JURNAL MULTIDISIPLIN MADANI (MUDIMA)

Homepage: https://journal.formosapublisher.org/index.php/mudima
ISSN: 2808-5639 (Online)
Research Article

Vol. 6, No. 6, June (2026)	DOI:https://doi.org/10.55927/mudima.v6i6.71	Page: 833-839

Sustainability Analysis of Coral Reef Conservation-Based Ecotourism: Integration of Sasi Local Wisdom and the RAPFISH Approach (Case Study: Ur Pulau Village, Southeast Maluku)

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ARTICLE INFO

Keywords: Ecotourism Management, Conservation, Coral Reefs, Evaluation Strategy

Received : 1 April
Revised : 23 May
Accepted : 24 June

ABSTRACT

Ur Pulau Village in Southeast Maluku has significant marine ecotourism potential thanks to its coral reef ecosystem, but faces the threat of degradation due to anthropogenic activities. This study aims to analyze the sustainability status of coral reef conservation-based ecotourism management in Ur Pulau Village multidimensionally. The research method uses a semi-quantitative approach with the Rapid Appraisal for Fisheries (RAPFISH) technique modified for ecotourism. The analysis was conducted on five dimensions of sustainability: (1) Ecology, (2) Economy, (3) Socio-Cultural, (4) Technology and Infrastructure, and (5) Law and Institutions. Data were collected through structured questionnaires, interviews, and observations of 38 key respondents consisting of the community, village government, tourism actors, and related agencies. The results of the Multidimensional Scaling (MDS) analysis show that the overall status of ecotourism management is in the Sustainable Category with an average index value of 60.56. The Legal and Institutional Dimension is the strongest dimension (67.93), which is supported by the ongoing local wisdom of Sasi. In contrast, the Technology and Infrastructure dimension is the weakest dimension (48.71) with a status of Less Sustainable. Leverage analysis identified the most sensitive attributes that need immediate attention, including coral damage due to poison/potash (ecology), high monitoring costs (economic), and low levels of education (social). This study confirms that Sasi local wisdom is a fundamental social capital, but long-term sustainability requires strategic interventions to strengthen environmentally friendly infrastructure and formalize customary institutions into village regulations

INTRODUCTION

Indonesia, as the world's largest archipelagic nation, lies at the center of the Coral Triangle and boasts the highest marine biodiversity globally. Coral reef ecosystems not only serve as coastal protection and habitat for thousands of species, but also serve as the economic backbone of millions of coastal communities through fisheries and tourism (Fauzi & Anna, 2005).

Ur Pulau Village in West Kei Kecil District, Southeast Maluku Regency, is one of the areas with 14,226.65 hectares of coral reef potential. This underwater beauty is a major attraction for ecotourism development. However, this potential is under serious threat. Destructive fishing activities, such as the use of explosives and potassium cyanide, as well as physical damage from boat anchors, have caused ecosystem degradation in many areas (Uar et al., 2016). Anthropogenic pressures such as destructive fishing, pollution, and poorly managed tourism activities have led to coral reef degradation in various coastal areas of Indonesia. This pressure threatens ecological sustainability as well as community economic opportunities.

In response, conservation-based ecotourism models have begun to be developed as an alternative sustainable management approach. Ecotourism aims to create economic incentives for local communities to engage in conservation (Setiawan & Wibowo, 2022). The uniqueness of Ur Pulau Village lies in the continued existence of the local wisdom of Sasi, a community-based resource management (CBM) system long practiced by the Kei indigenous people (Satria, 2015). Sasi regulates the timing and areas of marine resource utilization, aligning with modern conservation principles and Ostrom's (1990) theory of common-pool resource management.

In this context, conservation-based ecotourism has developed as an alternative approach expected to align environmental protection and local community welfare (UNWTO, 2018). Ecotourism emphasizes not only economic aspects but also integrates ecological, social, and institutional dimensions within a sustainable development framework.

Ur Pulau Village in Southeast Maluku Regency is one of the areas with potential for coral reef-based marine ecotourism. The uniqueness of this region lies in the continued application of the local wisdom of Sasi, a customary-based natural resource management system that regulates the timing, location, and method of marine resource utilization. Various studies have shown that Sasi plays a crucial role in maintaining the sustainability of coastal resources in Maluku (Satria, 2015; Warawarin et al., 2017). However, the effectiveness of Sasi in the context of modern ecotourism development and multidimensional sustainability challenges still requires comprehensive study. Although many studies have examined the effectiveness of Sasi (Warawarin et al., 2017) or used RAPFISH sustainability analysis separately (Fauzi & Anna, 2005), there is still a gap in research that integrates these two approaches in the context of coral reef ecotourism. What is the current status of ecotourism sustainability when measured multidimensionally? And to what extent does the local wisdom of Sasi contribute to that status?

This study aims to (1) Identify key attributes that determine the sustainability of coral reef conservation-based ecotourism in Ur Pulau Village; (2) Assess the status of management sustainability using RAPFISH analysis on five dimensions (ecology, economy, socio-culture, technology & infrastructure, law & institutions); and (3) Formulate recommendations for priority strategies to improve management sustainability.

METHODS

This research was conducted in Ur Pulau Village, West Kei Kecil District, Southeast Maluku Regency, Maluku Province. The location was selected purposively, considering that the village has potential coral reef ecosystems, practices Sasi local wisdom, and is currently developing ecotourism. This study employed a descriptive-semi-quantitative research design. The primary method used was Rapid Appraisal for Fisheries (RAPFISH), modified to assess ecotourism sustainability. RAPFISH is a Multidimensional Scaling (MDS) ordination technique capable of transforming qualitative and ordinal data from various attributes into a single quantitative sustainability index (Fauzi & Anna, 2002). The study population included all stakeholders involved in ecotourism management and conservation in Ur Pulau Village. The study sample consisted of 38 respondents selected through a combination of purposive and snowball sampling. Respondents consisted of: Ur Pulau Village Government (5 people), Village Community (20 people, including traditional leaders), Business

Actors (Homestay Owners) (5 people), Fishermen (10 people), Government Agencies (Southeast Maluku Tourism Office & Fisheries Office) (2 people), and Environmental Activists (3 people).

Data were collected through three methods: Questionnaire, used for RAPFISH attribute scoring assessment by 38 respondents, In-depth Interviews, conducted with key respondents (Head of Department, Village Head, Traditional Leader) to deepen understanding of the context, and Field Observation, to verify the physical condition of coral reefs and ecotourism facilities. Validation of the attributes used in the RAPFISH questionnaire was carried out through expert judgment and limited trials (Delphi method) to ensure the relevance of each attribute. Data analysis was carried out through several stages, namely: Attribute Determination: A total of 25-30 attributes were grouped into five dimensions of sustainability: (a) Ecology, (b) Economy, (c) Socio-Cultural, (d) Technology & Infrastructure, and (e) Law & Institutions. Attribute Scoring: Each attribute was given an ordinal score (e.g. 1-5) based on the criteria "Poor" to "Good" obtained from the questionnaire. RAPFISH Analysis (MDS): The ordinal scores of each dimension were analyzed using RAPFISH software to generate a sustainability index value on a scale of 0-100. Sustainability status is categorized as follows: 0-25 (Not Sustainable), 26-50 (Less Sustainable), 51-75 (Moderately Sustainable), and 76-100 (Highly Sustainable). Leverage Analysis: Used to identify attributes that have the most sensitive influence or the highest leverage on the sustainability index value in each dimension. Monte Carlo Analysis: Conducted to test the stability and reliability of the MDS analysis results against variations in scoring errors.

RESULTS AND DISCUSSION

Multidimensional Sustainability Status of Ecotourism

The results of the RAPFISH analysis indicate that the overall sustainability status of coral reef conservation-based ecotourism management in Ur Pulau Village is in the "Moderately Sustainable" category, with a composite index value of 60.56. This value indicates that current management is already aligned with sustainability principles, but still faces many challenges and requires significant improvement to achieve "Highly Sustainable" status. The Monte Carlo test results show very small differences in index values (<1%), indicating that the MDS analysis is stable and reliable.

Differences in sustainability status are clearly visible across dimensions, as summarized in Table 1.

Table 1. Multidimensional Sustainability Index (RAPFISH) Values

No	Dimensiin	Indeks Value (MDS)	Category
1	Legal & Institutional	67.93	Moderately Sustainable
2	Ecologycal	64.65	Moderately Sustainable
3	Socio-Cultural	62.77	Moderately Sustainable
4	Economic	58.76	Moderately Sustainable
5	Technology & Infrastructure	48.71	Less Sustainable
	Average Composite Index	60.56	Moderately Sustainable

The results in Table 1 indicate that the Legal and Institutional Dimension (67.93) is the strongest pillar, while the Technology and Infrastructure Dimension (48.71) is the weakest and most critical pillar.

Key Factor Analysis (Leverage) and Discussion per Dimension

The leverage analysis identified the attributes most influential (sensitive) to changes in the index value in each dimension. These attributes are the most effective strategic intervention points.

1. Legal and Institutional Dimension

The Legal and Institutional Dimension scored the highest (67.93), falling into the moderately sustainable category, with the most sensitive attribute being adherence to Sasi customary rules. This finding confirms that customary institutions still function effectively as a control mechanism for

marine resource utilization. This is the strongest dimension, emphasizing the central role of local wisdom. The highest leverage attribute in this dimension is "Compliance/Enforcement of Sasi Customary Rules" (12.9%). This high score is driven by the community's existence and adherence to the Sasi system. Sasi functions as an effective CBM mechanism, in line with the findings of Satria (2015) and Ostrom's (1990) principles in managing common pool resources. Sasi provides clear boundaries, utilization rules, and customary sanctions that must be adhered to. However, a weakness identified in interviews is that the Sasi system remains informal (hereditary) and has not been fully integrated into formal village regulations (Perdes). This formalization is important to provide greater legal force in the face of external pressures. Theoretically, Sasi reflects the principles of common-pool resource management as formulated by Ostrom (1990), particularly in the following aspects: clear boundaries, utilization rules based on local consensus, effective social sanctions, and high social legitimacy. Previous studies have also shown that Sasi has been proven effective in suppressing overexploitation and increasing the recovery of marine resources in Maluku (Satria, 2015; Ratna et al., 2016). In the context of ecotourism, the existence of Sasi functions as social capital that reduces formal supervision costs (transaction costs) and increases collective compliance, as demonstrated by Pretty & Ward (2001).

However, field findings indicate that Sasi remains informal and has not been institutionalized under positive law. This situation has the potential to weaken its reach to external actors, such as migrant fishermen and tourism investors. Therefore, integrating Sasi into Village Regulations (Perdes) is a crucial prerequisite for building adaptive, legal-formal hybrid institutions (Berkes, 2018).

2. Technology and Infrastructure Dimension

The Technology and Infrastructure dimension recorded the lowest score (48.71 – less sustainable), with the most sensitive attribute being the effects of fishing gear on coral reefs. This score indicates that the success of customary institutions has not been matched by adequate technical support and physical facilities. This is the weakest dimension and a major obstacle. The highest leverage attribute is "Effects of fishing gear on coral" (13.5%). This "Less Sustainable" status is due to two main factors. First, the continued use of environmentally unfriendly fishing gear (bottom nets, fishing lines that get caught in coral) and boat anchoring practices that damage coral. Second, there is a lack of environmentally friendly infrastructure supporting ecotourism, such as mooring buoys, designated snorkeling routes, and waste management facilities. Ecotourism cannot be sustainable if its basic infrastructure does not support conservation. Reef damage caused by boat anchors, non-selective fishing gear, and the lack of mooring buoys are classic problems in marine ecotourism management in developing countries (Davenport & Davenport, 2006). Without environmentally friendly infrastructure, tourism activities have the potential to become a source of new ecological pressures (tourism-induced degradation).

From a sustainable tourism perspective, infrastructure is not simply a physical facility, but rather an active conservation instrument that guides the behavior of resource users (UNWTO, 2018). Therefore, the weakness of this dimension poses a serious threat to long-term sustainability, even if other dimensions are relatively good.

3. Ecological Dimension

The ecological dimension scored 64.65 (fairly sustainable), but had the highest leverage attribute, coral death due to poison/potash use (15.2%). This leverage value indicates that a single destructive factor can drastically reduce the overall sustainability index. The ecological status is still quite good, but very vulnerable. The highest leverage attribute in this dimension was "Coral death due to poison/potash" (15.2%). This was the attribute with the highest leverage across the entire study, indicating that the threat from destructive fishing (though perhaps reduced) is the most crucial factor determining ecological health. A score of "fairly sustainable" indicates that the ecosystem still possesses resilience, likely due to protection by Sasi practices. However, a single bombing or poisoning incident can undo years of recovery. Chemical fishing is a major cause of coral reef degradation in the Coral Triangle (Burke et al., 2011). Although this practice has decreased due to the implementation of Sasi, these findings indicate that the management system remains partially preventative, not fully eradicative.

The resilience of coral reef ecosystems depends heavily on consistent, long-term protection. Acute

disturbances, even sporadic ones, can disrupt natural recovery processes that take years (Hughes et al., 2017).

4. Socio-Cultural Dimension

The socio-cultural dimension scored 62.77, falling into the "Sufficiently Sustainable" category, with a sensitive attribute being community education level. This finding highlights a paradox: social capital and community cohesion are strong, but individual technical capacity remains limited. Social capital in Ur Pulau Village is quite strong. The highest leverage attribute is "Community education level" (14.1%). Community participation in Sasi management and awareness are considered good. However, leverage analysis indicates that the relatively low level of formal education is a barrier to the adoption of modern conservation knowledge and ecotourism management skills (e.g., becoming a tour guide, managing a homestay). Human resource capacity building through non-formal education and training is crucial. In community-based ecotourism management, the level of education and environmental literacy determines a community's ability to manage tourism businesses, understand the economic value of ecosystem services, and adopt modern conservation practices (Scheyvens, 1999).

Low levels of formal education potentially limit the community's role to passive actors, rather than primary managers. Therefore, capacity building through non-formal training is key to transforming social capital into sustainable economic capital.

5. Economic Dimension

The economic dimension scored 58.76, falling into the Fairly Sustainable category. This result falls within the Fairly Sustainable category, with the sensitive attribute being the high costs of monitoring and maintenance. This finding indicates that although ecotourism is beginning to provide direct economic benefits, conservation financing mechanisms have not yet been internalized. Ecotourism is beginning to generate economic impacts, but not yet optimally. The highest leverage attribute is "Monitoring and maintenance costs" (13.8%). The community has experienced economic benefits through homestays and boat rentals. However, conservation costs (monitoring, Sasi patrols, restoration) remain high and often rely on self-help or external assistance. There is no clear mechanism for reallocating ecotourism revenue (e.g., through village levies or conservation funds) to finance ecosystem maintenance.

The social capital of the Ur Pulau Village community is relatively strong, reflected in their participation in management and adherence to customary rules. However, low levels of formal education are a barrier to developing ecotourism management capacity (Scheyvens, 1999). From an economic perspective, the benefits of ecotourism have been felt, but they have not been matched by sustainable conservation financing mechanisms (Pearce & Turner, 1990). Within the framework of environmental economics, sustainability is only achieved when economic benefits are able to cover management and conservation costs (cost recovery) (Pearce & Turner, 1990). Dependence on external assistance indicates the lack of a resilient local economic system. The implementation of a village-based ecotourism fee scheme or a community conservation fund could be a solution to improve financial sustainability (Wunder, 2015).

Management Strategy Formulation

Based on the synthesis of the MDS analysis and leverage, three priority strategies are recommended to improve the sustainability status from "Sufficient" to "Highly Sustainable":

1. Hybrid Institutional Strengthening Strategy (Top Priority):

Address weaknesses in the Legal & Institutional dimension. The strategy is to formalize local Sasi wisdom into Village Regulations (Perdes). This will create a "hybrid" system in which the power of customary law (Sasi) is strengthened by formal state legality (Perdes), thereby enabling it to address external violators.

2. Technology and Infrastructure Intervention Strategy (Addressing the Weakest Dimension):

Address the lowest score in the Technology dimension (48.71) and leverage "Fishing Gear Effects." Interventions should focus on providing environmentally friendly infrastructure, such as: (a) Installing mooring buoys at diving/snorkeling points to eliminate anchor damage; (b) Introducing alternative, non-destructive fishing gear; and (c) Development of basic ecotourism facilities (toilets, waste management).

3. *Ecological Threat Mitigation and Human Resource Development Strategy*:

Addressing the highest leverage attributes of "Coral death due to potassium" (15.2%) and

"Education level" (14.1%). This strategy includes: (a) Increasing marine surveillance patrols involving indigenous communities (Sasi guards) and village officials; and (b) Capacity building programs (training) for local communities to become ecotourism guides, provide simple coral restoration techniques, and provide homestay management.

CONCLUSION

The management status of coral reef conservation-based ecotourism in Ur Pulau Village is categorized as Fairly Sustainable (Index 60.56). The local wisdom of Sasi is a key pillar supporting sustainability, reflected in the highest score in the Legal and Institutional Dimension (67.93). However, this status is highly vulnerable due to the weak Technology and Infrastructure Dimension (48.71), characterized by a lack of environmentally friendly facilities and the persistence of destructive fishing practices.

The most crucial attribute requiring immediate attention is coral damage due to the use of poison/potash (leverage 15.2%). Long-term sustainability remains hampered by weak technology and infrastructure dimensions, as well as challenges in ecological, social, and economic aspects.

Sustainability can be achieved through strategies to strengthen formal institutions, such as incorporating Sasi into village regulations. Providing environmentally friendly infrastructure and increasing human resource capacity are key strategies for improving the sustainability status of ecotourism in coastal areas

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