies for the economic value that tourists place on a destination.

The higher the costs that are willing to be incurred, the higher the value of the benefits (utility) that tourists feel from the existence of these tourist destinations.

3.2 Regression analysis

The results of the calculation were then analyzed using the linear regression analysis method, where the average travel cost per zone was used as the independent variable (X) and the visitation rate per 1,000 people as the dependent variable (Y) to obtain the regression model Y = 2.8243–1.877 × 10-8 × X. The known equation is used to form a demand curve using the reaction function, and to simulate the ticket price from Rp. Zero until the number of visitors was zero.

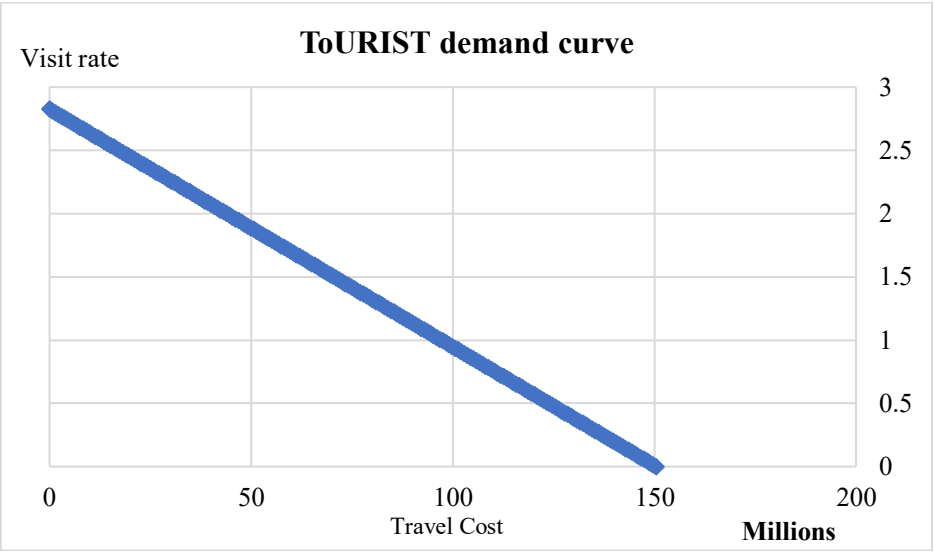

Fig. 2. Tourist demand curve.

The graph above shows that, if the cost of travel continues to increase, the visitation rate decreases linearly. At a point around IDR 150,428,000, the number of visitors drops to zero, which means that is the maximum point of price tolerance in this model. Thus, the maximum WTP obtained from the demand curve is IDR 150,468,833 and the number of visitors per year is 631,468, resulting in a consumer surplus of IDR 42,750,998,631,058.00. Theoretically, tourists receive additional benefits (beyond what they pay) of IDR 42.75 trillion per year from the existence of the Gili Matra Marine Tourism Park. In addition, with a total annual visitor number of 631,468 people, the total economic valuation of this tourist area can be calculated using the following formula:

$$\text{Economic Valuation} = \text{Average Actual Cost} \times \text{Number of Visitors} \quad (2)$$

The results of these calculations show that Gili Matra Marine Tourism Park provides an economic contribution of more than IDR 9.5 trillion per year. This figure not only reflects the huge economic potential of the marine tourism sector but is also an important basis for formulating sustainable management policies. In addition, this value also strengthens the position of Gili Matra Marine Tourism Park as a marine protected area that is not only ecologically important but also provides tangible economic benefits to the community and government, both directly through tourist spending and indirectly through business opportunities, employment, and other multiplier effects.

3.3 Ordination of sustainability aspects

The ordination stage aims to determine whether the ordination point is in a Good or Bad position based on the results of the sustainability index value on 5 (five) aspects, namely ecological, economic, social, institutional, and infrastructure, as indicators that are applied in providing strategy recommendations in the context of sustainable ecotourism development in the Gili Matra Marine Conservation Area.

3.3.1 Ecological aspects

The MDS ordination analysis of ecological aspects, which is an important aspect in the development of sustainable activities in Gili Matra MPA, includes 8 (eight) criteria, as indicated in **Table 1** The results indicate that from an ecological aspect, Gili Matra has a poor sustainability value with an ordination value of 44.91, as shown in **Fig. 3**.

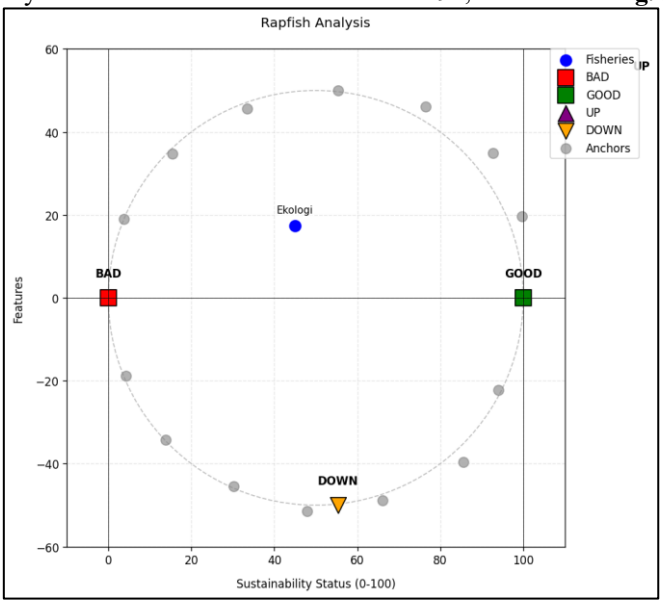

Fig. 3. Results of ecological aspect ordination.

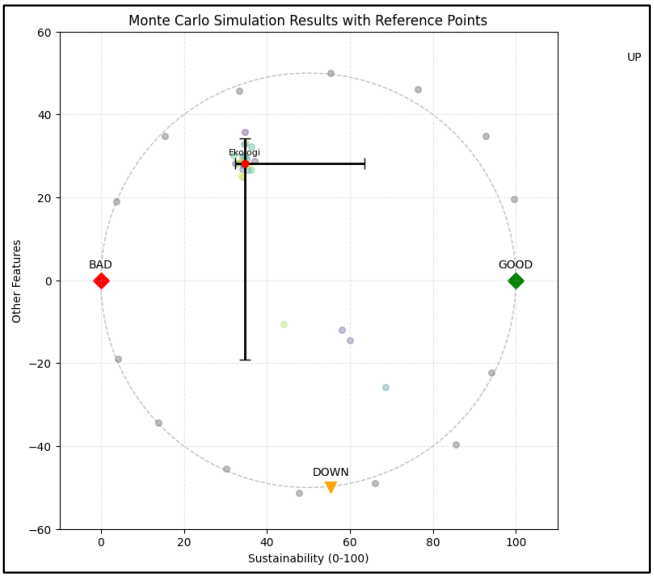

Fig. 4. Monte-Carlo analysis of ecological aspects.

The MDS ordination value was strengthened using Monte Carlo analysis as a validation technique for MDS analysis. The results of the Monte Carlo analysis show that the resulting ordination value can be used to assess the sustainability index from an ecological perspective. Monte Carlo analysis was used as a validation technique for MDS analysis. The results of the Monte Carlo simulation with 25 repetitions were spread over a distance with a small difference in the value. This small difference in value indicates that the error rate in the analysis process can be avoided or minimized. The results of the Monte Carlo analysis for ecological aspects are shown in **Fig. 4**.

3.3.2 Economic aspects

The results of the MDS ordination analysis of economic aspects, which include 6 (six) criteria as **Table 1** for the development of sustainable Ecotourism in Gili Matra MPA. The results showed that, from an economic perspective, the Gili Matra MPA has a fairly good sustainability value with an ordination value with an index number of 56.53, as shown in **Fig. 5**.

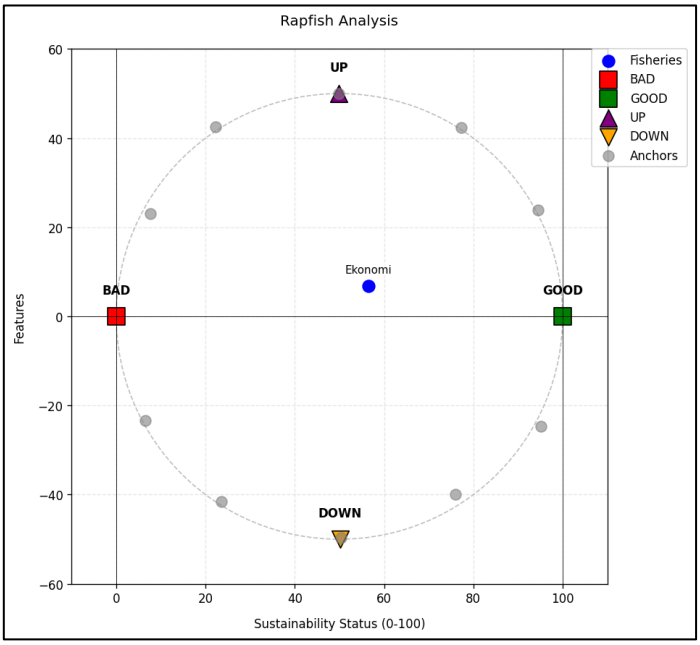

Fig. 5. Results of economic aspect ordination.

The MDS ordination value was strengthened using Monte Carlo analysis as a validation technique for MDS analysis. The results of the Monte Carlo analysis showed that the resulting ordination values can be used to assess the sustainability index from an economic perspective. The results of the Monte Carlo simulation with 25 repetitions were spread over a distance with a small difference in the value. This small difference in value indicates that the level of error in the analysis process can be avoided or minimized. The results of the Monte Carlo analysis for the economic aspects are shown more clearly in **Fig. 6**.

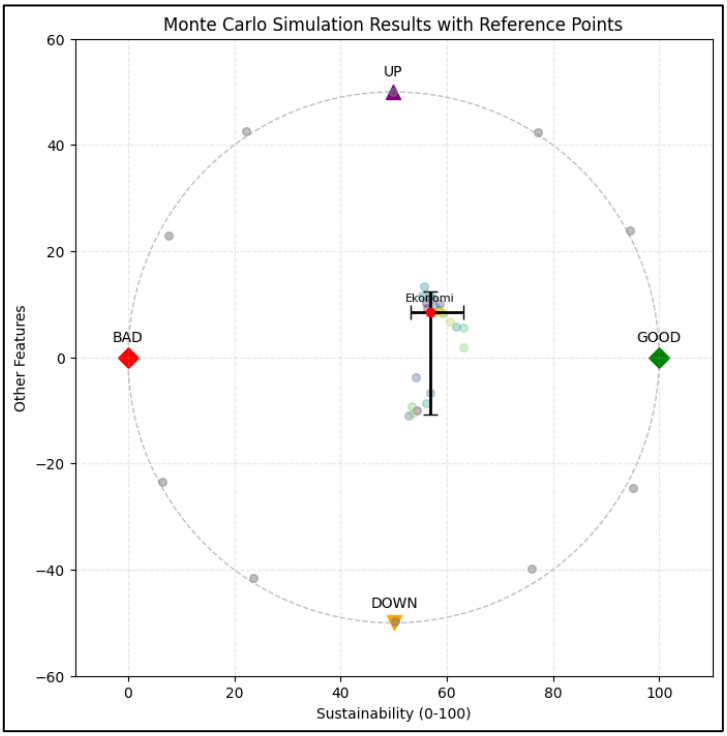

Fig. 6. Monte-Carlo analysis of economic aspects.

3.3.3 Social aspect

MDS ordination analysis of social aspects, which includes 6 (six) criteria, is shown in **Table 1.** for the development of sustainable Ecotourism in Gili
Matra MPA. The results showed that, from a social aspect, Gilimatra MPA has a poor sustainability value with an ordination value of 45.25, as shown in **Fig**. **7**.

The MDS ordination value was strengthened by Monte Carlo analysis as a validation technique for MDS analysis. The results of the Monte Carlo analysis show that the resulting ordination values can be used to assess the sustainability index from a social perspective. The results of the Monte Carlo simulation with 25 repetitions were spread over a distance with a small difference in the value. This small difference in value indicates that the level of error in the analysis process can be avoided or minimized. The results of the Monte Carlo analysis for social aspects are shown more clearly in **Fig. 8**.

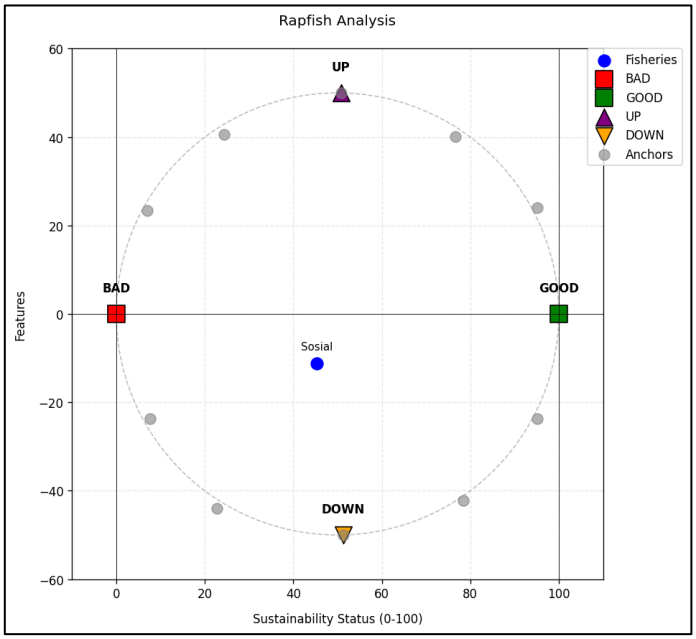

Fig. 7. Results of social aspect ordination.

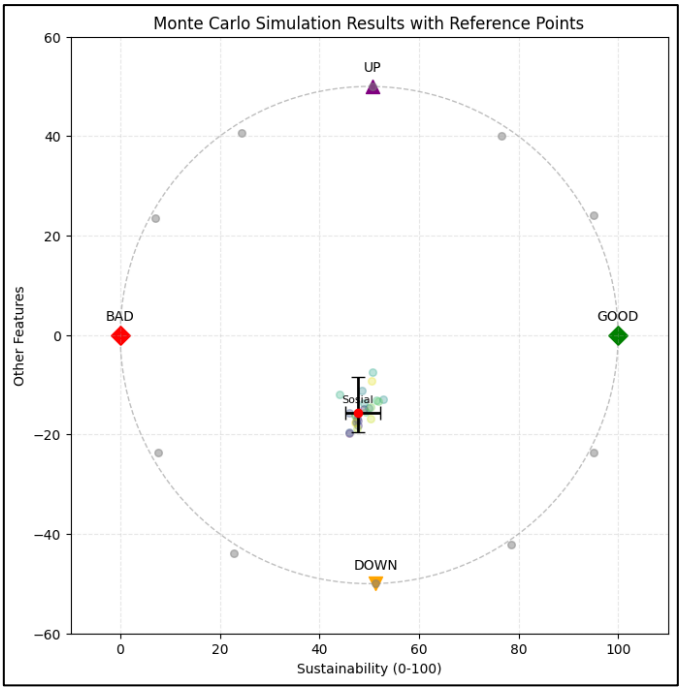

Fig. 8. Monte-Carlo analysis of social aspects.

3.3.4 Institutional aspects

The results of the MDS ordination analysis of institutional aspects, which include 6 (six) criteria as **Table 1** for the development of sustainable Ecotourism in Gili Matra MPA. The

results showed that, from an institutional perspective, the Gili Matra MPA has a fairly good sustainability value with an ordination value of 63.83, as shown in **Fig. 9**.

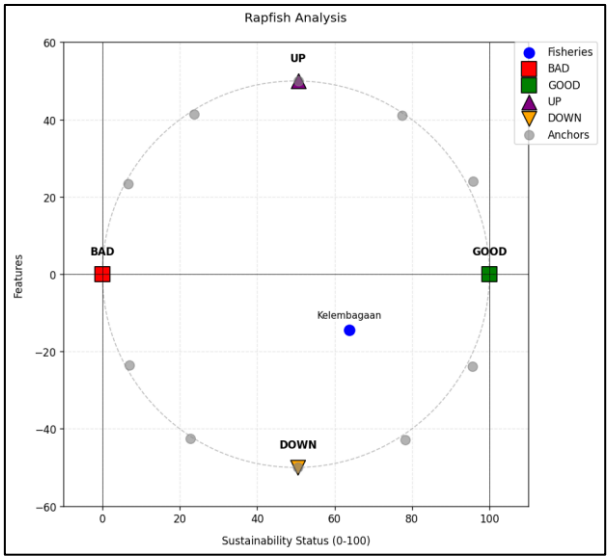

Fig. 9. Ordination results of institutional aspects.

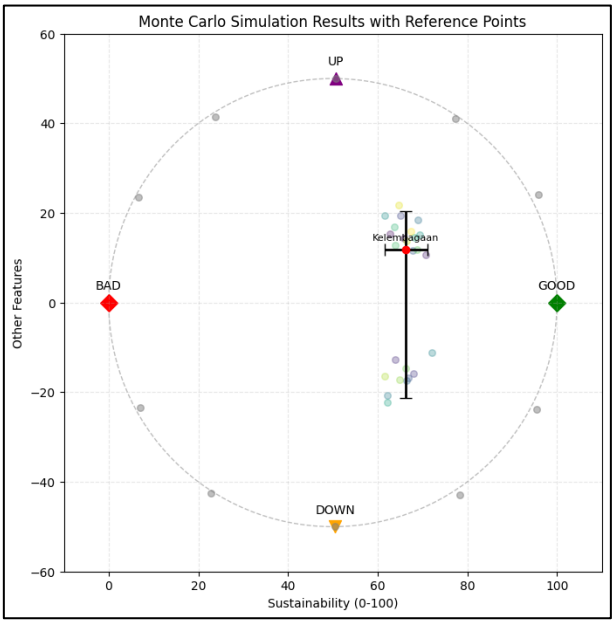

Fig. 10. Monte-Carlo analysis of institutional aspects.

The MDS ordination value was strengthened using Monte Carlo analysis as a validation technique for MDS analysis. The results of the Monte Carlo analysis showed that the resulting ordination value can be used to assess the sustainability index from an institutional perspective. The results of the Monte Carlo simulation with 25 repetitions were spread over a distance with a small difference in the value. This small difference in value indicates that the level of error in the analysis process can be avoided or minimized. The results of the Monte Carlo analysis for the institutional aspects are shown more clearly in **Fig. 10**.

3.3.5 Infrastructure aspect

MDS ordination analysis of infrastructure aspects, which includes 7 (seven) criteria as **Table 1** for the development of sustainable Ecotourism in Gili Matra MPA. The results showed that from the infrastructure aspect, Gili Matra MPA had a fairly good sustainability value with an ordination value of 58.32, as shown in **Fig. 11**.

The MDS ordination value was strengthened using Monte Carlo analysis as a validation technique for MDS analysis. The results of the Monte Carlo analysis show that the resulting ordination values can be used to assess the sustainability index from the infrastructure aspect. The results of the Monte Carlo simulation with 25 repetitions spread over a distance with a small difference in value. This small difference in value indicates that the level of error in the analysis process can be avoided or minimized. The results of the Monte Carlo analysis for infrastructure aspects are shown in **Fig. 12**.

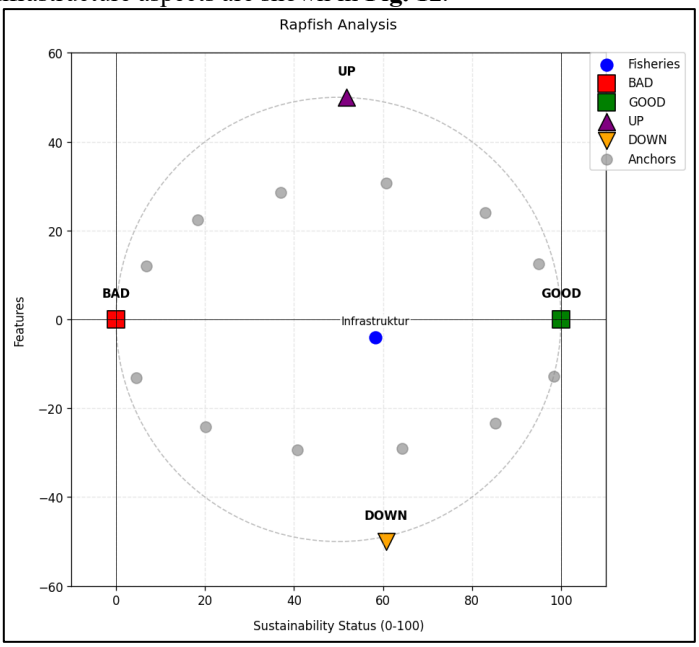

Fig. 11. Ordination result of infrastructure aspect.

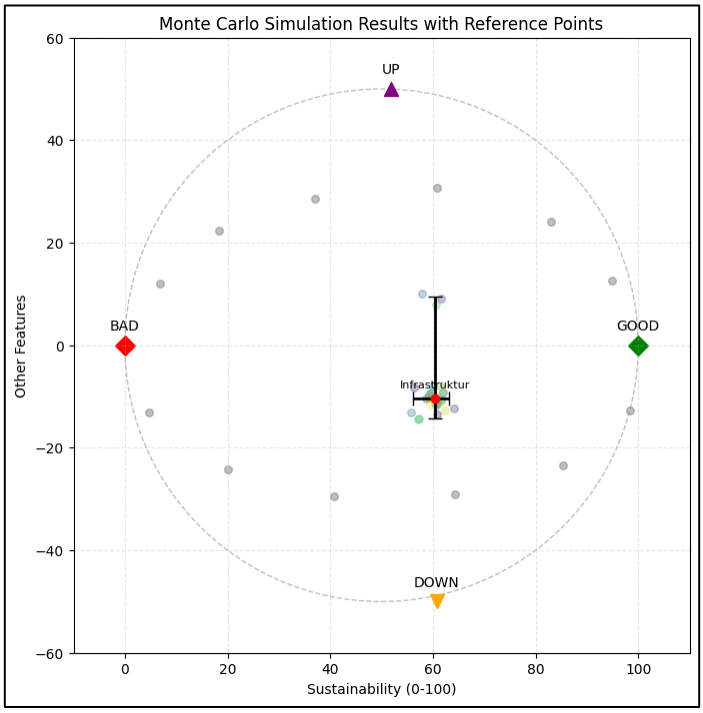

Fig. 12. Monte-Carlo analysis of infrastructure aspects.

The results of the sustainability analysis show that it met the goodness of fit and high confidence interval correlation. This can be seen from the statistical measurement of each dimension for r-squared ranging from 97.04% to 98.96%. The measurement of the stress value for each dimension ranged from 10.21% to 17.21%. Therefore, the size of the stress value for all dimensions met the statistically required criterion of less than 20%. The results of the statistical parameter measurements for each dimension are listed in **Table 7**. The sustainability status value of each aspect is then displayed in the form of a flyer diagram, as shown in **Fig. 13**.

Table 7. Sustainability index and statistical measurement of stress value and r-squared.

No	Aspect	Sustainability Value	Stress Value	R^2 (Squared Correlation)
1	Ecology	44.91	17.21%	97.04%
2	Economy	56.53	11.32%	98.72%
3	Social	45.26	12.04%	98.55%
4	Institutional	63.83	10.21%	98.96%
5	Infrastructure	58.32	11.83%	98.60%

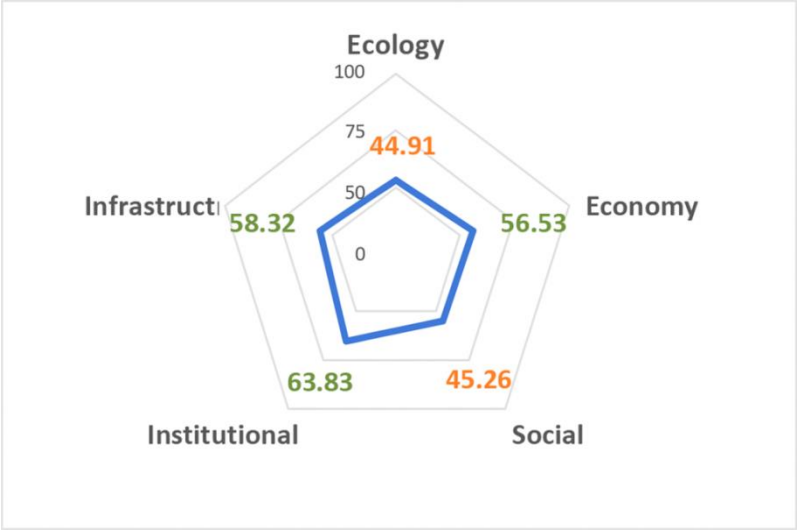

Fig. 13. Sustainability index value flyer diagram.

The sustainability index value in this study uses the MDS ordination value for each of the ecological, economic, social, institutional, and infrastructure aspects. Based on the results of the MDS ordination analysis, the sustainability index value was classified as moderately sustainable. The index values of institutional, infrastructure, and economic aspects are classified as sustainable, while the index value for ecological and social aspects is classified as less sustainable. This suggests that the government, through the management of the Gilimatra Marine Protected Area, needs to improve the ecological and social aspects to support sustainable ecotourism.

3.3.6 Results of analysis of leverage for factors sustainable ecotourism development

In this study, the results of the ordination analysis on the aspects with the smallest index value are used to determine which indicators are sensitive to further assessment of the results of the leverage analysis. A leverage analysis was used to identify the most sensitive attributes that influenced the sustainability index value in each aspect. Attributes with high sensitivity values can be the driving factors that determine the success of sustainable ecotourism development strategies in Gili Matra.

Based on the results of the MDS ordination analysis, the ecological aspect is the aspect of sustainability with the smallest value. Leverage analysis of ecological aspects shows that there are 4 (four) factors with the greatest sensitivity value as leverage factors for success in the implementation of ecotourism development in Gili Matra: (1) environmental degradation, (2) changes in small island landscapes, (3) increased waste and potential pollution, and (4) changes in the extent and condition of seagrass and coral reef ecosystems. These four factors are management priorities because the decline in ecological quality will directly impact the attractiveness of marine tourism; therefore, controlling them is a conservation policy priority. The results of the leverage analysis for ecological aspects are presented in **Fig. 14**.

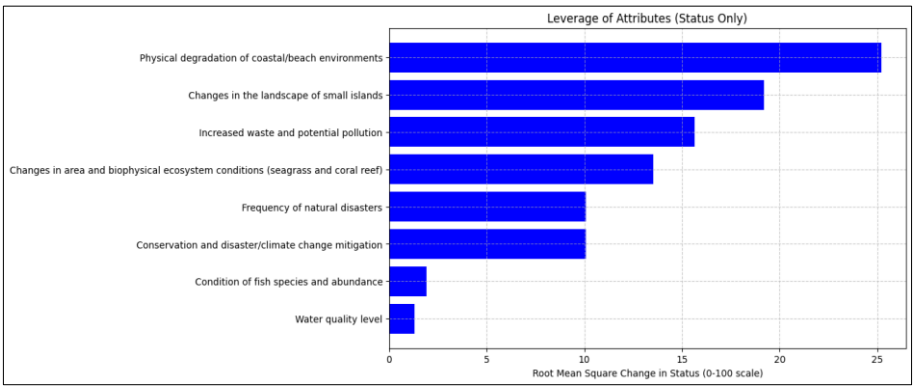

Fig. 14. Leverage analysis of ecological aspects.

The results of the leverage analysis on economic aspects show that there are 3 (three) main leverage factors in the successful implementation of mini-tourism development in Gili Matra: (1) labor absorption, (2) increase in local products, and (3) improvement of public infrastructure. These findings indicate that economic sustainability in the Gili Matra area is closely related to the capacity of local communities to participate actively in the tourism economic chain. The stronger the community involvement, the higher the distribution of economic benefits. The full results of the leverage analysis for the economic aspects are presented in **Fig. 1Fig**. 15.

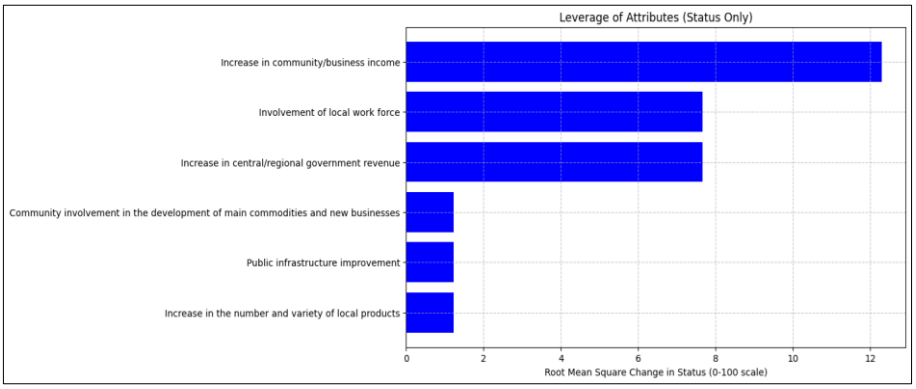

Fig. 15. Leverage analysis of economic aspects.

The results of the leverage analysis on social aspects show that there are 3 (three) leverage factors that most influence the successful implementation of ecotourism in Gili Matra: (1) circulation of drugs/other dangerous products, (2) community conflicts with tourists, and (3) conflicts over the use of marine space. This factor emphasizes the need to strengthen social and cultural regulations and encourage the creation of harmonization between communities, tourists, and business actors to minimize social friction. The full results of the leverage analysis for social aspects are presented in **Fig. 16**.

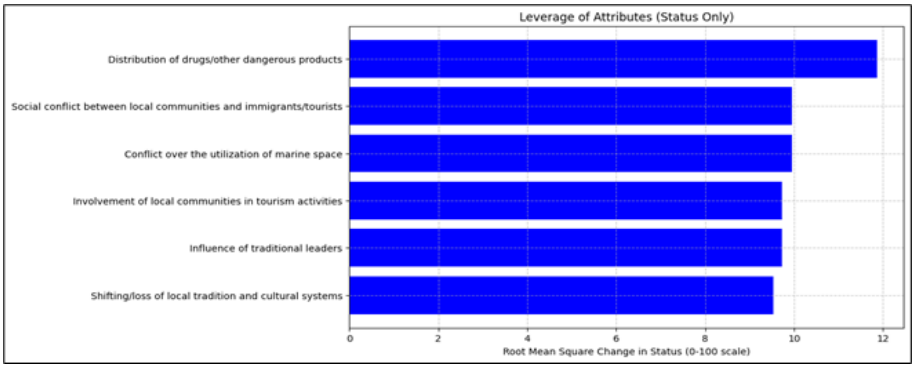

Fig. 16. Leverage analysis of social aspects.

The results of the leverage analysis on institutional aspects show that there are 2 (two) main leverage factors in the successful implementation of ecotourism development in Gili Matra: (1) coordination between stakeholders and the community and (2) ease of licensing services. These two factors are important because solid institutions will strengthen the effectiveness of conservation area management, while supporting the creation of a conducive tourism business climate. The full results of the leverage analysis for institutional aspects are presented in **Fig. 17**.

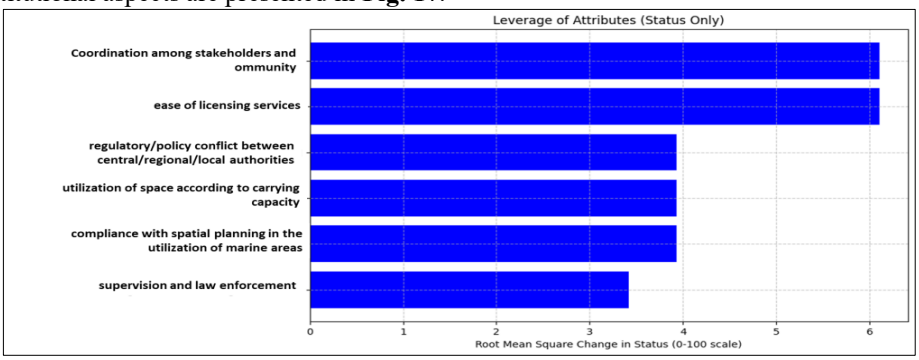

Fig. 17. Leverage analysis of institutional aspects.

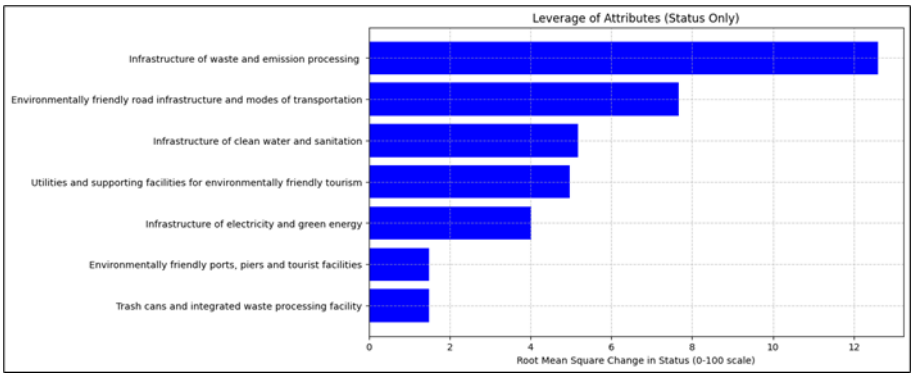

Fig. 18. Leverage analysis of infrastructure aspects.

The results of the leverage analysis on infrastructure aspects show that there are 2 (two) main leverage factors in the successful implementation of ecotourism development in Gili Matra: (1) waste and emission treatment infrastructure and (2) road infrastructure and

environmentally friendly modes of transportation. The presence of environmentally friendly infrastructure will not only improve the quality of tourism services but also preserve the carrying capacity of the ecosystem in the long term. The full results of the leverage analysis for the infrastructure aspects are presented in **Fig. 18**.

Based on the results of the leverage analysis of each aspect, the most influential factors in supporting the successful development of sustainable ecotourism in the Gili Matra MPA are (1) control of physical degradation of the coastal and beach environment, (2) waste and pollution management, (3) provision of waste and emission treatment infrastructure, (4) prevention of the circulation of hazardous products, (5) strengthening coordination between stakeholders, and (6) management of social conflicts between communities and tourists. This order of priority confirms the need for integrative policies that not only focus on economic aspects but also pay attention to ecological sustainability, social harmonization, and the effectiveness of institutional governance.

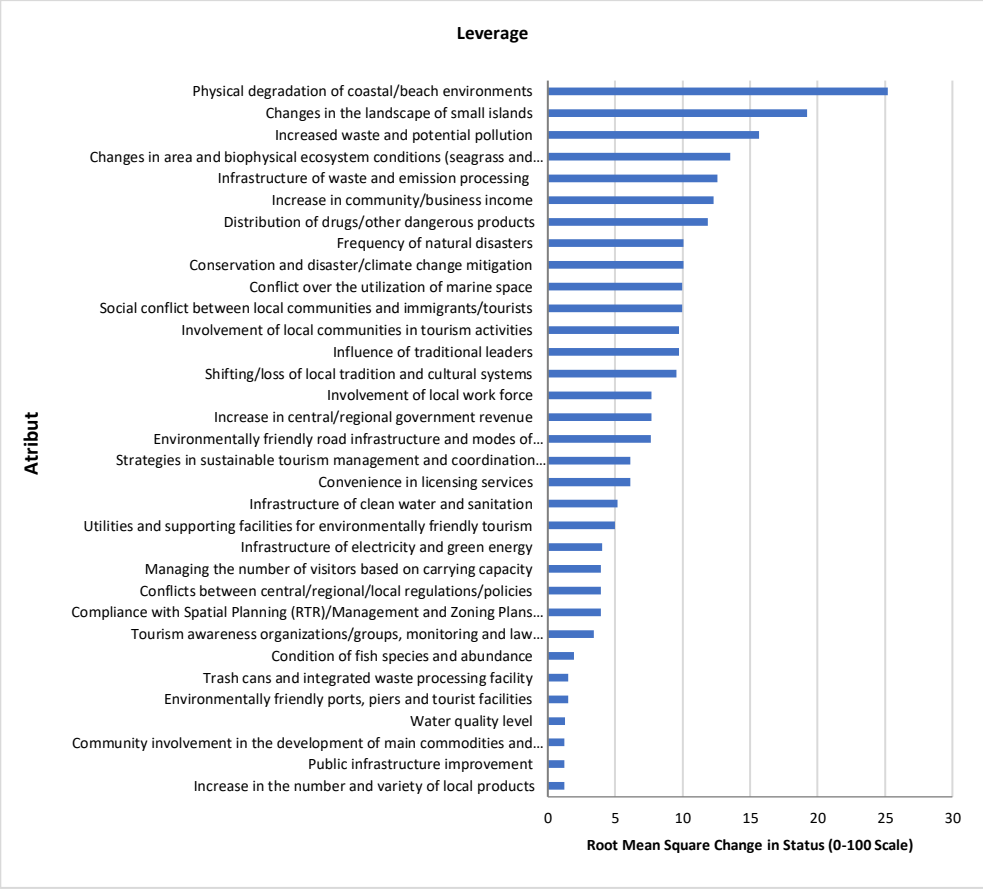

Fig. 19. Leverage analysis of priority leverage factors for the sustainable of ecotourism in Gili Matra.

4 Conclusions

Marine ecotourism in the Gili Matra Marine Tourism Park generates substantial economic benefits for both the local communities and the national economy. The Travel Cost Method (TCM) effectively captures the recreational value received by visitors, which exceeds their

actual expenses, indicating high tourist willingness to pay and strong destination attractiveness.

The sustainability assessment through the MDS approach shows that Gili Matra's ecotourism development is **moderately sustainable**, with relatively good performance in the institutional (63.83), infrastructure (58.32), and economic (56.53) dimensions. However, **ecological (44.91)** and **social (45.26)** aspects remain less sustainable and require greater attention. Key leverage factors influencing sustainability include coastal environmental degradation, small-island landscape changes, waste and pollution management, social conflict potential, inter-stakeholder coordination, and waste treatment infrastructure.

These findings emphasize that sustainable ecotourism success depends not only on economic potential, but also on maintaining ecological integrity and social harmony. Therefore, policy priorities should focus on the following:

1. **Ecological protection**: enforcing coral reefs, seagrass, and mangrove conservation; regulating visitor numbers; and improving waste and pollution management.
2. **Community-based social policies**: strengthening local participation, preserving cultural identity, and reducing resident–tourist conflicts.
3. **Institutional integration**: enhancing coordination among central, local, and conservation authorities, supported by NGOs, academia, and community groups.
4. **Green infrastructure development**: promoting eco-friendly energy, waste treatment, and sustainable transport systems.
5. **Local economic empowerment**: diversifying local products, supporting MSMEs, and increasing ecotourism-related employment.

Overall, the sustainable management of the Gili Matra MPA requires an **integrated, data-driven policy framework** that balances ecological conservation, social inclusion, institutional governance, and economic prosperity. Such evidence-based and collaborative governance is essential to ensuring the long-term resilience and sustainability of marine ecotourism in this region.

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