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Full Length Research Article

Jurang Jero Nature Tourism Object in Indonesia: Is it Sustainably Managed?

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ABSTRACT

Community-based tourism has become an alternative sustainable development strategy that enhances local livelihoods while promoting forest conservation, especially in areas where resource use is limited. This study used a five-dimensional framework, including ecological, economic, social, nature tourism services, and institutional dimensions, to assess the sustainability status of the Jurang Jero Nature Tourism Object's management. Field observations and respondent interviews were used to gather primary data, which was then analyzed using a rapid appraisal technique for fisheries (Rapfish) modified for Rap-tourism. The results show that management of the Jurang Jero Nature Tourism Object is moderately sustainable, reflecting balanced performance across ecological, economic, social, institutional, and nature tourism service dimensions. Even though the ecological and social dimensions are comparatively strong, more advancements in nature tourism and economic dimensions are required. Improving sustainability and promoting advancement require increased cooperation between stakeholders. Recommended strategies include strengthening human resource capacity through targeted training, developing environmentally sustainable tourism infrastructure, and improving the quality of tourism services and attractions through corporate social responsibility initiatives.

1. Introduction

National parks are conservation areas that aim to protect biodiversity, especially flora and fauna whose natural habitat has been disturbed (MacKinnon et al. 2020; Marselle et al. 2019). National park management needs attention, especially in the preservation of biodiversity, to maintain the function of forests as controllers of climate change impacts (Reindrawati et al. 2022). The high ecological, economic, and social value of national parks has led many stakeholders to play a role in management activities (Sutata et al. 2023). One activity in the national park is community-based tourism, which prioritizes conservation values and community involvement through responsible utilization.

Nature tourism is an integral aspect of managing national parks (Wiratno et al. 2022), as it serves as a bridge between economic development and biodiversity conservation within communities (Anggraini and Gunawan 2021; Asih and Nugroho 2025). This is supported by the position of IUCN (2022) that community participation in nature tourism activities to achieve

economic improvement is a secondary goal of national park management, while the main objective is biodiversity conservation. Moreover, nature tourism supports the Sustainable Development Goals (SDGs), specifically SDG 1 (End Poverty), SDG 2 (Zero Hunger), and SDG 8 (Decent Work and Economic Growth) (Khalili et al. 2020). The situation led to the definition of community-based tourism (CBT) as a form of empowerment implemented by managers to ensure community participation in nature tourism management (Yanes et al. 2019). The process is also expected to provide economic benefits to the community and to support environmental conservation (Hanum et al. 2018; Madjid et al. 2025).

Nature tourism emphasizes aspects of tourism and is considered more complex due to its relationship with the surrounding community and managers' ability to manage resources (Reindrawati et al. 2022). Sustainable nature tourism is defined as tourism activities that are economically profitable and do not require sacrificing the value of resources comprising biophysical components and the community in the future (Sørensen and Grindsted 2021). When nature tourism is not sustainably managed, it can lead to significant environmental degradation (land-use changes and garbage accumulation), local community disruption (reduced social equity and cultural erosion), and economic disparities (Baloch et al. 2023; Hasan et al. 2025; Utama et al. 2024). Several studies have examined sustainability in tourism across various regions (Abdillah et al. 2023; Sambou et al. 2019; Sukuryadi et al. 2021; Sutata et al. 2024), commonly assessing sustainability through ecological, economic, social, and institutional dimensions. Therefore, this study assessed sustainable nature tourism across ecological, economic, social, and institutional dimensions, in line with previous studies.

The Jurang Jero Nature Tourism Object (JJNTO) is a management permit granted to communities living near forests, allowing them to actively participate in forest management activities. Mount Merapi National Park is developing JJNTO to reduce interactions and dependence among communities living near forests, especially through sand mining activities that negatively impact ecological aspects (Sulaksono and Hadiyan 2015). The management of JJNTO must be sustainable to ensure that economic and ecological benefits are not disrupted. Otherwise, there is a concern that the community will return to sand mining in Mount Merapi National Park as their main source of income. The ideal condition is expected to occur as described in the study by Fattah et al. (2023), in which the community, which previously used resources without considering sustainability, changes its habits to become very concerned about resource sustainability.

Several studies have evaluated the sustainability of various nature tourism destinations in Indonesia, but none have focused on JJNTO. Therefore, this study aimed to assess the sustainability index of JJNTO and determine the contribution of each assessment dimension. The results of this study will provide information on the current state of JJNTO management with respect to its sustainability. Managers can use this information to improve dimensions that have not yet achieved maximum scores. Furthermore, managers must ensure the preservation of biodiversity and the continuous reduction of community sand mining activities.

2. Materials and Methods

2.1. Description of Study Area

JJNTO is located in Srumbung Sub-District, Magelang Regency, Central Java, Indonesia (**Fig. 1**). The site lies on the southwestern slope of Mount Merapi, one of Indonesia's most active volcanoes (Chasanah and Sakakibara 2022). Designated as part of the MMNP utilization zone, the JJNTO area covers 93.93 ha, or about 11.80% of the Srumbung Resort's management area.

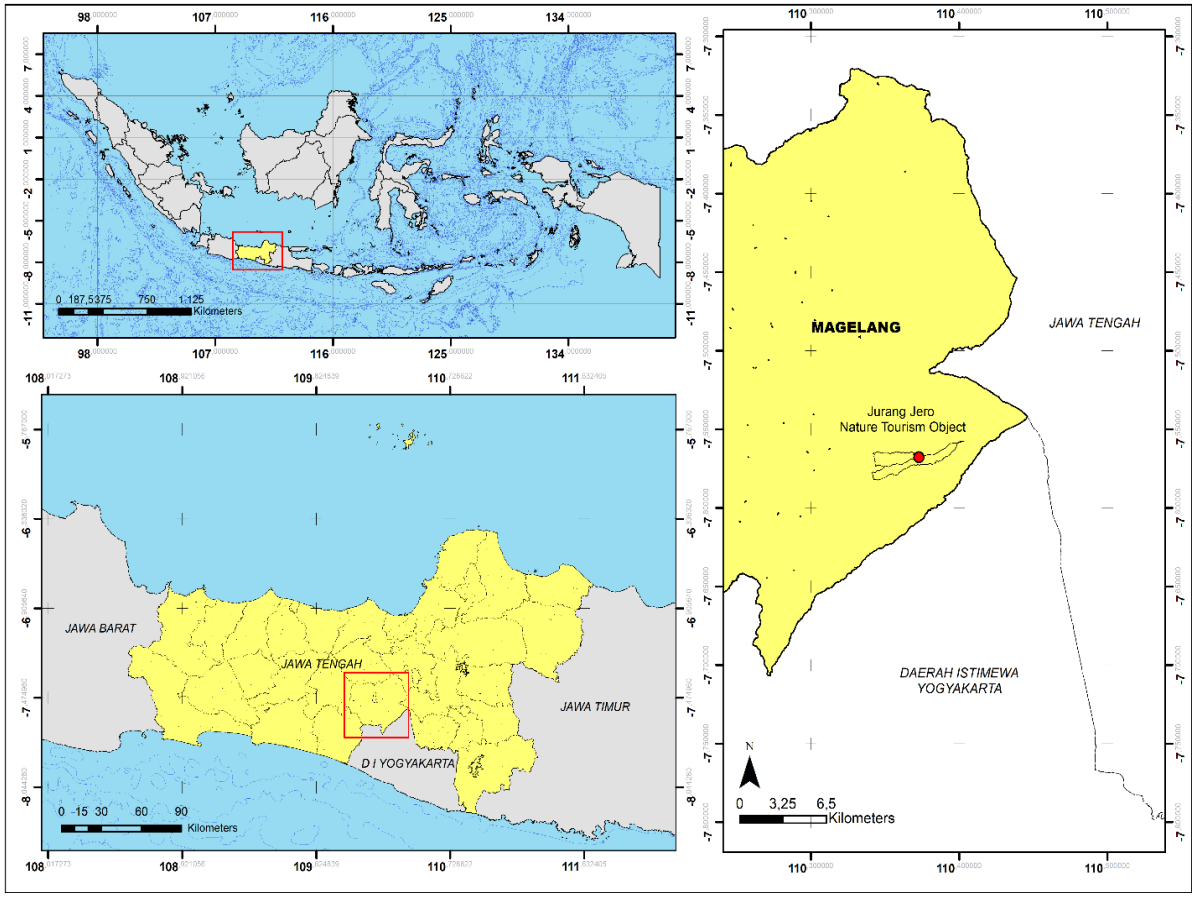

Fig. 1. Study map.

JJNTO was chosen as the study site based on several considerations. In 2021, the Indonesian Ministry of Tourism and Creative Economy awarded the region a Certificate of Cleanliness, Health, Safety, and Environmental Sustainability (CHSE). The CHSE certificate provides tourists with crucial assurance that the destination is clean, safe, and compliant with sustainable tourism principles (Purwaningsih et al. 2022). Furthermore, JJNTO operates under a Community-Based Tourism (CBT) model, in which officially sanctioned business licenses enable local communities to manage nature tourism actively. The JJNTO is a valuable case for assessing the sustainability of nature-based tourism within a conservation context because of its participatory approach, which demonstrates how conservation goals are integrated with local economic empowerment.

2.2. Population and Sample

The population of this study consisted of tourists, the community, and JJNTO operators. The number of respondents was determined in accordance with the principles of sustainability and

sufficiency. The focus was not on the quantity but on the completeness of the data and information obtained from respondents (Putra et al. 2023). The process resulted in the selection of 30 JJNTO tourists, 14 buffer-village communities, and 8 JJNTO operators as respondents. Tourists were selected through accidental sampling based on criteria including visiting JJNTO, meeting the study team by chance, and being over 17 years old. The respondents from the community were selected through purposive sampling with the criteria: (1) living around JJNTO, (2) over 17 years old, and (3) conducting regular activities related to JJNTO. Moreover, the operators were selected through purposive sampling with a focus on active participation in the management of JJNTO.

2.3. Data Collection

A combination of primary and secondary data was collected in this study. Primary data were obtained through a series of field observations, interviews, and questionnaires distributed at JJNTO from July to August 2022. Meanwhile, secondary data were collected from trusted sources, such as management plan documents and annual performance reports, with a focus on planting activities, forest resource inventory, and protection systems for the ecological dimension. The others include economic programs for the local community (economic dimension), the number of visitors to JJNTO (nature tourism service dimension), and training programs for operators (institutional dimension). The blending of primary and secondary data was aimed at obtaining more complex and reliable information that described actual conditions.

The JJNTO sustainability index was determined based on five dimensions: ecological, economic, social, nature tourism services, and institutional. Each dimension consists of attribute components that range from 6 to 10, as presented in **Fig. 2**. Moreover, each attribute was in the range of 0-3, where 0 represented poor, and 3 represented good, and had 4 options to avoid providing a middle or neutral value and ensure the response tended towards a specific side.

2.4. Data Analysis

Data were analyzed using the multidimensional scaling (MDS) method with the rapid appraisal technique for evaluating fisheries sustainability (Rapfish) analysis software, modified to the rapid appraisal technique for evaluating tourism sustainability (Rap-tourism). MDS is a statistical method that simplifies complex datasets by converting multidimensional information into a lower-dimensional representation (Saputro et al. 2023). Moreover, Rap-tourism analysis has the advantage of accelerating information gathering in determining sustainability status through participatory activities, supported by visualization to facilitate stakeholder understanding in decision-making (Sutata et al. 2024).

The MDS method has two stages of analysis, including 1) leverage and 2) Monte Carlo. A leverage analysis was conducted using root mean square (RMS) values to identify sensitive attributes across the ecological, economic, social, nature tourism services, and institutional dimensions. This was based on the condition that the attribute in a dimension with the highest RMS value was sensitive. Moreover, a higher RMS value for an attribute in a dimension indicates a greater role in influencing the sustainability index (Putri et al. 2022). In this study, the highest, one or two, RMS value of each dimension was the point when the operators needed to take further action. More specifically, improving or optimizing sensitive attributes can enhance a sustainability index (Putri et al. 2022).

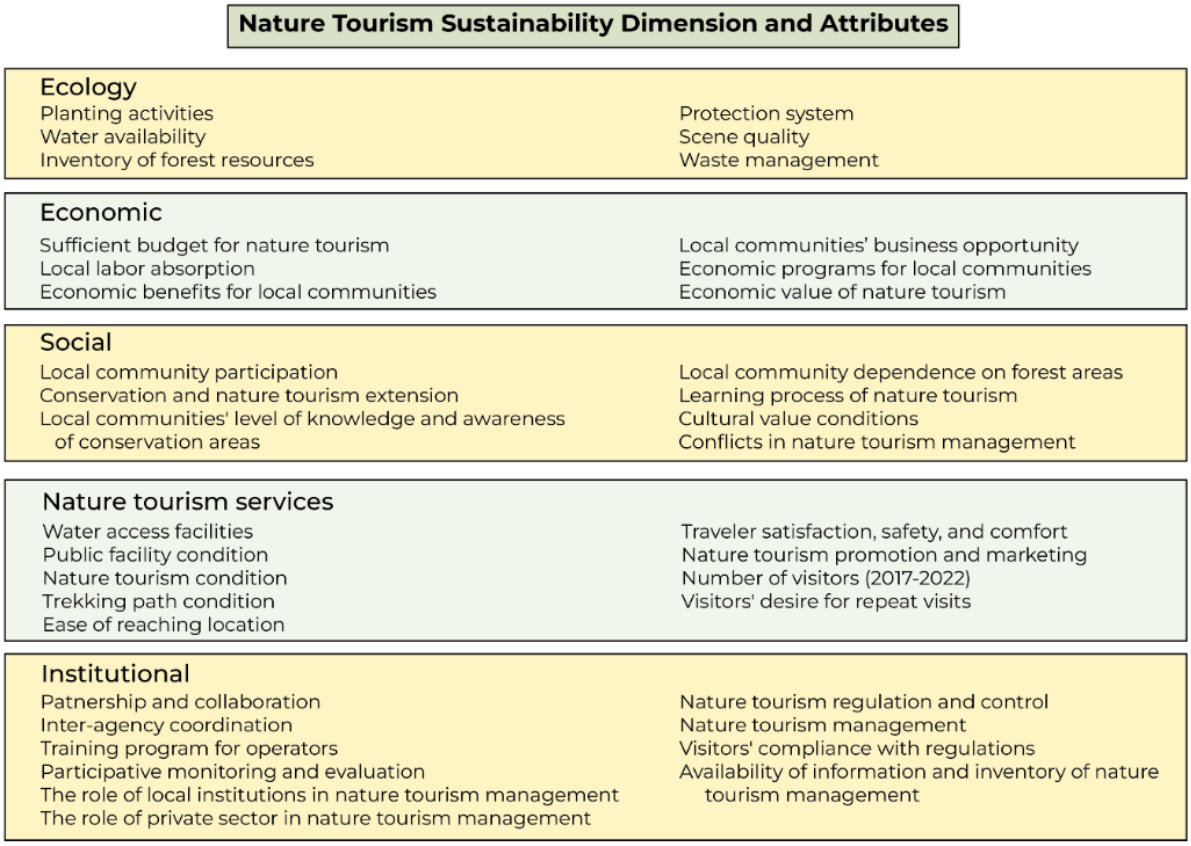

Fig. 2. JJNTO sustainability dimensions and attributes.

Monte Carlo is an estimate of the effect of errors in the analysis process with a 95% confidence interval (Abdillah et al. 2023). The assessment of ecotourism sustainability index in Rap-tourism ranges from 0–100%, with values < 50% indicating unsustainability and values > 50% indicating sustainability (Suharno et al. 2019). The sustainability index category of nature tourism management is comprehensively divided into four categories in **Table 1**.

Table 1. Categories of sustainability index (Sumule et al. 2023)

No	Index value (%)	Category
1	0.00–25.00	Unsustainable
2	25.01–50.00	Less sustainable
3	50.01–75.00	Moderately sustainable
4	75.01–100.00	Sustainable

3. Results and Discussion

3.1. Validation Test (R-Square and Stress Value)

Goodness-of-fit in MDS analysis was evaluated using the stress value and the coefficient of determination (R^2). A model is considered good when the stress value is less than 0.25 and R^2 is close to 1 (100%) (Narendra et al. 2019). This is because a low-stress value indicates high accuracy and a good model, while a high R^2 value indicates the ability to effectively explain data variation (Amanda et al. 2024; Fattah et al. 2023). **Table 2** summarizes the analyses conducted, and all five dimensions satisfy existing criteria because the stress values are less than 0.25 (0.14–0.17) and R^2

values are close to 1 (0.93–0.95). Therefore, the obtained model is considered reliable and adequately represents the actual conditions of the study area, providing a sound basis for assessing the sustainability status.

Table 2. Validation test results in each dimension

Dimension	Stress Value	R^2
Ecological	0.15	0.94
Economic	0.17	0.93
Social	0.15	0.94
Nature Tourism Service	0.15	0.94
Institutional	0.14	0.95

3.2. Monte Carlo Analysis

Monte Carlo analysis in Rap-Tourism serves to evaluate random errors across all assessed attributes. Uncertainties such as high stress values, incomplete scoring information, and data entry errors are addressed in Monte Carlo analysis (Ardiansyah et al. 2024; Kusdiyantoro et al. 2023). **Table 3** shows that the difference (delta) between the sustainability index and Monte Carlo results for each dimension is less than 5% (0.03% to 1.29%). This relatively small deviation demonstrates that the sustainability index is highly reliable and robust; random errors do not significantly affect the assessment (Purwaningsih et al. 2021).

Table 3. Analysis result of MDS and Monte Carlo

Dimension	Sustainability index (%)	Monte Carlo (%)	Delta (%)	Sustainability status
Ecological	73.00	71.84	1.16	Moderately sustainable
Economic	57.79	58.51	0.72	Moderately sustainable
Social	71.09	69.80	1.29	Moderately sustainable
Nature Tourism Service	56.90	56.93	0.03	Moderately sustainable
Institutional	64.36	64.07	0.29	Moderately sustainable

The delta values found in this study are lower than those reported by Djuwendah et al. (2023), indicating better data consistency. When compared with other recent studies, the observed range is similar to that reported by Sadad et al. (2022) and Wahyu et al. (2024), suggesting that the degree of certainty remains within the usual threshold for sustainability assessments using Raptourism. These results demonstrate the ordination results dependability for assessing sustainability status and support its methodological robustness and stability.

Fig. 3 shows the sustainability index for JJNTO management at Srumbung Resort according to each dimension. The five assessed dimensions were categorized as moderately sustainable (50.01–75.00%) and ranged from 56.90 to 73.00%. The ecological dimension ranked first at 73.00%, followed by social (71.09%), institutional (64.36%), economic (57.79%), and nature tourism service (56.90%). The results showed that the ecological dimension had the highest sustainable index, which is consistent with the goal of managing conservation areas.

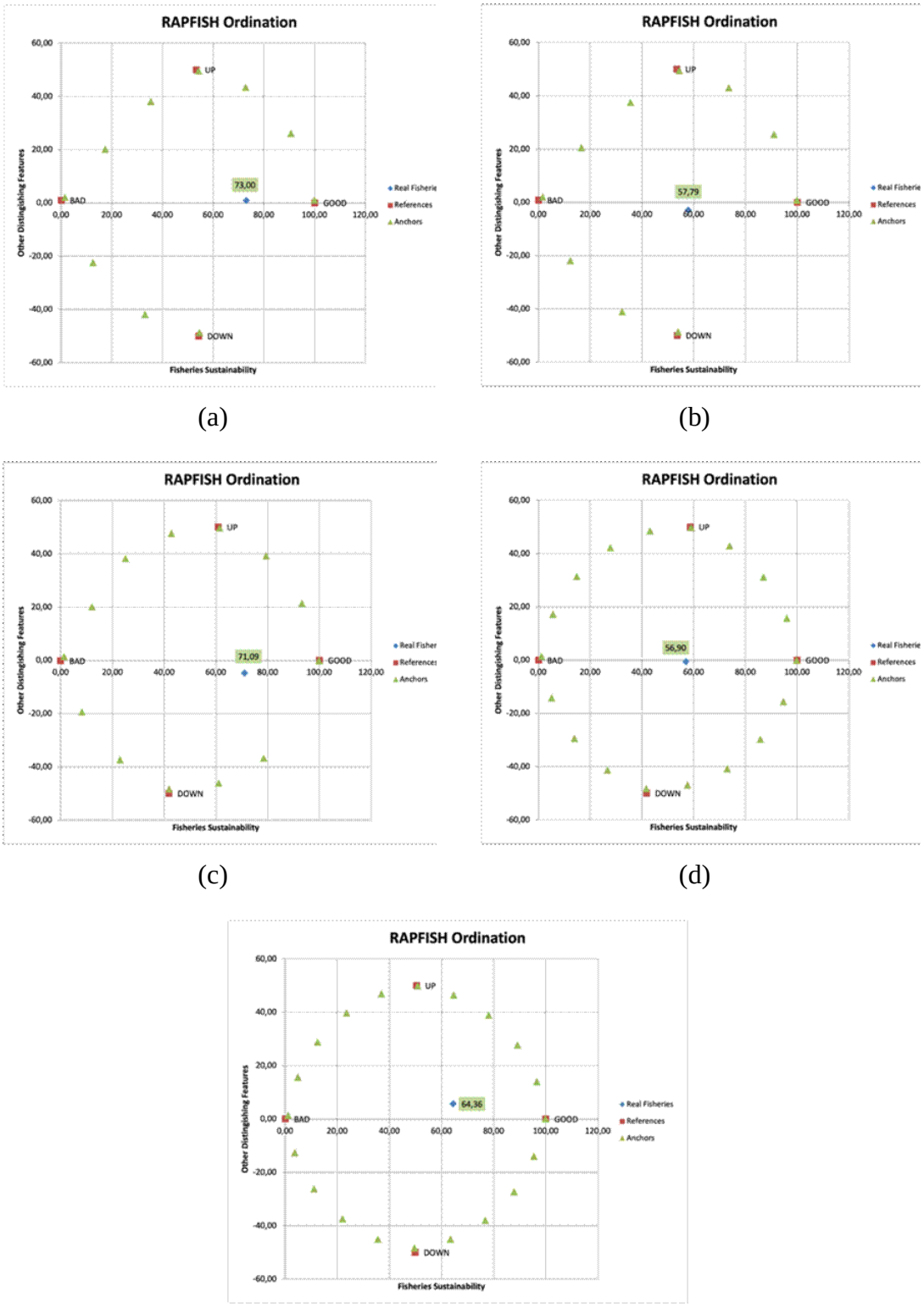

Fig. 3. Sustainability status of JJNTO based on: (a) ecological, (b) economic, (c) social, (d) nature tourism services, and (e) institutional dimensions.

3.3. Ecological Dimension

The ecological dimension of the sustainability index ranked highest, with a score of 73%, placing it in the moderately sustainable category. This dimension received the highest rating

because tourism activities take place in a conservation area where biodiversity conservation is a primary activity of the MMNP management. It aligns with the studies by Sadad et al. (2022) and Sambou et al. (2025), which found that the ecological dimension has the highest value and is categorized as sustainable. Conservation areas, considered the most crucial factor in forest management, are believed to affect both conditions. In such contexts, the conservation function naturally dominates management objectives, emphasizing the maintenance of ecosystem stability, habitat protection, and biodiversity conservation as the primary goals of nature-based tourism management.

Six ecological attributes were used in a leverage analysis to determine which had the greatest impact on the sustainability index. Water availability was found to be the most sensitive and dominant attribute influencing the ecological dimension, with the highest RMS value of 7.70% (**Table 4**). According to Sinha et al. (2020), there is a reciprocal relationship between water availability and tourism development.

Table 4. Leverage analysis of the ecological dimension

Attribute	RMS
Planting activities	4.27
Water availability	7.70
Inventory of forest resources	5.07
Protection system	5.48
Scene quality	3.91
Waste management	2.61

In addition to sustaining ecological processes, water resources are vital for tourism facilities, attractions, and community needs (Makanda et al. 2022; Mustafayev et al. 2024). Both ecological integrity and local livelihoods may be undermined when water supplies become uneven or deteriorate due to pollution, overuse, or shifting climate patterns. To maintain the ecological aspects of nature tourism development in conservation areas like JJNTO, efficient water management should be given top priority.

3.4. Economic Dimension

MMNP has unique characteristics compared to other conservation areas due to the area's periodic volcanic activity (Akmalia et al. 2020). Moreover, the surrounding community is the main concern for the managers in developing and implementing management plans. This is mainly because the community uses the natural resources in the conservation area, such as water sources, firewood, and grass for animal feed, as well as land encroachment and sand mining (Wijayati and Rijanta 2020). MMNP and the drinking water industry provide a total economic value of IDR 426,230,560,828/year (~USD 26,165,159) (Harjanti et al. 2024). As a comparison, the community around Mount Merbabu National Park uses the water for daily life, valued at IDR 15,061,089,768/year (~USD 911.48) (Dewi et al. 2024). Both are believed to be significant economic contributions of national parks to communities around conservation areas.

The results showed that the sustainability index for the economic dimension was significantly lower than that for the ecological dimension, at 57.79%. A study by Sadad et al. (2022) supports this, finding that the economic dimension is lower than the ecological dimension. Also, the sustainability value index is similar to that reported by Arif et al. (2025). These three

results validate that economic dimensions are not the main focus in the development of national parks.

The establishment of JJNTO is based on the principle of CBT, such as a) involving and empowering community participation in setting direction and decision-making; b) improving social well-being and quality of life; c) establishing a fair and transparent benefit-sharing mechanism, and d) promoting environmentally sustainable practices within the community (ASEAN 2022). However, the focus is currently more on conservation efforts, as evidenced by the ecological dimension having the highest sustainability index. The strict conservation regulations, such as restrictions on development and economic activities in the JJNTO area, certainly have a less-than-optimal impact on the local economy, as villagers working mainly as operators are affected.

The growth of science has led to a reduced understanding that conservation and economic aspects are two different paths (Tucker et al. 2023). The two concepts can be combined through a series of planning activities, including engaging various stakeholders, implementing management in accordance with regulations, and regular monitoring. Moreover, nature tourism activities in conservation areas are believed to be an effort to balance ecological and economic aspects through community empowerment (Wali et al. 2017).

Leverage analysis of the economic dimension showed that 1 attribute, economic programs for the local community (**Table 5**), was more sensitive than the other 5, with an RMS value of 0.84 as observed from the secondary data obtained from MMNP. The trend was associated with the organization of economic programs by MMNP in Ngargosoko and Tegalrandu Villages, which border the JJNTO area, as well as with routine activities conducted by some individuals in the area. Some of the programs implemented include (1) assistance through community empowerment in Tegalrandu Village in 2023, which produced a conservation agreement. Another was the (2) coaching for Jurang Jero Tourism Group in 2020 by providing support for one package of nature tourism equipment. There was also (3) group coaching on business permits (in Indonesian: *Izin Usaha Pemanfaatan Jasa Wisata Alam*/IUPJWA) in the form of a cooperative in 2020, which led to IDR 50,000,000 (~USD 3,069) support. Several community programs have been conducted, but efforts are needed to enhance the sustainability of the economic dimension. This can be achieved by increasing the intensity of economic programs for local villagers, in accordance with the community's needs, through the JJNTO-developed activities.

Table 5. Leverage analysis of the economic dimension

Attribute	RMS
Sufficient budget for nature tourism	0.48
Local labor absorption	0.13
Economic benefits for the local community	0.16
Local community business opportunity	0.41
Economic programs for the local community	0.84
Economic value of nature tourism	0.34

3.5. Social Dimension

The results of the sustainability analysis conducted on the social dimension produced an index of 71.09% and were categorized as moderately sustainable (50.01–75.00%). Meanwhile, the Monte Carlo value was 69.80%, with a delta of 1.29%, the highest among the other dimensions.

The trend showed that the social dimension had higher uncertainty, but the delta was below the 5% threshold, suggesting the data could be used. The analysis of the 7 attributes showed that the level of knowledge and awareness of the local community towards conservation areas was the most sensitive, with an RMS of 6.69% (**Table 6**).

Table 6. Leverage analysis of the social dimension

Attribute	RMS
Local community participation	2.61
Local community level of knowledge and awareness of conservation areas	6.69
Conflict in nature tourism management	4.61
Local community dependence on forest areas	5.23
Conservation and nature tourism extension	2.96
Culture value conditions	4.13
Learning process of nature tourism	0.85

The community was found to have a moderate level of knowledge and awareness of conservation areas, as analyzed from primary data collected via a questionnaire. This showed that the local community lacked a deep understanding of the permitted activities in conservation areas. Consequently, JJNTO operators and the local government have to amplify the socialization and empowerment actions within the conservation area buffer villages, specifically Ngargosoko and Tegalrandu, given the potential social impact of the community on the sustainability of JJNTO tourism activities.

Community engagement in nature-based tourism activities in conservation areas enhanced the potential for success and helped sustain and introduce cultural identity to tourists (Mayett-Moreno et al. 2017). Moreover, the extent of community engagement was found to be largely dependent on the individuals' knowledge of the tourism development policy, especially in the conservation areas (Sianipar et al. 2024). Furthermore, the joint efforts with outside stakeholders, such as governmental agencies, non-governmental organizations, and the private sector, are equally important (Triprajawan et al. 2024). These collaborations foster the impact and the sustainability of the initiative (Zulkifli et al. 2025). Hence, the integration of active community engagement, sufficient policy knowledge, and the unique natural and cultural resources of the region are the fundamental pillars to attain sustainable CBT management. This leads to enhanced quality and quantity of community engagement, ensuring that tourism development is in balance with conservation efforts and provides local communities with fair socio-economic opportunities.

3.6. Nature Tourism Service Dimension

In developing JJNTO, the community is supposed to have it as an alternative source of economic development to reduce dependence on sand mining activities (Faida et al. 2021). A parameter commonly used in defining successful nature tourism management is the number of tourists, which is determined by the type of attractions on offer diversified (Murniati et al. 2025). Some of the attractions offered by JJNTO include the observation deck for viewing Mount Merapi, *Pinus merkusii* stands, Tugu Elang, exploration of MMNP through downhill activities, and campgrounds, as shown in **Fig. 4**.

(a) (b)

(c) (d)

Fig. 4. Attractions at JJNTO are: (a) *Pinus merkusii* stands, (b) tugu elang, (c) observation deck to enjoy the view of Mount Merapi landscape, and (d) campgrounds.

The nature tourism service dimension comprises 9 attributes and has a sustainability index of 56.90%, placing it in the moderately sustainable range (50.01–75.00%). The Monte Carlo value was 56.93% with a delta of 0.03%, the smallest of the other dimensions. This showed that the sustainability index assessment results were relatively stable and had lower uncertainty than those of other dimensions. The most sensitive attribute in the nature tourism service dimension was the promotion and marketing of natural tourism (**Table 7**), with an RMS value of 2.18%. Promotion in tourism activities includes naming tourist attractions, organizing tourism events, and offering periodic promotional prices, all of which affect the number of visitors (Costantino et al. 2024). This attribute was assessed among JJNTO tourists selected as respondents, and the promotion and marketing activities conducted, specifically through social media such as Facebook and Instagram, were reported to be important in influencing tourists' expectations of the attractions visited (Tadesse et al. 2022).

The operators also partnered with the private sector, namely Indonesian Travel Agent Association (ASTINDO), to lure tourists through tourist packages. Nevertheless, this promotional and marketing intervention proved ineffective, requiring critical approaches or measures to increase tourist numbers. It is expected that the JJNTO operators enhance the effectiveness of promotional and marketing interventions in the future through various innovative approaches that were not initially or were not used before. Some of the approaches required include using social platforms such as TikTok and YouTube, which are more interactive and extensive and among the best platforms for online video marketing (Garganas 2024). In addition, there is a need to engage

influencers or vloggers who would, in an interesting way, introduce the destinations of JJNTO, showcase tourist testifiers or unique experiences that can be achieved by tourists from JJNTO destinations, and establish more strategic partnerships with other players like online travel agencies such as Traveloka and Tiket.com. To achieve this through Srumbung Resort, the stakeholder that assists the community in managing the JJNTO, the government must establish the facilities needed by the operators to undertake the approaches. This would be achieved through training, with the aim of improving marketing through various approaches, using financial support to undertake marketing/placement effectively. Furthermore, it is worth noting that the effectiveness of these approaches would enhance the sustainability of JJNTO's services, especially in the nature tourism sector.

Table 7. Leverage analysis of the nature tourism service dimension

Attribute	RMS
Water access facilities	0.26
Public facility condition	0.06
Nature tourism conditions	0.12
Trekking path condition	0.18
Ease of reaching the area	0.21
Traveler satisfaction, safety, and comfort	0.04
Nature tourism promotion and marketing	2.18
Number of visitors (2017–2022)	0.10
Visitors' desire for repeat visits	1.28

3.7. Institutional Dimension

The sustainability index for 10 attributes in the institutional dimension was 64.36%, which is classified as moderately sustainable since it falls between 50.01% and 75.00%. The stress value was 0.1421, lower than those for other dimensions, indicating that the MDS configuration had the least distortion and that the results could be interpreted more accurately and reliably. The R^2 value was 0.9488, the highest among the other dimensions. This showed that the model used in sustainability analysis had high accuracy in explaining variations in the data related to the institutional dimension. Leverage analysis identified 2 sensitive attributes in the dimension (**Table 8**), including (1) the role of local institutions in nature tourism management (RMS = 3.89) and (2) nature tourism regulation and control (RMS = 3.85). These results align with the study by Sutata et al. (2024), which found that coaching and assistance to communities, as well as the availability of regulations, are influential in the institutional dimension. Moreover, existing regulations must be supported by the availability of personnel to carry out supervisory activities, so that visitors do not violate the rules (Sadad et al. 2022).

Both attributes contributed significantly to the existence of JJNTO management, as it is managed by Jurang Jero Asri Tourism Group, which comprises members from the buffer zone villages of Ngargosoko and Tegal Randu. There are also forest farmer groups in each village that support nature tourism management, in addition to tourism groups. Jurang Jero Asri Tourism Group has been actively involved in planning, implementing, and evaluating activities at various stages, but participation is limited to certain individuals. Forest management that involves various stakeholders, including the community in an inclusive manner, has been proven to increase the chances of successful conservation area management (Byamukama et al. 2025). Therefore, efforts

are needed to increase wider participation from the local community, both through socialization and economic empowerment based on nature tourism. This is required to ensure that management of JJNTO becomes more inclusive and sustainable, and to provide more equitable benefits for the buffer villages.

Table 8. Leverage analysis of the institutional dimension

Attribute	RMS
Partnership and collaboration	0.01
Inter-agency coordination	0.30
Training program for operators	0.71
Participative monitoring and evaluation	0.91
The role of local institutions in nature tourism management	3.89
The role of the private sector in nature tourism management	0.68
Nature tourism regulation and control	3.85
Nature tourism management	1.09
Visitor compliance with regulations	1.37
Availability of information and inventory of nature tourism management	1.62

The regulations and controls governing nature tourism can serve as a guideline for operators and tourists on the premises of JJNTO. In contrast, their absence leads to utilization without due consideration for ecological aspects, which are the main value of sustainability. Therefore, the regulations tend to be strict and aim to maintain a balance between environmental conservation and the sustainable use of nature tourism (Rusdi et al. 2020). Some of these include restrictions on the establishment of permanent buildings as stipulated in the Ministry of Environment and Forestry Regulation Number P.13 of 2020, the need for tourists to comply with environmental codes of conduct, such as not disturbing wildlife, and the existence of signboards and prohibition boards to guide visitor behavior and minimize ecological disturbance.

3.8. Sustainability Status of JJNTO

The overall sustainability index for the management of JJNTO was 61.77%, classified as moderately sustainable (50.01–75.00%), as observed in **Fig. 5**. The results further showed that the stress and R^2 values were 0.1311 and 0.9566, respectively. The stress value was below the threshold of < 0.25, which led to the consideration of a good model fit. The relatively high R^2 value, which was close to 1, also reflected a strong model fit. Meanwhile, previous studies on the sustainability status of tourism in Indonesia reported tourism in the less (Abdillah et al. 2023; Sukuryadi et al. 2021), moderate (Sutata et al. 2024), and sustainable (Sambou et al. 2019) categories, with index values ranging from 31.34% to 76.49%. This shows the need for different efforts from operators based on differences in actual sustainability status and the most influential dimensions and attributes.

The kite diagram of the five sustainability dimensions, presented in **Fig. 6**, classified JJNTO's management as moderately sustainable. This shows the need for improvement to achieve a sustainable category with the prioritization of the facilities to be arranged according to the lowest sustainability value, including (1) Nature tourism service, (2) Economic, (3) Institutional, (4) Social, and (5) Ecological aspects. Therefore, the main concern is to improve the quality of tourism services, which is the dimension with the lowest level of sustainability. This can be achieved by

improving the capacities of JJNTO operators, constructing eco-friendly tourism facilities and infrastructure, adding tourism products, or promoting tourism. Moreover, better integration of the ecological, social, economic, and institutional dimensions is imperative to adopt a holistic approach to the sustainable management of nature tourism (Ardiansyah et al. 2024; Dangi and Jamal 2016).

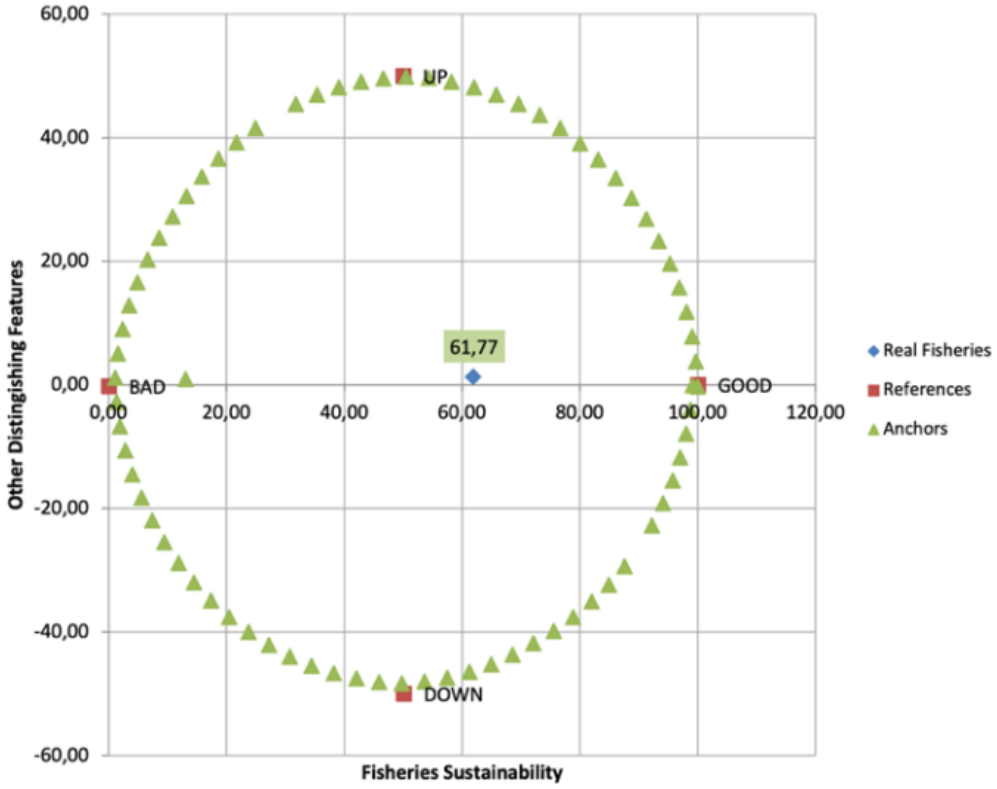

Fig. 5. Overall sustainability status of JJNTO.

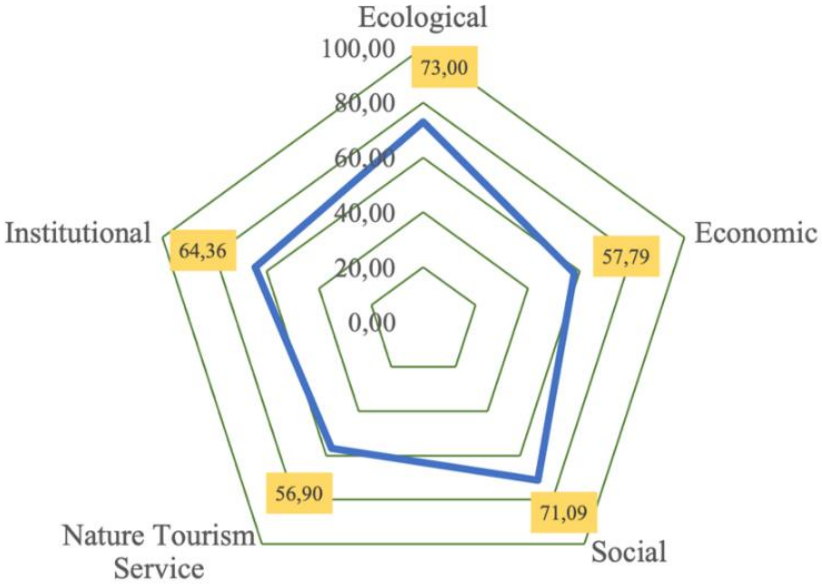

Fig. 6. Radar chart of JJNTO sustainability index.

Monitoring and evaluation activities need to be carried out periodically to assess the sustainability of implemented programs and identify necessary improvement efforts. (Byiringiro 2025; Mandić et al. 2025). The ecological dimension is positioned as the last priority, as its sustainability index is already close to the sustainable category, at only about 2% below. However, to maintain its current performance, continuous ecosystem monitoring and preventive measures are required to protect it from potential damage from activities such as uncontrolled tourism or habitat disturbance. JJNTO could develop into a sustainable nature-based tourism destination that generates long-term economic benefits for local communities while preserving the ecological integrity of the MMNP ecosystem by implementing an effective, integrated strategy across all dimensions.

4. Conclusions

The stands of *Pinus merkusii*, the *Tugu Elang*, MMNP exploration through downhill activities, an observation deck for taking in views of Mount Merapi, and a camping area are just a few of the natural attractions at JJNTO, which was developed based on the CBT concept. The JJNTO management was categorized as moderately sustainable, reflecting relatively balanced performance across the dimensions of ecological, economy, social, institutional, and nature tourism services. Although all dimensions were rated moderate, nature tourism services had the lowest index for JJNTO's sustainable management. Therefore, this dimension is a top priority for improving the sustainability status of JJNTO. Furthermore, sensitive attributes in each dimension need to be well managed for further advancement to the sustainable category. This study recommends that JJNTO management maintain the ecological value of the MMNP conservation area by optimizing existing space, strengthening community capacity through training and mentoring, and improving tourism facilities and services to enhance visitor experience and local socio-economic benefits. Practically, these findings highlight the importance of integrating sustainability principles into management policies and practices by developing environmentally friendly infrastructure, implementing Corporate Social Responsibility (CSR) programs to support local initiatives, and instituting community-based training to build long-term resilience. These strategies can guide policymakers and managers in achieving a balanced approach to ecosystem conservation, economic growth, and community well-being in protected area tourism.

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Author Contributions

D.F.S.: Conceptualization, Methodology, Software, Formal Analysis, Writing – Original Draft Preparation; R.S.: Conceptualization, Methodology, Supervision; M.I.N.M.: Writing – Original Draft Preparation.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI And AI-Assisted Technologies in the Manuscript Preparation

Not applicable.

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