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# Sustainability impact analysis using information entropy to enhance Madura's rural tourism performance

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**Abstract.** Tourist villages in Indonesia have seen rapid development in recent years. The allure of natural beauty and traditional culture has motivated many tourists to visit tourist villages. This presents an opportunity for the Telaga Biru tourist village located on Madura Island to enhance its destination performance. This research aimed to develop strategies to improve the performance of the Telaga Biru tourist village, considering sustainable tourism indicators. The instruments used for measuring sustainable tourism performance comprised 14 indicators divided into four aspects: environmental, economic, social, and cultural. This study employed the Fuzzy Importance Performance Impact Analysis (FIPIA) and the Multi-Attribute Utility Theory (MAUT) method. The FIPIA method was used to identify indicators of improvement. The assessment of the indicators uses fuzzy numbers on three parameters, including the level of importance, performance, and the impact of indicators on achieving performance goals. Whereas, the MAUT method was used to rank improvement strategies. The results of this research indicate that six strategies are prioritized for improvement: creating social media accounts for destination (utility value of 0.46), offering ticket discounts (0.44), maintaining cleanliness and setting up a tourism monitoring center (0.38), regularly updating facilities and attractions (0.380), organizing cultural activities (0.33) and introducing unique attractions through batik practices (0.26). Therefore, the collaboration of all stakeholders involved in managing tourism villages will enhance the effectiveness of implementing this strategy.

## 1 Introduction

Indonesia is a country with numerous islands rich in natural resources that can become tourist attractions. This can significantly contribute to increasing income for both the country and local communities. Tourism plays a vital role in transforming the economy by providing opportunities for entrepreneurial activities and creating job opportunities [1].

Madura Island has attractive tourism potential, including historical, religious, natural, and cultural attractions. Madura is composed of four regencies: Bangkalan, Sampang, Pamekasan, and Sumenep. Often referred to as a hidden paradise, Madura boasts various tourism potentials, ranging from the western to the eastern tip of the island [2].

Bangkalan Regency is a regency in Madura and has a considerable number of tourist attractions, including natural, cultural, artificial, and religious tourism. Natural attractions in Bangkalan include Konang Natural Fire Tourism, Geger Mountain, Bidadari Dhurjan Waterfall, Galis Subdistrict Waterfall, Bumi Anyar Beach, Biru Beach, Plebunan Yellow Cave, Petapa Cave Beach, Maneron Beach, Rongkang Beach, Kemuning Siring Beach, Sepuluh Subdistrict Mangrove Forest, and Tlangoh Beach. Artificial attractions include Lighthouses, City Recreation Parks, Jaddih Chalk Hills, and Pelalangan. Cultural attractions include Bull Racing, the Bangkalan Museum, and Paseseh Batik Village. Religious tourism includes the Makam Air Mata Ibu, Sultan Abdul Kadirun Tomb, Syeichona Cholil Tomb, and Sunan Cendana Tomb. The abundance of tourist destinations in Bangkalan Regency attracts many domestic and international tourists.

In order to boost economic growth and create job opportunities in rural areas, the government is developing tourist villages in regions with tourism potential. The development of tourist villages also preserves the natural environment, resources, and cultural heritage of these villages. According to data from the Ministry of Tourism and Creative Economy (Kemenparekraf) in 2023, Indonesia has a total of 4,674 tourist villages spread across 38 provinces.

Tourist villages are tourism destinations whose development is centered around a village and involves local customs and traditions [3]. The development of tourist villages is carried out in villages that possess natural beauty, unique characteristics, and the cultural traditions of the local community. These characteristics become the hallmark of a village, making it suitable for tourism [4]. The development of village tourism can also encourage residents to preserve the natural environment and cultural traditions of their villages [5].

One such example is Biru Beach, managed by Telaga Biru Village in the Tanjung Bumi sub-district of Bangkalan. Biru Beach has been open to the public since

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2019. Previously, this area was a 2-hectare milkfish pond that had been abandoned for 16 years, but it has now been transformed into an attractive tourist destination. The head of Telaga Biru Village has tried to innovate by using the village's potential to increase the village's original income. With Biru Beach as a tourist destination, local people can be involved and employed in its development. Biru Beach employs a total of 18 staff members and has 35 individuals managing kiosks selling various food, beverages, and batik craft souvenirs [6].

At the end of the COVID-19 pandemic in 2022, the number of tourists increased beyond the targets set by the government. The number of foreign tourists visiting tourist attractions reached 5.5 million, surpassing the target of 1.8 to 3.6 million tourists. Meanwhile, the number of domestic tourists visiting tourist attractions has reached 800 million, exceeding the target of 550 million tourists [7]. Conversely, Telaga Biru tourist village experienced a decline in the number of tourists from 2021 to 2022, dropping from 28,228 to 8,736 visitors. Suboptimal management of the tourist sites directed to a decrease in the number of tourists. A lack of optimal management can be observed as the managers of Pantai Biru Beach failed to maintain the cleanliness and upkeep of the facilities. Furthermore, Biru Beach is still in the developmental stage, and thus, many of its facilities are not yet fully functional or complete. This results in dissatisfied tourists visiting Pantai Biru Beach.

Performance is a crucial aspect of tourism development. Performance is defined as the outcome of action or activity undertaken to complete a task [8]. Tourism performance can be considered good if the predetermined goals are achieved and sustainable. Sustainability refers to the preservation and authenticity of environmental, social, cultural, and economic conditions in the local area. Therefore, tourism development must use and maintain the sustainability of the environment, economy, society, and culture to ensure the continuity of tourism [9]. Sustainable tourism performance can positively impact the number of visitors, as good performance can increase tourist arrivals [10].

There are several criteria for sustainable tourism, including economic, social, environmental, and cultural sustainability. Economic sustainability involves enhancing the economic sector and its long-term implementation. Social sustainability refers to the role of stakeholders and local communities in the construction and development of sustainable tourism areas, highlighting their roles as supporting communities that encompass interaction, interrelation, and linkage. Environmental sustainability emphasizes the importance of considering the condition of natural resources for the development and advancement of sustainable tourism. Cultural sustainability concerns the preservation of a community's cultural heritage, which must be maintained [11].

Numerous studies have been conducted on performance measurement, including research using the FIPIA and MAUT methods. The FIPIA (Fuzzy Importance Performance Impact Analysis) method is an advanced version of the simpler IPA (Importance Performance Analysis) method. The inclusion of fuzzy numbers in the FIPIA minimizes the level of subjectivity among visitors when determining the priority of service indicators [12].

The multi-attribute utility theory (MAUT) is a method used to identify, measure, and evaluate multiple attributes of an organization [13]. The MAUT transforms various interests into numerical values on a scale of 0 to 1, where 0 represents the worst option and 1 represents the best option [14]. The final result of the MAUT method is a ranking order from the evaluation, identifying the choices of the decision-maker [15].

Based on the above discussion, this study aimed to determine strategies for improving sustainable tourism performance in Telaga Biru using FIPIA and MAUT methods.

## 2 Method

The object of this research was the Telaga Biru tourism village in Bangkalan Regency. Data collection was conducted using three methods: observation, interviews, and questionnaires. Observation was the initial step taken before conducting interviews and distributing questionnaires. Questionnaires were distributed to visitors to Telaga Biru Tanjung Bumi tourism village. The research flow is illustrated in Fig. 1.

This study utilized two types of data: primary and secondary data. Primary data were obtained from questionnaires distributed to tourists visiting the Telaga Biru Tanjung Bumi. The collected data were then analyzed using the FIPIA and MAUT methods.

### 2.1 FIPIA

The FIPIA (Fuzzy Importance Performance Impact Analysis) method is used to evaluate service attributes by employing fuzzy numbers across three parameters: the level of importance, the performance achieved, and the impact of attributes on the achievement of business objectives [12]. This method is an advancement of the IPA (Importance Performance Analysis) method. Although IPA uses only simpler parameters, namely the level of importance and the performance of the service attributes, FIPIA incorporates the impact of the attributes. The use of fuzzy numbers addresses responder subjectivity in decision-making [16]. The use of fuzzy numbers in this method is implemented as follows:

$$Deff_{ij}^{imp} = \frac{i_{ij+2}m_{ij+}u_{ij}}{4} \quad (1)$$

$$p_{kj} = \frac{x_{kj}}{\sum_{k=1}^{t} x_{kj}}, j=1,\ldots,m \; ; k=1,..,t \quad (2)$$

$$Ej = -\frac{1}{In\,(t)}\sum_{k}^{t} = 1\,(PkjlnPkj)\; k=1..,t \; ; \; j=1,.,m \quad (3)$$

$$Impact_j = \frac{E_j}{\sum_{j=1}^{m} Ej} \;, j=1,\ldots,m \quad (4)$$

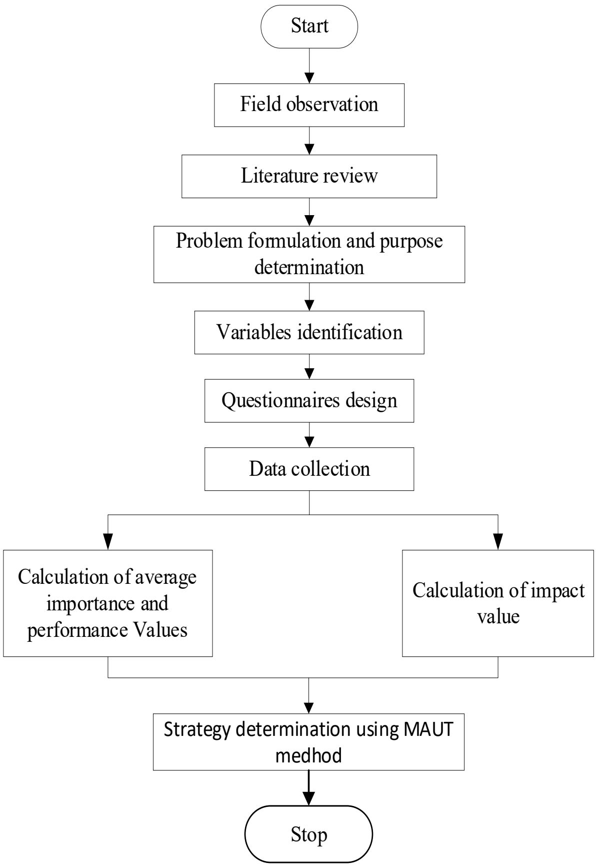


**Fig. 1.** The steps of research.

### 2.2 Multi-Attribute Utility Theory (MAUT)

According to [13], the MAUT (Multi-Attribute Utility Theory) method is utilized in decision-making to identify, measure, and evaluate multiple attributes of an organization. MAUT enables decision-makers to simplify a complex problem into a straightforward hierarchy and aims to evaluate various qualitative and quantitative factors based on existing uncertainties. This method can be used when decision-makers should select an alternative decision from several options, which are evaluated based on multiple criteria or attributes. The steps involved in the MAUT method are as follows:

1. Decompose the decision into different dimensions.
2. Determine the importance weights for each criterion.
3. List all alternatives.
4. Calculate the utility of each alternative according to its attributes using the appropriate equation. (5)

$$U(x) = \frac{x - xi^-}{xi^+ + xi^-} \tag{5}$$

Annotation:
$U(x)$ = Normalization of the weight of alternative x
$x$ = Alternate weight
$xi^-$ = Worst weight of the Xth criterion
$xi^+$ = Best weight of the Xth criterion

### 2.3 Research Variables

The research variables used in this study comprise four variables: environmental, cultural, economic, and social. The variables used in this study are presented in the following Table 1.

**Table 1.** Sustainable tourism indicators.

| Variables | Indicator | Literature |
|---|---|---|
| Environmental | Maintaining destination environment | [14] |
| | Health and safety | [15] |
| | Availability of clean water sources | [1] |
| | Waste management | |
| | A ride made using environmentally friendly materials | [15] |
| Culture | Local cultural information | [15] |
| | Access to traditional culture | |
| | Protecting artistic heritage | |
| Economy | The level of attractiveness of a destination compared to similar destinations | [1] |
| | Job opportunities | [14] |
| | Tourism promotion | [15] |
| Social | Tourist activities | [14] |
| | Local community activities | |
| | Stakeholder role | |

## 3 Results and Discussion

### 3.1 Analysis of FIPIA

The initial step toward enhancing sustainable tourism performance was to use the FIPIA analysis method. The results of visitor assessments regarding importance and performance were averaged, and expert evaluations were used to calculate impacts, as shown in Table 5. The expert evaluations were converted into triangular fuzzy numbers. For example, if Expert 1 assigns a value of 2 (disagree) to the indicator "environmental maintenance of the destination," this value was converted using a triangular fuzzy number to (1, 2, 3). The results of converting expert evaluations were presented in Table 2.

**Table 2.** The results of the expert performance assessment conversion.

| **Experts** | **Indicator** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **X1** | **X2** | **X3** | **…** | **X6** | **X7** | **X8** |
| 1 | (1,2,3) | (2,3,4) | (1,2,3) | … | (3,4,5) | (1,2,3) | (1,2,3) |
| 2 | (2,3,4) | (2,3,4) | (2,3,4) | … | (3,4,5) | (3,4,5) | (3,4,5) |
| 3 | (3,4,5) | (2,3,4) | (2,3,4) | … | (3,4,5) | (3,4,5) | (3,4,5) |
| 4 | (2,3,4) | (2,3,4) | (2,3,4) | … | (2,3,4) | (2,3,4) | (2,3,4) |
| 5 | (2,3,4) | (3,4,5) | (2,3,4) | … | (2,3,4) | (3,4,5) | (3,4,5) |

The results of the conversion of expert evaluations are defuzzified using equation (1). The defuzzification results are presented in Table 3. Subsequently, normalization of the values was performed using equation (2).

**Table 3.** Defuzzification results of expert performance assessment.

| **Experts** | **Indicator** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **…** | **12** | **13** | **14** |
| 1 | 2 | 3 | 2 | … | 4 | 2 | 2 |
| 2 | 3 | 3 | 3 | … | 4 | 4 | 4 |
| 3 | 4 | 3 | 3 | … | 4 | 4 | 4 |
| 4 | 3 | 3 | 3 | … | 3 | 3 | 3 |
| 5 | 3 | 4 | 3 | … | 3 | 4 | 4 |

The normalization results are presented in Table 4. The following normalization, the information entropy was calculated using Equation (3). The impact values for each indicator were then calculated using Equation (4).

**Table 4.** The normalization results of expert performance assessment.

| Experts | Indicator | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | … | 12 | 13 | 14 |
| 1 | 0.133 | 0.188 | 0.143 | … | 0.222 | 0.118 | 0.118 |
| 2 | 0.200 | 0.188 | 0.214 | … | 0.222 | 0.235 | 0.235 |
| 3 | 0.267 | 0.188 | 0.214 | … | 0.222 | 0.235 | 0.235 |
| 4 | 0.200 | 0.188 | 0.214 | … | 0.167 | 0.176 | 0.176 |
| 5 | 0.200 | 0.250 | 0.214 | … | 0.167 | 0.235 | 0.235 |

The impact assessment results from the expert evaluations are shown in Table 5. The impact value is assessed by comparing the value of the information entropy results for each indicator with the total value of the indicator's information entropy. The average performance value of first indicator was 3.10, the expected value was 4.65, and the impact value of the expert views was 0.0716.

**Table 5.** Performance level, importance and impact assessment.

| Code | Indicator | Average | | |
|---|---|---|---|---|
| | | Performance | Importance | Impact |
| X1 | Maintaining the destination environment | 3.10 | 4.65 | 0.0716 |
| X2 | Health and safety | 3.16 | 4.52 | 0.0719 |
| X3 | Availability of clean water sources | 3.61 | 4.60 | 0.0719 |
| X4 | Waste management | 3.73 | 4.59 | 0.0706 |
| X5 | A ride made from environmentally friendly local materials | 3.84 | 4.47 | 0.0719 |
| X6 | Local cultural information | 3.09 | 4.42 | 0.0712 |
| X7 | Access traditional culture | 3.33 | 4.23 | 0.0711 |
| X8 | Protection of artistic heritage | 3.37 | 4.44 | 0.0719 |
| X9 | The level of attractiveness of a destination compared to similar destinations | 3.11 | 4.53 | 0.0705 |
| X10 | Job opportunities | 3.78 | 4.58 | 0.0713 |
| X11 | Tourism promotion | 3.01 | 4.52 | 0.0716 |
| X12 | Tourist activities | 3.77 | 4.56 | 0.0719 |
| X13 | Local community activities | 3.88 | 4.32 | 0.0713 |
| X14 | Stakeholder role | 3.58 | 4.33 | 0.0713 |

## 3.2 The FIPIA mapping results

The average performance and importance values and impact values are mapped onto a Cartesian diagram. To minimize measurement errors, the median value was selected during mapping [19]. The mapping diagram of the FIPIA analysis results consists of three sections: a diagram of performance and importance levels, as shown in Fig. 2; an impact vs. performance diagram for attributes with high expectation levels, as shown in Fig. 3; and an impact vs. performance diagram for attributes with low expectation levels, as shown in Fig. 4.

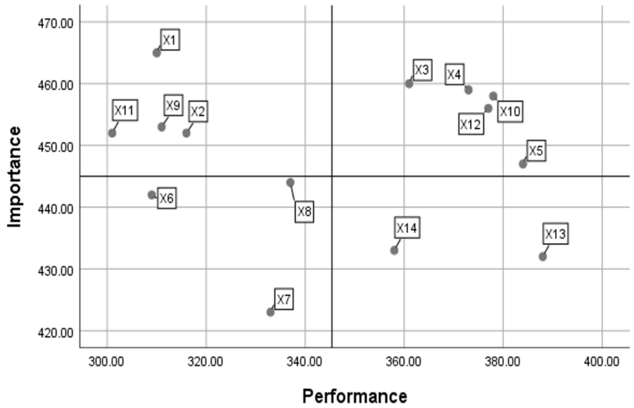


**Fig. 2.** Diagram of performance and importance.

Based on Fig. 2, the results of the Cartesian diagram mapping consist of four quadrants. The first quadrant has high expectations but low performance, consisting of indicators $X_1$, $X_2$, $X_9$, and $X_{11}$. The second quadrant has high expectations and high performance, consisting of indicators $X_3$, $X_4$, $X_{10}$, and $X_{11}$. Quadrant three has low expectations and low performance, consisting of indicators $X_6$, $X_7$, and $X_8$. Quadrant four has low expectations and high performance, consisting of indicators $X_5$, $X_{13}$, and $X_{14}$. The performance expectation mapping will identify both high and low performing individuals.

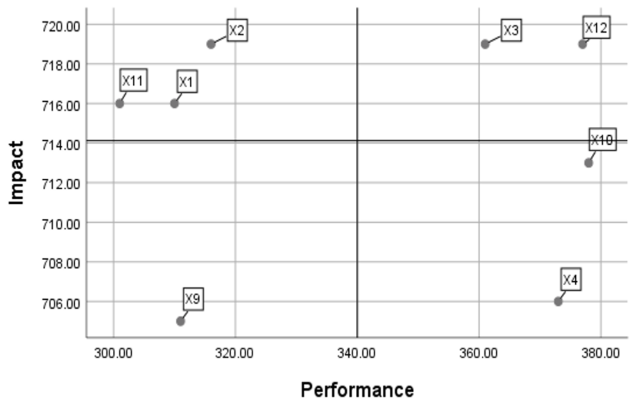


**Fig. 3.** Diagram of impact and performance with high expectations.

The results of the Cartesian diagram mapping comprise two categories: indicators with a high impact and indicators with a low impact shown in Fig. 3. The indicators with a high impact are located in quadrants one and two, comprising of indicators $X_1$, $X_2$, $X_3$, $X_{11}$, and $X_{12}$. Indicators with a low impact are located in quadrants three and four, comprising of indicators $X_4$, $X_9$, and $X_{10}$.

In the following Fig. 4, the results of the Cartesian diagram mapping consist of two-types: indicators with high and low impact. Indicators with high impact are in quadrants one and two, consisting of indicators $X_8$ and $X_5$. Indicators with low impact are in quadrants three and four, consisting of indicators $X_6$, $X_7$, $X_{13}$, and $X_{14}$.

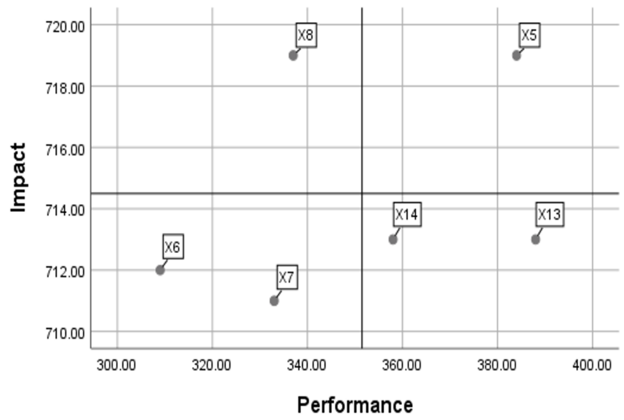


**Fig. 4.** Diagram of impact and performance with low expectations.

Enhancing tourism performance should prioritize the allocation of resources based on the most crucial indicators [20]. Based on the mapping results, it is possible to identify the indicators that require improvement. The summarized results of the mapping are presented in Table 6.

**Table 6.** The results of performance, importance, and impact mapping.

| code | Importance | Performance | Impact |
|---|---|---|---|
| X1 | High | Low | High |
| X2 | High | Low | High |
| X3 | High | High | High |
| X4 | High | High | Low |
| X5 | Low | High | High |
| X6 | Low | Low | Low |
| X7 | Low | Low | Low |
| X8 | Low | Low | High |
| X9 | High | Low | Low |
| X10 | High | High | High |
| X11 | High | Low | High |
| X12 | High | High | High |
| X13 | Low | High | Low |
| X14 | Low | High | Low |

The mapping results identified four indicators that needed improvement: environmental maintenance of the destination, health and safety, attractiveness of the destination compared to similar destinations, and tourism promotion. Four indicators were identified for strategic development to be implemented by the management of the Telaga Biru tourist village. The quality of a destination is crucial for attracting tourism output, such as the number of visitors and the amount of money spent [21].The result is six strategies: (1) Regular maintenance of facilities and attractions, especially repairing those that are starting to deteriorate, (2) maintenance of cleanliness and establishing a tourism monitoring post, (3) Adding new attractions that are not available at similar destinations, (4) Organizing traditional cultural events at the destination, such as creating Batik, (5) Creating social media accounts for the destination, and (6) Offering vouchers with every ticket purchase. Management should adapt to attract tourists. Tourists exhibit various backgrounds, characteristics, needs, and goals, which influence their choice of destinations. Therefore, developing an appropriate strategy to improve tourism performance is crucial [22].

### 3.3 Analysis of MAUT

MAUT analysis is a simple method of decision-making. This method's decision-makers calculate the utility value of each strategy [23]. This method's input comprises six improvement strategies generated from the prior analysis. These six strategies were reviewed through interviews with management regarding costs, length, and infrastructure readiness, as well as their perspectives on the relevance of improving these metrics. The results of the interviews with management are presented in Table 7.

**Table 7.** Decision index value

| Strategy | Criteria | | | |
|---|---|---|---|---|
| | Cost | Time | Infrastructure | Expert opinion |
| 1 | 0.67 | 0.55 | 0.59 | 1 |
| 2 | 1.00 | 0.64 | 0.45 | 1 |
| 3 | 0.67 | 0.55 | 0.31 | 1 |
| 4 | 0.67 | 0.64 | 0.45 | 1 |
| 5 | 1.00 | 0.91 | 0.59 | 1 |
| 6 | 1.00 | 0.55 | 0.59 | 1 |

The results from the interviews were used to assess maximum and minimum values for each alternative across all criteria. Following this, normalization calculations were performed using equation (5). Normalization involves changing the scale of data of different dimensions to a uniform scale. Matrix normalization is performed by comparing the worst and best alternative weights. Before performing the normalization stage, determine each criterion's maximum and minimum values. The normalization results are presented in Table 8.

**Table 8.** Normalizing decision values

| Strategy | Criteria | | | |
|---|---|---|---|---|
| | Cost | Time | Infrastructure | Expert opinion |
| 1 | 0.00 | 0.00 | 0.31 | 1.00 |
| 2 | 0.20 | 0.08 | 0.15 | 1.00 |
| 3 | 0.00 | 0.00 | 0.00 | 1.00 |
| 4 | 0.00 | 0.08 | 0.15 | 1.00 |
| 5 | 0.20 | 0.30 | 0.31 | 1.00 |
| 6 | 0.20 | 0.00 | 0.31 | 1.00 |

The normalized values were then multiplied by the weights assigned to each criterion and summed for each indicator to determine the ranking of each indicator. The ranking results for each indicator are presented in Table 9.

**Table 9.** Strategic decision ranking

| Strategy | Criteria | | | | Total | Rank |
|---|---|---|---|---|---|---|
| | Cost | Time | Infrastructure | Expert opinion | | |
| 1 | 0.000 | 0.000 | 0.120 | 0.260 | 0.38 | 4 |
| 2 | 0.055 | 0.005 | 0.060 | 0.260 | 0.38 | 3 |
| 3 | 0.000 | 0.000 | 0.000 | 0.260 | 0.26 | 6 |
| 4 | 0.000 | 0.005 | 0.060 | 0.260 | 0.33 | 5 |
| 5 | 0.055 | 0.021 | 0.120 | 0.260 | 0.46 | 1 |
| 6 | 0.055 | 0.000 | 0.120 | 0.260 | 0.44 | 2 |

According to MAUT analysis, these six strategies are ranked in order. Strategies 5, 6, and 2 yield the maximum utility values. Strategy five had the highest utility value of 0.46, strategy two had the lowest utility value of 0.38, and strategy six had an intermediate value of 0.44. The key resources required to deliver quality destination experiences are simultaneously being considered [24]. In addition, investigations into tourists' perceptions of sustainable tourism initiatives are limited [25]. These empirical findings serve as a foundation for developing novel tourism destination strategies.

## 4 Conclusion

Sustainable tourism development is a tourism concept that can have long-term impacts on all local communities' present and future environmental, social, cultural, and economic conditions. This concept follows the direction of developing tourist villages. The concept behind developing tourist villages is to transform them into popular tourist destinations by integrating natural and cultural attractions, providing comprehensive public tourism services, and ensuring convenient accessibility while preserving traditional village community life.

To enhance the performance of the Telaga Biru tourist village, an investigation was conducted on 14 indicators of sustainable tourism. Furthermore, the assessment of the indicators uses fuzzy numbers on three parameters, including the level of importance, performance, and the impact of indicators on achieving performance goals. Based on the mapping results, four indicators were produced as priority indicators for improvement: maintenance of the destination environment, health and safety, destination attractiveness compared to similar destinations, and tourism promotion. According to the following criteria: cost, time, infrastructure, and expert opinion, six consecutive strategies were needed to conduct the performance improvement programs. Based on the research findings, the recommended strategies for enhancing sustainable tourism performance in Telaga Biru include creating a social media account, offering ticket discounts, maintaining cleanliness and setting up a tourism monitoring centre, regularly updating facilities and attractions, organizing cultural activities and introducing unique attractions through batik practices.

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