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Social and ecological perspectives on sustainable multicultural community tourism in the mangrove ecosystems of Mandar Village Indonesia

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Abstract

The interaction between ecology and society is crucial for achieving the sustainability of the mangrove ecosystem and the well-being of the multicultural Mandar Village community. The primary objective of this research is to investigate the development of sustainable multicultural community-based mangrove tourism from a social-ecological system perspective in Mandar Village, Indonesia. This study employs a spatial suitability index analysis, a multidimensional sustainability approach utilizing MDS (Rapfish), and a social-ecological system (SES) analysis to evaluate the suitability, sustainability levels, and interaction dynamics between social and ecological components within mangrove tourism management. The multicultural community of Mandar Village, comprising the Mandar, Madurese, Osing, Javanese, Arab, Chinese, and other ethnic groups, develops coastal tourism through environmental quality enhancement efforts underpinned by cross-ethnic collaboration. The main mangrove species in the tourism area include *Rhizophora mucronata*, *Sonneratia alba*, and *Avicennia marina*. The Tourism Suitability Index was 56.41% at station 1 and 58.97% at station 2, categorizing both as conditionally appropriate. The sustainability status is rated as moderately sustainable at 56.55%, influenced mostly by characteristics such as mangrove thickness, labor absorption, tourist perception, and management rules. The mangrove environment, nature tourism, the Fisheries Service, water quality, and fisheries extension workers are the most prominent nodes in the degree centrality of the social-ecological system's interactions. The primary elements linking the nodes are the mangrove ecosystem and ecotourism. The categorization illustrates the intricacy of the relationship, resulting in the establishment of seven groupings based on analogous traits. Managers need to enhance their capacity to oversee mangroves, address ongoing community concerns regarding the removal of debris from these ecosystems, develop innovative educational tourism attractions centered on mangroves, and foster collaboration between the government and community to bolster mangrove sustainability and economic prospects for community welfare. The development of mangrove tourism should integrate sustainable paradigms anchored in an eco-surplus culture. This integration is crucial, as the overarching success of a



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destination should no longer be gauged exclusively by conventional metrics such as visitor influx and economic dividends, but rather by its demonstrable capacity to catalyze tangible ecosystem protection, restoration, and regeneration. This paradigm shift repositions the mangrove ecosystem—transcending its conventional role as a mere recreational commodity—into an indispensable ecological core. Consequently, it calls for a governance framework that strictly adheres to environmental carrying capacities, fortifies social responsibility, and cultivates collective pro-environmental behaviors. This multicultural community plays an instrumental role in actualizing Sustainable Multicultural Community-Based Tourism (SMCBT) through cross-ethnic collaboration, the integration of cultural values, and mangrove conservation initiatives, thereby fortifying the socio-ecological sustainability of coastal tourism.

Keywords Mangrove tourism, Suitability, Sustainability, Interaction, Social-ecological system

1 Introduction

Mangrove forests are natural resources in tropical regions that provide significant ecological and economic advantages. Indonesia is an archipelagic nation possessing the largest mangrove forests globally [3, 37]. The total amount of existing mangroves in Indonesia, according to the 2021 national mangrove mapping, is 3,364,080 hectares, whereas the area of potential mangrove habitat is 756,183 hectares, attributed to eroded areas, vacant land, degraded mangroves, ponds, and newly formed land. East Java encompasses 27,222 hectares of mangroves, with area percentages classified as dense at 47.26%, moderate at 46.08%, and sparse at 6.66%. Consequently, East Java is the region with the most extensive mangrove forests on the island of Java [9] (Fig. 1). The mangrove ecosystem serves as a green belt for coastal regions, playing a crucial role in sustaining environmental equilibrium, preventing erosion, offering habitat for diverse fauna, and delivering economic advantages to the community [52]. It also contributes to climate change mitigation [20] and possesses the capacity to sequester carbon [4, 7, 38, 41, 42].

Mangrove ecosystems have ecological advantages and can also be leveraged for tourism development [17]. The attractiveness of diverse mangrove habitats attracts tourists and enhances understanding of their role in mitigating climate change effects [35]. The utilization of mangrove ecosystems for tourism aligns with the transition from traditional tourism, characterized by mere travel, to contemporary tourism, which encompasses educational and conservation objectives [45]. Management of sustainable tourism positively influences coastal habitats; yet, tourism activities may adversely affect these ecosystems if tourists engage in harmful behaviors [12]. The efficient administration of mangrove tourism through the engagement of coastal communities enhances the sense of ownership and is intrinsically linked to the mangrove ecosystem [14, 19, 27].

In 2002, the Banyuwangi Regency Government initiated the establishment, management, and regulation of the tourist sector by adopting Local Regulation No. 40 of 2002, which addresses the promotion of tourism while preserving nature and culture. The strategy to advance the tourist sector under Regent Anas's leadership was implemented via the 2010 RPJMD (Regional Medium-Term Development Plan), wherein tourism development was executed in a cohesive manner with stakeholders. The advancement of tourism in Banyuwangi commenced in 2012 with the initiation of the Banyuwangi Festival. Since 2016, initiatives to enhance the competitiveness of the tourism cluster have been grounded in the creative economy sector. In 2019, Banyuwangi Regency initiated

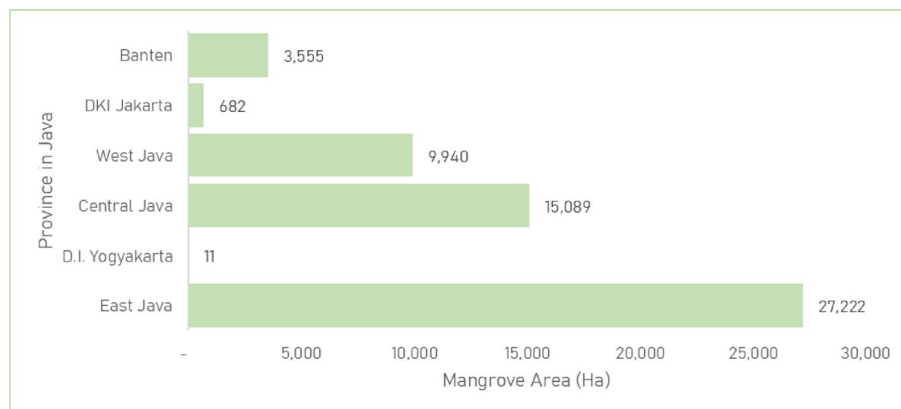


Fig. 1 Mangrove area ecosystems on Java Island

the *Kota Tanpa Kumuh* (KOTAKU) program. The Banyuwangi Festival reached its peak in 2020 with 120 events. The Banyuwangi Festival comprises a collection of tourism promotions presented as cultural and ecological tourism activities. The presence of Kampung Mandar in tourism development has been a challenge for the Banyuwangi Regency Government, as it was the most impoverished community in Banyuwangi before to 2017. In 2017, the youth of Kampung Mandar, alongside the multicultural community, local government, and CSR BUMN, transformed the slum's image into a clean environment. Kampung Mandar is adjacent to the Boom Marina beach tourism site, inaugurated in 2015 by PT Pelabuhan Indonesia III as an international tourist destination by the central government, aiming to host a sailing race in 2017, thus prompting the local government to enhance the surrounding environment. The advancement of tourism in Banyuwangi Regency has positively influenced the influx of domestic and international visitors in 2024, totaling 3,405,145 tourists. The tourist strategy adopted by Banyuwangi Regency has proven to be an effective method for rehabilitating the ecology of rivers and mangroves in Kampung Mandar via tourism education, community-based management, and organized conservation practices.

The management of Mandar Village mangrove tourism exemplifies the interplay between social dynamics and ecology, serving not just as a tourist attraction but also enhancing the local economy and promoting sustainable environmental conservation. Moreover, it necessitates cooperation and comprehension among stakeholders to guarantee equitable mangrove exploitation that reconciles commercial and ecological objectives. The ethnic diversity in Mandar Village, encompassing the Mandar, Osing, Javanese, Madurese, Chinese, and Arab communities, engenders distinctive socio-cultural dynamics in the stewardship of the mangrove ecosystem. Each ethnic group contributes local knowledge, values of wisdom, and diverse resource usage techniques to establish a multicultural community-based mangrove management system. Previous literature on mangrove tourism has predominantly examined ecological functions, economic benefits, and community participation in isolation. Consequently, empirical studies investigating the interdependencies among these elements within an integrated socio-ecological system framework remain notably scarce. In Mandar Village, such interactions are manifested through the complex dynamics among local communities, tourism stakeholders, institutional governance structures, and the intrinsic ecological functions of the mangrove ecosystem. These relationships are particularly evident in patterns of resource

utilization, conservation practices, and tourism development initiatives. Comprehending these intricate interactions is imperative, as the long-term sustainability of mangrove tourism is dictated not only by baseline ecological conditions but also by the capacity of social and institutional actors to maintain a delicate equilibrium among environmental conservation, community livelihoods, and tourism expansion.

Multicultural community-based mangrove management in Mandar Village illustrates a governance framework shaped by complex interactions between socio-cultural diversity and coastal ecosystem dynamics within a social-ecological system perspective. Ethnic diversity generates a spectrum of local knowledge, normative values, and resource utilization practices that are integrated into collective management. Consequently, the mangrove ecosystem functions as both an ecological and a social space, facilitating interest negotiation, consensus building, and role distribution among various community groups. The multicultural community plays a pivotal role in shaping adaptive governance through active engagement in the planning, implementation, and monitoring of conservation efforts and tourism development. Cross-cultural interactions facilitate the exchange of knowledge and experiences, thereby driving the formation of social learning mechanisms that are responsive to environmental shifts and tourism-induced pressures. This management approach evolves by integrating local knowledge, empirical experiences, and existing institutional frameworks to establish a collaborative multi-actor network. Furthermore, the decision-making process is highly participatory, relying on mutual consensus that reflects social legitimacy and the equitable representation of diverse ethnic groups. Ultimately, the presence of a multicultural community bolsters system resilience through cross-cultural collaborative networks, adaptive role distribution, and collective capacity to navigate environmental dynamics. This framework strengthens reciprocal human–environment interactions and enhances the system's overall capability to maintain the stability and long-term sustainability of the mangrove ecosystem. The primary objective of this research is to investigate the development of sustainable multicultural community-based mangrove tourism from a social-ecological system perspective in Mandar Village, Indonesia. Specifically, this study seeks to:

1. Assess the suitability level of the mangrove area as a tourism destination;
2. Evaluate the multidimensional sustainability of the mangrove tourism;
3. Analyze the interactions within the social-ecological system involving the multicultural community, tourism stakeholders, and mangrove ecosystem functions; and
4. Examine the role of eco-surplus cultural values in shaping pro-environmental behavior and supporting community-based tourism management.

2 Literature review

2.1 Sustainable development

Sustainable development is characterized as development that fulfills existing demands without jeopardizing the capacity of future generations to satisfy their own requirements [6]. Sustainable development should encompass social, environmental, and economic sustainability, utilizing all three to commence the process [18, 28]. The widely recognized three-circle diagram (Fig. 2), originally introduced by Barbier in 1987 in the work *The Concept of Sustainable Economic*, illustrates the fundamental dimensions of this paradigm [36]. The Sustainable Development Goals (SDGs) represent a comprehensive framework of 17 global objectives adopted by the United Nations in 2015.

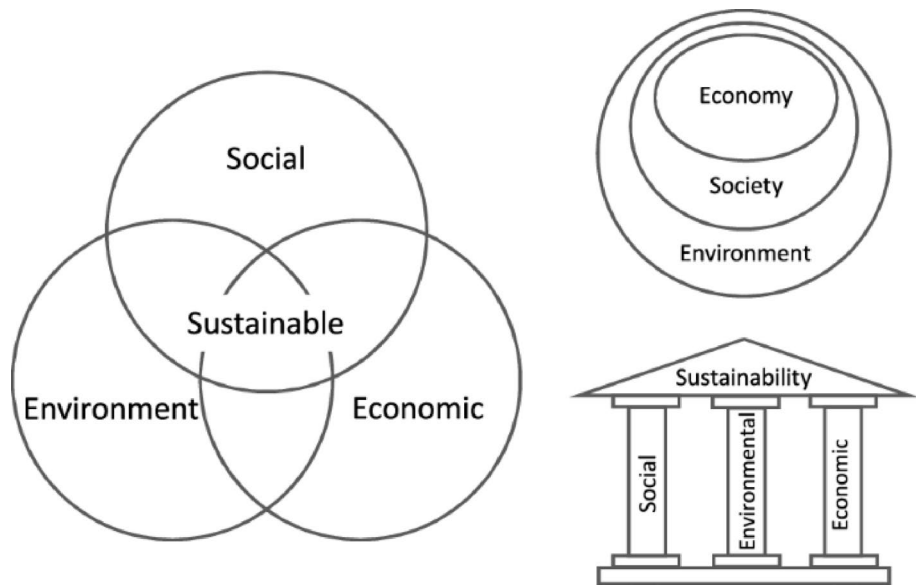


Fig. 2 Left: a typical representation of sustainability depicted as three intersecting circles. Right: More accurate alternative depictions, including the literal ‘pillar’ approach and concentric circles. *Source:* Purvis et al. [36]

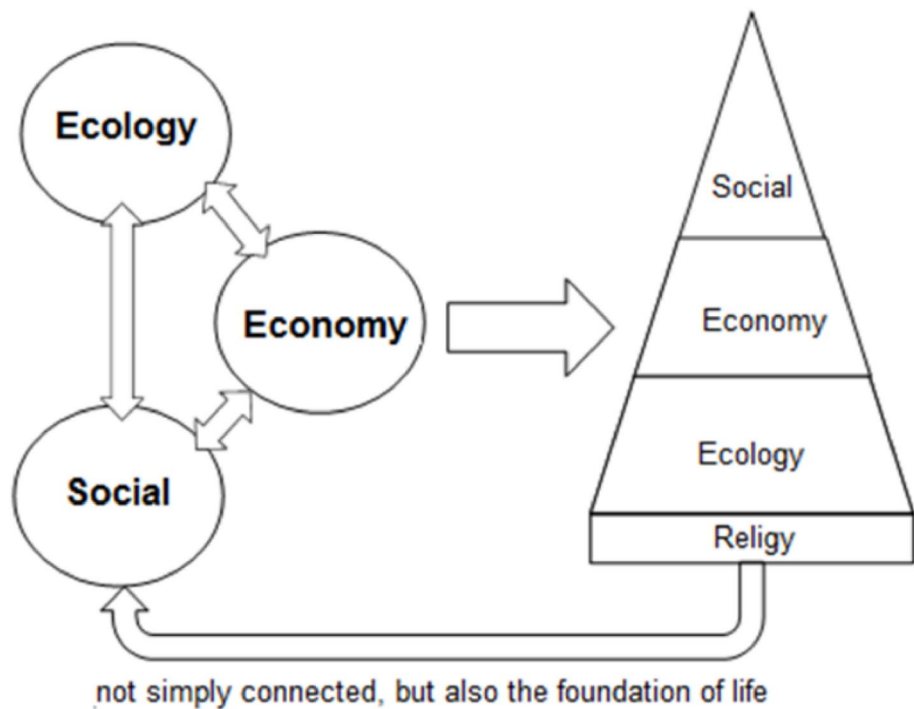


Fig. 3 The transition from the circular paradigm to the pyramidal paradigm model. *Source:* Susilo and Purwanti [43]

This framework serves as a universal call to action for all nations, whether developed or developing, to foster a global partnership aimed at eradicating poverty, safeguarding the planet, and ensuring universal peace and prosperity by the year 2030 [47].

The emerging paradigm in marine and coastal resource management necessitates a shift from the traditional circular model to a pyramidal structure (Fig. 3). In this hierarchy, ecology serves as the fundamental base, the economy occupies the central tier, and

the social dimension resides at the apex. This approach posits that ecological and economic sustainability function as the requisite foundation for achieving social harmony. Within the Indonesian context, the application of this pyramid is fortified by religious values acting as a spiritual foundation; this base ensures a sustainable and holistic equilibrium of energy ascending from the bottom to the summit of the structure [43].

The concept of an 'eco-surplus culture', initially introduced by Vuong in 2021, is posited as a cultural paradigm that fundamentally prioritizes the protection and restoration of the natural environment. It is operationalized as a collective matrix of pro-environmental attitudes, values, beliefs, and behaviors strategically aimed at mitigating anthropogenic ecological footprints while simultaneously advancing nature conservation and ecological restoration. Furthermore, public perceptions regarding the deleterious consequences of biodiversity loss—encompassing environmental degradation, economic stagnation, diminished opportunities for nature-based recreation, adverse public health outcomes, and the erosion of knowledge—demonstrate a robust positive correlation with pro-conservation attitudes. In this context, access to comprehensive biodiversity information is deemed critical for cultivating an eco-surplus culture and mobilizing financial resources for conservation initiatives [30]. The literature suggests that public inclination toward nature-based recreation presents a highly viable and sustainable funding mechanism for biodiversity conservation within protected areas and the preservation of urban green spaces. To garner sustained public backing for the development of biodiversity-rich parks, it is imperative to closely evaluate societal perceptions of park quality, user satisfaction metrics, and the underlying willingness to pay (WTP). Current scholarship further underscores that both social connectedness and nature connectedness significantly amplify park utilization rates and the financial contributions of urban residents. Urban parks function as vital nexuses for social interaction that catalyze pro-environmental civic engagement, such as volunteering, afforestation efforts, and community-led fundraising. Ultimately, nature connectedness serves as a foundational element in fostering an eco-surplus culture, as it engenders a profound sense of stewardship, belonging, and moral responsibility toward the environment. Empirical data reveals that a substantial majority of respondents demonstrate a willingness to donate to afforestation projects in public parks (84.10%) and national park conservation efforts (94.95%). Furthermore, 91.21% acknowledge biodiversity loss as a tangible and significant environmental crisis [22]. The paradigm of an eco-surplus culture posits that environmental protection, restoration, and regeneration need to be established as fundamental prerequisites for long-term economic resilience, political stability, and societal well-being. Conventional environmental protection frameworks, inherently shaped by growth-oriented and techno-centric economic paradigms, are critiqued for their underlying logical fallacies and structural vulnerabilities. In response to these deficiencies, the semiconducting principle of monetary and environmental value exchange is proposed. This principle dictates that while environmental value can be converted into monetary terms, the reverse—translating monetary value back into intrinsic environmental value—is fundamentally unattainable. Cultivating an eco-surplus culture facilitates the recognition of nature's intrinsic worth, thereby transforming the natural environment into an object of care. This profound ecological consciousness can often be catalyzed by serendipitous moments, which subsequently drive the formation of pro-environmental values and actions conducive to ecological preservation and restoration. Consequently,

at the policy level, there is an imperative to integrate sustainability principles comprehensively across all sectors, primarily through the formal recognition of nature's intrinsic value [48].

2.2 Sustainable tourism

Sustainable tourism is defined as tourism that comprehensively accounts for its current and future economic, social, and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities. The Principles of Sustainable Tourism, as outlined by the [51], comprise the following twelve aims:

1. *Economic viability* To ensure the viability and competitiveness of tourism destinations and enterprises, enabling them to continue to prosper and deliver benefits in the long term.
2. *Local prosperity* To maximize the contribution of tourism to the economic prosperity of the host destination, including the proportion of visitor spending that is retained locally.
3. *Employment quality* To strengthen the number and quality of local jobs created and supported by tourism, including the level of pay, conditions of service, and availability to all without discrimination by gender, race, disability, or other ways.
4. *Social equity* To seek a widespread and fair distribution of economic and social benefits from tourism throughout the recipient community, including improving opportunities, income, and services available to the poor.
5. *Visitor fulfillment* To provide a safe, satisfying, and fulfilling experience for visitors, available to all without discrimination by gender, race, disability, or other ways.
6. *Local control* To engage and empower local communities in planning and decision-making about the management and future development of tourism in their area, in consultation with other stakeholders.
7. *Community well-being* To maintain and strengthen the quality of life in local communities, including social structures and access to resources, amenities, and life support systems, avoiding any form of social degradation or exploitation.
8. *Cultural richness* To respect and enhance the historic heritage, authentic culture, traditions, and distinctiveness of host communities.
9. *Physical integrity* To maintain and enhance the quality of landscapes, both urban and rural, and avoid the physical and visual degradation of the environment.
10. *Biological diversity* To support the conservation of natural areas, habitats, and wildlife, and minimize damage to them.
11. *Resource efficiency* To minimize the use of scarce and non-renewable resources in the development and operation of tourism facilities and services.
12. *Environmental purity* To minimize the pollution of air, water, and land and the generation of waste by tourism enterprises and visitors.

In 1997, REST characterized Community Based Tourism (CBT) as tourism that emphasizes environmental, social, and cultural sustainability, managed and owned by the community for the community, aimed at enhancing visitors' awareness and understanding of the community and its local lifestyle. Community-Based Tourism (CBT), introduced by Suansri Potchana in 2003, represents a distinct tourism model with characteristics that diverge significantly from mass tourism. Unlike conventional commercial models

driven primarily by investor profit maximization, CBT prioritizes the socio-environmental impacts of tourism activities. Originating from community development strategies, this approach utilizes tourism as a vehicle to bolster the organizational capacity of rural communities, ensuring that resource management is conducted through active local participation. According to [34], the fundamental principles of CBT include:

1. Recognizing, supporting, and promoting community ownership of tourism;
2. Involving the community from the onset across all operational aspects;
3. Fostering community pride;
4. Enhancing the quality of life;
5. Ensuring environmental sustainability;
6. Preserving local uniqueness and cultural character;
7. Facilitating cross-cultural learning;
8. Respecting cultural diversity and human dignity;
9. Distributing benefits equitably among community members;
10. Allocating a fixed percentage of revenue to community development activities.

Sustainable community-based tourism (SCBT) was introduced to address the deficiency in the literature about sustainable tourism and community-based tourism, encompassing four dimensions: economic, ecological, socio-cultural, and governance [8]. The authors present the concept of Sustainable Multicultural Community-Based Tourism, emphasizing inter-ethnic collaboration to safeguard ancestral cultural identities within the context of sustainable community-oriented coastal tourism development. It is imperative to enrich this concept through the lens of a sustainable tourism paradigm anchored in an eco-surplus culture. Consequently, sustainability should be reconceptualized not merely as social collaboration and cultural preservation, but fundamentally as a proactive endeavor to drive the protection, restoration, and regeneration of coastal ecosystems. The eco-surplus culture is manifested in the management practices cultivated within this multicultural society, characterized by shifts in community values and behaviors that actively generate ecological benefits rather than merely mitigating negative impacts. Furthermore, cultural diversity acts as a catalyst for social learning, cross-ethnic collaboration, and shared responsibility toward the mangrove ecosystem. Inter-ethnic mutual cooperation (*gotong royong*) transcends its traditional function of maintaining social harmony and cultural identity; it emerges as a potent collective force that centralizes nature—specifically the mangrove ecosystem—within the framework of equitable, resilient, and intergenerationally-oriented tourism management. This profound synthesis ultimately culminates in the proposed novel framework of sustainable multicultural community-based tourism (Fig. 4).

3 Research method

This study was carried out in the mangrove tourism region of Mandar Village, Banyuwangi Regency, from August 2024 to January 2025 (Fig. 5). This study utilized judgment sampling methods to choose respondents regarded most relevant and important in the management of mangrove tourism in Kampung Mandar. The sample included the Traditional Leader, KUB, Poklahsar, Pokdarwis, Pokmaswas, Disperik, Disbudpar, Bakesbangpol, Diskop, Dinas PU/PUPR, DLH, ATR/BPN, Extension Workers, FPK, community leaders, Lurah Mandar, PPI, PLN, and Danlanal. The selection of these informants was



Fig. 4 Conceptual framework of sustainable multicultural community-based tourism

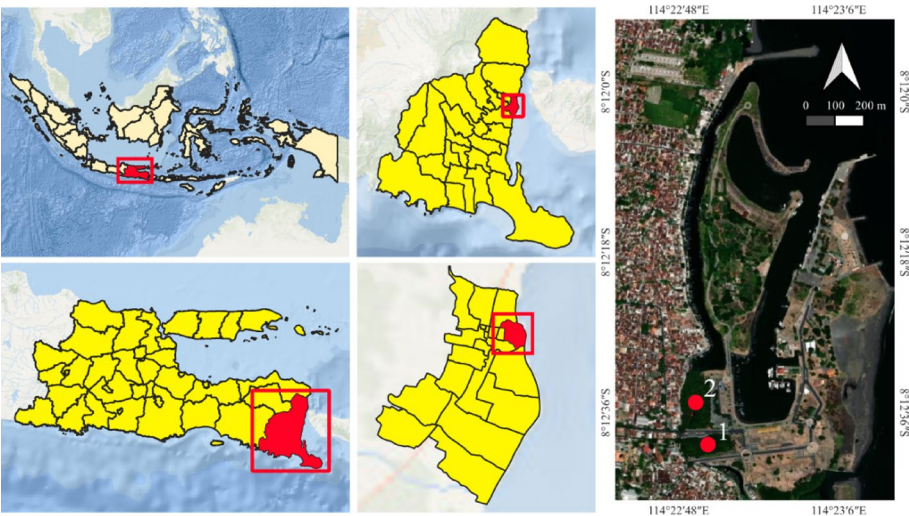


Fig. 5 Observation station for mangrove tourism, Mandar Village (Station 1: 8° 12' 39.60" E, 114° 22' 52.10" N; Station 2: 8° 12' 36.71" E, 114° 22' 53.08" N)

predicated on their degree of involvement and strategic significance in the development and management of the Kampung Mandar mangrove tourism area.

Data analysis was conducted to assess the viability of mangrove tourism utilizing the mangrove tourism suitability index. Rapfish Multidimensional Scaling (MDS) was employed to evaluate the sustainability of mangrove tourism, while the socio-ecological system framework was applied to examine interactions in mangrove tourism management. The analysis of the Tourism Suitability Index (TSI) confirms that the biophysical conditions of the study area are highly suitable for supporting mangrove ecosystems as ecotourism attractions, thereby establishing a robust ecological foundation for sustainable management. Within the Multi-Dimensional Scaling (MDS) Rapfish analysis,

the TSI values serve a critical function in reinforcing ecological indicators, which are employed as a primary metric for sustainability within the ecological dimension. Furthermore, the integrated findings from the TSI and MDS-Rapfish analyses substantiate the application of the Social-Ecological System (SES) framework. This integration explicitly highlights the interrelationships and feedback mechanisms among the core subsystems: the Resource System (RS), Resource Units (RU), Governance System (GS), and Actors (A) (Table 1).

The Tourism Suitability Index (TSI) analysis is employed to assess the alignment between mangrove tourism activities and existing biophysical conditions, ensuring optimal resource utilization without inducing ecological degradation. Concurrently, the sustainability analysis of mangrove tourism serves to evaluate management performance across ecological, economic, social, and governance dimensions. The findings from both analyses are subsequently utilized as a foundation for a social-ecological system (SES) analysis based on Ostrom’s framework. This integrative approach is designed to elucidate the interactions among resource components, actors, and institutions in fostering sustainable mangrove tourism management.

The stages in analyzing the Tourism Suitability Index (TSI) are as follows:

1. Mangrove thickness was analyzed based on spatial imagery obtained from the Google Earth application. At each observation station, measurements were conducted digitally by drawing a line perpendicular from the landward boundary to the outermost edge of the mangrove vegetation facing the sea.
2. Species density refers to the quantity of individuals of a given mangrove species i inside a specified unit area, represented by the formula:

Table 1 Data analysis, data sources, and data collection methods

No	Analytical focus/ variable	Data source	Data collection method
1	Tourism suitability index		
	a. Mangrove canopy thickness	Primary	Mangrove thickness parameters were calculated by utilizing spatial imagery from Google Earth applications
	b. Mangrove density	Primary	<i>In-situ</i> vegetation density data were empirically collected employing the transect line plot method with dimensions of 10×10 m
	c. Mangrove species	Primary	Data were procured through direct field observations across designated stations established via purposive sampling. Species identification was systematically cross-referenced with standard mangrove taxonomical manuals
	d. Tides	Secondary	Secondary oceanographic tidal data were officially sourced from the Geospatial Information Agency (BIG)
	e. Associated biota	Primary	Faunal biodiversity data were acquired through a triangulation of field observations, semi-structured interviews with managers of the mangrove tourism, local communities and fishers, and subsequent taxonomic identification utilizing mangrove biota guidebooks
2	Mangrove tourism sustainability	Primary	Multidimensional sustainability data were comprehensively aggregated via field observations, in-depth interviews, structured questionnaires, document reviews, and Focus Group Discussions (FGDs). This approach holistically evaluated the ecological, economic, socio-cultural, and governance dimensions
3	Social-ecological system	Primary	Systemic data were gathered employing observations, interviews, questionnaires, document analyses, and FGDs. The analytical process was strictly anchored in Ostrom’s Social-Ecological Systems (SES) framework to systematically delineate the complex interactions among actors, resource systems, resource units, governance systems, and resulting outcomes

$$K = \frac{n_i}{A}. \quad (1)$$

Total density refers to the quantity of all mangrove individuals inside a specified unit area, represented by the following formula:

$$KT = \frac{\sum n}{A}. \quad (2)$$

Description: K = Density of species-I; KT = Total density; A = Total area of sampling area (sample plot area); n_i = Total number of individuals of species-I; $\sum n$ = Total number of stands of all species.

3. Mangrove species were identified by comparing the morphological features of leaves, fruits, and root structures observed in the Kampung Mandar mangrove tourism area with descriptions provided in standard mangrove taxonomic guidebooks.
4. Tidal condition measurements were not carried out directly in the field; instead, secondary data from the Geospatial Information Agency (Badan Informasi Geospasial, BIG), relevant to the study location and period, were employed.
5. Biota data acquisition was conducted utilizing visual techniques [24]. The collection of biota data was carried out through direct field observation methods. The biota encountered were visually identified based on morphological characteristics, referring to a mangrove biota identification guidebook, without capturing or collecting any specimens. To enhance data accuracy, the observation results were further corroborated through interviews with the managers of the mangrove tourism site in Kampung Mandar, who possess local knowledge regarding the biota inhabiting the surrounding mangrove ecosystem.

This study did not involve animal experimentation, animal handling, invasive procedures, biological sampling, or collection of faunal specimens. Observations of the ecological components of the mangrove ecosystem were conducted non-invasively through visual observation and field documentation. Any fauna encountered during the study were recorded solely as supporting ecological data, without being touched, captured, relocated, manipulated, or subjected to any form of treatment. Consequently, approval from an animal ethics committee or an Institutional Animal Care and Use Committee (IACUC) was not required for this study.

The analysis of the mangrove tourism suitability index was conducted using several primary parameters, namely mangrove thickness, mangrove density, mangrove species, tidal range, and the types of biota present in the Kampung Mandar mangrove area (Table 2).

Tourism activities need to be adapted to the conditions of natural resources and their utilization. The tourism suitability index serves to identify ecosystems suitable for tourism [49]. The mangrove tourism category encompasses five elements with two assessment classifications:

$$TSI = \sum \left(\frac{N_i}{N_{maks}} \right) \times 100\%.$$

Table 2 Parameters, weights, categories, and ecotourism suitability scores. Source: Yulianda [53]

No	Parameters	Weights	Categories	Scores
1	Mangrove thickness (m)	5	> 500	3
			> 200–500	2
			50–200	1
			< 50	0
2	Mangrove density (100 m ²)	3	> 15–20	3
			> 10–15	2
			5–10	1
			< 5	0
3	Mangrove type	3	> 5	3
			3–5	2
			1–2	1
			0	0
4	Tides (m)	1	0–1	3
			> 1–2	2
			> 2–5	1
			> 5	0
5	Biota objects	1	Fish, shrimp, crab, molluscs, reptiles, birds	3
			Fish, shrimp, crab, molluscs	2
			Fish, molluscs	1
			One of the aquatic biota	0

Description: TSI = Mangrove tourism suitability index; Maximum value: 39; Suitable: 75–100%; Conditionally suitable: 50–< 75%; Not suitable: < 50%; N_i = Value of the i -th parameter (weight $\times$ score); N_{maks} = Maximum value of a tourism category.

The sustainability of mangrove tourism in Mandar Village, Banyuwangi Regency, Indonesia was evaluated across four dimensions utilizing a questionnaire administered to experts, with each indicator of the five dimensions rated on a scale from 1 (poor) to 3 (excellent). A higher score signifies that mangrove tourism is in a favorable state. The stages of analysis comprise the analytical process [21]:

1. *Multi-dimensional scaling (MDS)* This ordination technique is employed to assess the positioning of favorable and unfavorable spots.
2. *Monte Carlo (MC)* Monte Carlo analysis assesses the impact of stochastic errors employed to estimate the ordination value utilized.
3. *Leverage* Utilize leverage analysis to identify the traits that are responsive to each dimension of sustainability—namely environment, economy, socio-culture, and governance—in enhancing the assessed index value.

The procedure for analyzing the sustainability of mangrove tourism in Mandar Village encompasses the following stages:

1. Determination of dimensions and attributes
 - a. Defining the sustainability dimensions to be analyzed, specifically: ecological, economic, socio-cultural, and governance (Table 3).
 - b. Identifying specific attributes within each dimension based on existing literature and actual field conditions.
2. Data collection and scoring

Table 3 Dimensions, attributes, and sustainability scores of mangrove tourism. *Source:* Adapted from Dangi and Jamal [8]

No	Dimension	Attribute	Score
1	Ecological	Area carrying capacity	1 = exceeds carrying capacity; 2 = meets carrying capacity; 3 = below carrying capacity
		River water quality	1 = poor; 2 = moderate; 3 = good
		Precipitation	1 = low; 2 = moderate; 3 = high
		Riverbank alteration	1 = high alteration, 2 = moderate alteration, 3 = low alteration
		Mangrove density	1 = 5–10; 2 > 10–15; 3 = > 15–20
		Mangrove thickness	1 = 50–200 m; 2 = > 200–500 m; 3 = > 500 m
		Mangrove species diversity	1 = 1–2 species; 2 = 3–5 species; 3 = > 5 species
		Associated fauna types	1 = Fish, mollusks; 2 = Fish, shrimp, crabs, mollusks; 3 = Fish, shrimps, crabs, mollusks, reptiles, birds
2	Economic	Tidal range	1 = > 2–5 m; 2 = > 1–2 m; 3 = 0–1 m
		Profitability	1 = low; 2 = moderate; 3 = high
		Government assistance	1 = low; 2 = moderate; 3 = high
		Managers' capability in Tourism operation	1 = inadequate; 2 = adequate; 3 = highly capable
		Employment generation	1 = low; 2 = moderate; 3 = high
		Utilization of local products	1 = 1 product; 2 = 2–3 products; 3 = > 4 products
3	Socio-cultural	Equity in wage distribution	1 = inequitable; 2 = moderately equitable; 3 = highly equitable
		Tourism management conflicts	1 = severe conflict; 2 = mild conflicts; 3 = no conflict
		Quality of tourism facilities	1 = poor quality; 2 = moderate quality; 3 = good quality
		Managers' knowledge in tourism operation	1 = low knowledge; 2 = moderate knowledge; 3 = high knowledge
		Tourist perception	1 = poor; 2 = moderate; 3 = good
		Community participation	1 = low participation; 2 = moderate participation; 3 = high participation
4	Governance	Implementation of <i>Sapta Pesona</i>	1 = inadequate; 2 = adequate; 3 = well-implemented
		Tourism attraction development	1 = inadequate; 2 = adequate; 3 = good
		Managers' capability in utilizing information technology	1 = inadequate; 2 = adequate; 3 = capable
		Eco-friendly tourism facility development	1 = inadequate; 2 = adequate; 3 = good
		Stakeholder involvement	1 = low; 2 = moderate; 3 = high
		Tourism management group	1 = inactive; 2 = group exists and is moderately active; 3 = group exists and is highly active
		Human resource training and development	1 = 1–2 times/year; 2 = 3–5 times/year; 3 = > 5 times/year
		Tourism management regulations	1 = no regulations; 2 = regulations exist and are moderately enforced; 3 = regulations exist and are well-enforced

- a. Gathering data through field observations, in-depth interviews, and documentation.
- b. Assigning a score to each attribute using a 1–3 ordinal scale to reflect the actual conditions.

3. Data matrix construction

- a. Inputting the assigned scores into an attribute x analysis object matrix.
- b. Utilizing this matrix as the foundational data for the multidimensional analysis process.

4. Multidimensional Scaling (MDS) Analysis

- a. Conducting MDS analysis (ordination) to map the sustainability position within an ordination space.
- b. Generating a sustainability index value ranging from 0 to 100 for each respective dimension.

5. Determination of sustainability status

Categorizing the generated index values into the following sustainability statuses (Table 4).

f. Leverage analysis (attribute sensitivity)

- a. Identifying the most sensitive attributes that exert the most significant influence on the overall sustainability value.
- b. Utilizing these findings to establish concrete management priorities.

g. Goodness of fit test

Evaluating the stress value (<0.25) and the coefficient of determination (R^2 approaching 1) to ensure the reliability and validity of the model. The goodness of fit in MDS analysis is assessed using the S-stress value and the coefficient of determination (R^2). A low S-stress value signifies an excellent fit [16]. The model is considered satisfactory if the study yields an S-stress value below 0.25 ($S < 0.25$) and an R^2 value nearing 1 (100%) [32]. An analysis utilizing the Rapfish software tool yielded the sustainability index value for Mandar Village Indonesia's mangrove tourism, as presented in Table 3, categorized into four sustainability status levels: none, low, adequate, and sustainable.

h. Monte Carlo analysis

- a. Testing the stability of the analytical results through random data simulation.
- b. Comparing the MDS outputs with the Monte Carlo results to assess the level of uncertainty or error margins.

i. Result interpretation

- a. Integrating the findings derived from the sustainability indices, leverage analysis, and Monte Carlo simulations.
- b. Elucidating the practical and theoretical implications for mangrove tourism management within the broader social-ecological system framework.

The procedure for analyzing the social-ecological system (SES) of mangrove tourism in Mandar Village comprises the following stages:

1. Data typology

Table 4 Categories of sustainability status. Source: Pitcher and Preikshot [33]

Index value	Category
0–25	unsustainable
> 25–50	Less sustainable
> 50–75	Sufficiently sustainable
> 75–100	sustainable

- a. *Primary data* Gathered through interviews, field observation, and Focus Group Discussions (FGDs) with key stakeholders, including the Tourism Awareness Group (*Pokdarwis*), the multicultural community, government officials, and business actors.
 - b. *Relational data* Pertaining to inter-actor relationships, specifically encompassing collaboration, information flows, conservation efforts, and decision-making processes.
2. Actor and relational identification
 - a. Defining the *nodes* (representing the actors) and *edges* (representing the relational ties).
 - b. Structuring these relationships into an adjacency matrix, employing either a binary (0–1) format or a weighted format based on interaction intensity.
 3. Data processing via RStudio
 - a. Data sets are compiled in a.csv format and imported using the `read.csv()` function.
 - b. The adjacency matrix is subsequently transformed into a network object utilizing the `igraph` package, specifically through the `graph_from_adjacency_matrix()` function.
 4. Centrality analysis

Connectivity analysis of the Social-Ecological System of mangrove tourism using RStudio program, encompassing degree centrality, betweenness centrality, and cluster centrality. The centrality measure indicates that nodes with a greater number of direct connections will exhibit greater dominance than those with fewer or no connections.

- a. Degree centrality: Measuring the extent of an actor's interconnectedness within the network.

Consequently, degree centrality (DC) is merely the degree of each node. The degree of a node refers to the quantity of connections it possesses with other nodes [26]. The equation for degree centrality is as follows:

$$C_D(n_i) = \frac{\sum_1^j e_{ij}}{N - 1}$$

where $C_D(n_i)$: centrality degree (n_i) in the network (degree); N : total number of nodes in the system; e_{ij} : the edge between node (i) and node (j).

- b. Betweenness centrality: Evaluating an actor's role as a broker or bridge connecting different parts of the network.

Betweenness Centrality (BC) quantifies the extent to which a node lies on the shortest paths connecting other nodes in a network, necessitating that those paths traverse through that node. Consequently, nodes with elevated connectedness exhibit greater dominance as they are positioned to monitor or regulate the flow of information inside the network [26]. The equation for betweenness centrality is as follows:

$$C_B(n_i) = \sum_{j < k} g_{jk}(n_i) / g_{jk}$$

where $C_B(n_i)$: betweenness centrality (n_i) in the network (betweenness); g_{jk} : the geodesic between nodes j and k ; $g_{jk}(n_i)$: the number of geodesics between nodes j and k that contain node i .

- c. Closeness centrality: Assessing the proximity or ease of access to information among actors.

Cluster Centrality (C_c), or community discovery, is a method for quantifying centrality in a social network, emphasizing the proximity of an actor to all other actors. C_c will compute the centrality weight of a node by summing the shortest distances between node i and other nodes [25]. Community detection is assessed with the subsequent formula:

$$C_C = \frac{N - 1}{\sum_{j \neq i}^n d(n_i, n_j)}$$

where C_c : cluster centrality in the network; $d(n_i, n_j)$: distance between nodes (n_i) and (n_j); N : the number of nodes in the network.

- d. Network visualization

- a. The resulting social network is visually mapped within the RStudio environment.
- b. Visual parameters are configured such that *node* size correlates with the centrality level, while *node* color differentiates the actor categories.

- e. SES interpretation

- a. Identifying key systemic actors and underlying collaboration patterns.
- b. Elucidating the role of the established network in bolstering the sustainability of multicultural community-based mangrove tourism.

This study adopted the Social–Ecological System (SES) framework proposed by Ostrom to analyze interactions among key system components in mangrove tourism management. The SES was organized into four subsystems: Resource System (RS), Resource Units (RU), Governance System (GS), and Actors (A) (Table 5). These components were conceptualized as nodes within a social–ecological network to capture both social and ecological interdependencies.

1. Data on interactions among SES components were collected through structured interviews and questionnaires administered to purposively selected stakeholders directly involved in mangrove tourism management. Respondents were asked to identify the presence and intensity of interactions among components, including actor–actor, actor–resource, and actor–governance relationships. The responses were subsequently transformed into an adjacency matrix, in which rows and columns represent SES nodes and cell values indicate the existence and strength of relationships.
2. Centrality analysis was conducted following the principles of Social Network Analysis (SNA), with degree centrality used to quantify the relative importance of each node within the SES network. Degree centrality values were calculated using standard

Table 5 Node and node code of social ecological system

Social ecological system	Node	Node code
Resource system (RS)	Coastal Mandar Village	CoVillMan
	Mangrove	Mangrv
	Water quality	Klts_Ar
	River	River
Resource unit (RU)	Mangrove density	Krptn_Mgrv
	Mangrove thickness	Ktbln_Mgrv
	Mangrove biota	Bta_Mgrv
	Mangrove Biodiversity	KeanMgrv
Governance system (GS)	Ministry of Marine Affairs and Fisheries	KKP
	Fisheries Agency	Disperikan
	Culture and Tourism Agency	Disbudpar
	Environmental Agency	DLH
	Cooperatives, Micro-enterprises, and Trade Agency	Diskop_UMP
	Public Works and Water Resources Agency	DPUP
	Fisheries Training and Extension Center	BPPP
	National Land Agency	BPN
	PT Pelindo Properti Indonesia	PPI
	State Electricity Company	PLN
	Extension Officers	Pnylh
	Fisheries Cooperative	Koperik
	Joint Business Group	KUB
	Tourism Awareness Group	Pokdarwis
	Community Surveillance Group	Pokmaswas
	Processing and Marketing Group	Poklahsar
	Indonesian Tourism Entrepreneurs Association	HPI
	Indonesian Tour & Travel Agencies Association	ASITA
	Tour and Travel Agencies Association	ATAP
	Mangrove Management Regulation	Reg_Mang
	Tourism Management Regulation	Reg_Wsta
	Banyuwangi Festival	B-Fest
Actor (A)	Nature Tourism	NatTouri
	Culinary Tourism	CuliTour
	Cultural Tourism	CulTour
	Tourists	Wiswn
	Mandar village community	Msy Kmp Mandar
	Javanese ethnic	Sk Jwa
	Mandar ethnic	Sk Mndar
	Madurese ethnic	Sk Mdura
	Osing ethnic	Sk Osng
	Arab ethnic	Etn Arb
	Chinese ethnic	Etn Tghoa
Interaction (I)	Multicultural Community-Based Management	Pglln_MK
	Waste	Smph
	Polluting activities	Aktv_Pncmrn
	Mangrove processing	Pnglh_Mgrv
Outcome (O)	Sustainability	Susta
External (E)	Climate change	CliChang
	Tidal fluctuation	Pasut_Lt

SNA formulas and applied consistently across all nodes to ensure comparability. The resulting centrality scores reflect the structural role of each component in maintaining connectivity and interactions within the social–ecological system.

3. The results of the centrality analysis were subsequently integrated with the Tourism Suitability Index and the MDS–Rapfish sustainability analysis, to strengthen the interpretation of sustainability performance. This integrated approach provides a comprehensive assessment of how social structures, governance arrangements, and ecological conditions jointly influence the sustainability of mangrove tourism within the SES framework.

4 Result

4.1 Assessment of mangrove tourism viability in Mandar Village

The selection of Stations 1 and 2 was predicated on the location of the mangroves situated in the vicinity of the Mandar Village residential area, as well as the ecosystem conditions that previously experienced degradation but have demonstrated improvement in tandem with ongoing rehabilitation and management efforts. The amount of mangrove tourism in Mandar Village is quantified by a perpendicular line extending from the riverbank to the outermost mangrove vegetation adjacent to the sea. The proliferation of mangrove trees is a natural occurrence. Station 1 exhibits the greatest thickness at 164.83 m, whilst station 2 measures 96.52 m (Table 6). Consequently, based on the mangrove thickness parameters at both stations, Mandar Village’s mangrove tourism is deemed less suited for ecotourism, as the thickness falls between the range of 50–200 m.

Mangrove tourism in Mandar Village features three varieties of mangroves, including *Rhizophora mucronata* (Fig. 6a), characterized by its lustrous leaves, broad elliptical shape with acuminate tips, and both supporting and aerial roots. Secondly, *Sonneratia alba* (Fig. 6b) possesses distinctive features including green, oval-shaped leaves with rounded tips, respiratory roots, and spherical, flat, green fruit resembling apples. Third, *Avicennia marina* (Fig. 6c) possesses oval or elliptical leaves, respiratory roots, and grayish-green fruit like a mango. The mangrove species commonly discovered and spread in mangrove tourism is *Avicennia marina* (Table 7).

The mangrove environment exhibits varying species abundance (Table 8). The maximum density at station 2 is 45 trees per 100 m², while the minimum density at station 1 is 28 trees per 100 m². The rehabilitated mangrove area, initiated by the government, seeks to regulate community behavior to prevent littering and restore the compromised mangrove ecology. This mangrove habitat is in proximity to residential areas, culinary enterprises, processing businesses, Boom Beach tourism, and fishing boat docking facilities.

The tidal conditions in the Mandar Village mangrove tourism region, as indicated by tidal data (Fig. 7) from the Geospatial Information Agency (BIG), demonstrate that there are two high tides and two low tides each day, characterized by varying sea level elevations and durations. The peak tidal measurement of 1.142 m occurred in October 2024 (01:00 WIB), with an average tidal height of 0.88 m, for the period from October 2024 to

Table 6 Thickness of mangrove tourism in Mandar Village

Observation station	Thickness (m)
1	164.83
2	96.52

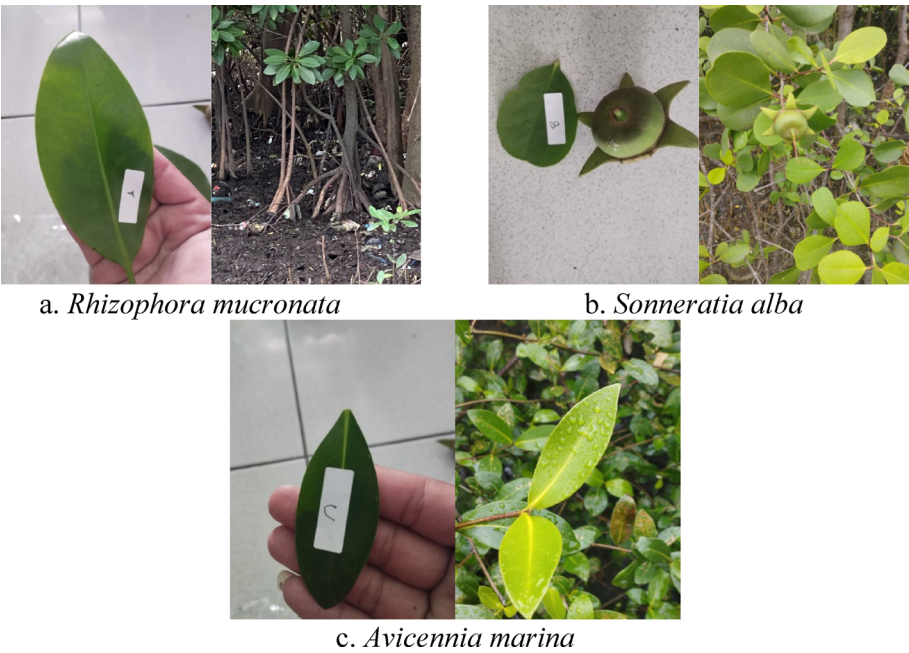


Fig. 6 Varieties of mangrove in Mandar Village

Table 7 Varieties of mangrove

No	Varieties of mangrove	Station	
		I	II
1	<i>Rhizophora mucronata</i>	++	+
2	<i>Sonneratia alba</i>	+	++
3	<i>Avicennia marina</i>	+	+++

Description: (+) few = 1–10 individuals, (++) moderate = 11–20 individuals, (+++) many ≥ 20 individuals

Table 8 Density of mangrove species in Mandar Village

No	Varieties of mangrove	Tree level (per station)	
		I	II
1	<i>Rhizophora mucronata</i>	16	1
2	<i>Sonneratia alba</i>	6	17
3	<i>Avicennia marina</i>	6	27
	Jumlah	28	45
Total per individual station/100 m ²		9	15

January 2025. The minimum level was recorded in October at –1.144 m at 08:00 WIB, with an average of 0.99 m. The tidal conditions of the Mandar Village mangrove tourism area are classified as suitable, as they typically remain below 1 m.

Mangrove biota encompasses mammals, birds, reptiles, amphibians, crustaceans, mollusks, and fish, all of which inhabit and interact within the mangrove ecosystem [31]. The mangrove ecosystem serves as a feeding, spawning, and nursery ground, attracting fish and creating a conducive habitat for aquatic biota [39]. Field observations and conversations with managers indicate that the Mandar Village mangrove tourism area encompasses diverse biota, including both aquatic and terrestrial species. In the research location, the predominant species of aquatic biota observed are mudskippers, mullet, kacang, kerong-kerong, and oysters (Table 9). Kacang fish are species that inhabit

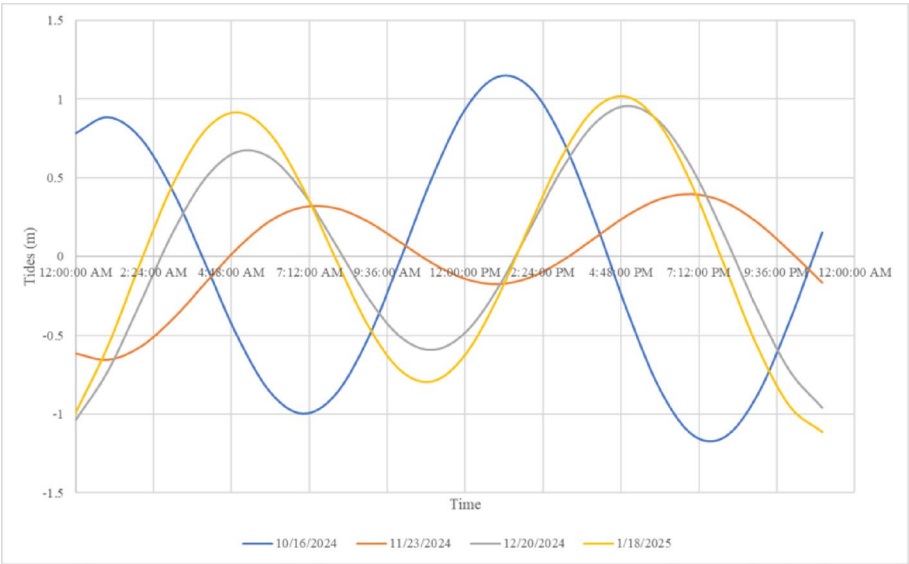


Fig. 7 Tidal patterns in Mandar Village

Table 9 Categories of mangrove tourism biota in Mandar Village

Type	Local name	Scientific name	Station	
			1	2
Fish	<i>Gelodok</i>	<i>Oxudercinae</i>	+	+
	<i>Belanak</i>	<i>Moolgarda seheli</i>	–	+
	<i>Sliding</i>	<i>Pempheris schwenkii</i>	–	+
	<i>Mujair</i>	<i>Oreochromis mossambicus</i>	+	–
	<i>Kacangan</i>	<i>Tylosurus crocodilus</i>	–	+
	<i>Gabus</i>	<i>Channa striata</i>	–	+
	<i>Kerong-kerong</i>	<i>Terapon sp</i>	–	+
	<i>Kepiting bakau</i>	<i>Scylla tranquebarica</i>	+	+
Crustaceans	<i>Kepiting biola</i>	<i>Uca</i>	+	+
	<i>Ketam</i>	<i>Varuna litterata</i>	+	+
	<i>Udang putih</i>	<i>Panaeus merguensis</i>	+	+
	<i>Udang windu</i>	<i>Penaeus monodon</i>	–	+
Molluscs	<i>Tiram</i>	<i>Crassostrea Gigas</i>	+	+
Reptiles	<i>Biawak</i>	<i>Varanus</i>	–	+
	<i>Ular tambak</i>	<i>Cerberus schneiderii</i>	–	+
	<i>Kadal mangrove</i>	<i>Emonia atrocostata</i>	–	+
Birds	<i>Kuntul besar</i>	<i>Egretta alba</i>	+	+
	<i>Blekok sawah</i>	<i>Ardeolla speciosa</i>	+	+

Description: (–) not found, (+) found

mangrove regions during high tide in search of sustenance. The terrestrial fauna associated with the species commonly identified is the great egret (*Egretta alba*). The reptilian species commonly observed at the research site includes monitor lizards (*Varanus salvator*).

4.2 The sustainability of mangrove tourism in Mandar Village

A sustainability number approaching 100 indicates a superior sustainability status, while conversely, a lower value signifies a diminished status. If it approaches zero, the sustainability status will deteriorate [46]. The evaluation of the sustainability state of Mandar

Village mangrove tourism, based on four criteria (Fig. 8), is 56.55%, indicating a moderate level of sustainability. Nonetheless, it necessitates development and more efficient administration to attain a greater degree of sustainability.

In the MDS Rapfish analysis, leverage values are utilized to identify the sensitive attributes that exert the most significant influence on the sustainability status within each dimension. Attributes exhibiting high leverage values indicate a dominant role in determining the overall level of sustainability. Within the ecological dimension, mangrove thickness yielded the highest leverage value, serving as a critical indicator that reflects the underlying ecosystem conditions. Employment generation plays a pivotal role in the economic dimension, whereas tourist perception is reflective of the socio-cultural dimension. Concurrently, within the governance dimension, regulatory frameworks emerge as a key factor in supporting management effectiveness. Consequently, these identified attributes are designated as primary priorities in ongoing efforts to enhance the sustainability of mangrove tourism (Fig. 9).

Monte Carlo analysis is employed to assess the impact of stochastic errors on the estimation of the ordination value utilized. Monte Carlo analysis is valuable for examining the impact of attribute score inaccuracies, data entry mistakes, or absent data [23]. The outcomes of the Monte Carlo analysis reveal that the sustainability status value of Mandar Village mangrove tourism closely aligns with the findings derived from the MDS Rapfish research. The Monte Carlo analysis (Table 10) conducted in this study was performed 25 times, yielding little and minor differences in the results. This indicates that the ordination procedure has effectively mitigated random mistakes that may occur from discrepancies in researcher assessments or inaccuracies in data entry. Consequently, it can be inferred that the investigation into the sustainability of Mandar Village mangrove tourism has employed a robust and precise model.

The precision of the MDS Rapfish analysis is ascertained by the S-Stress value derived from the computation of the S value. A low S-Stress value signifies great precision (goodness of fit), whereas a high S-Stress value denotes the contrary. In this Rap-beachtour, an optimal model is characterized by an S-Stress value less than 0.25 (<25%) and a coefficient of determination (R^2) nearing 1.0 or 100%. Conversely, an S-Stress value exceeding

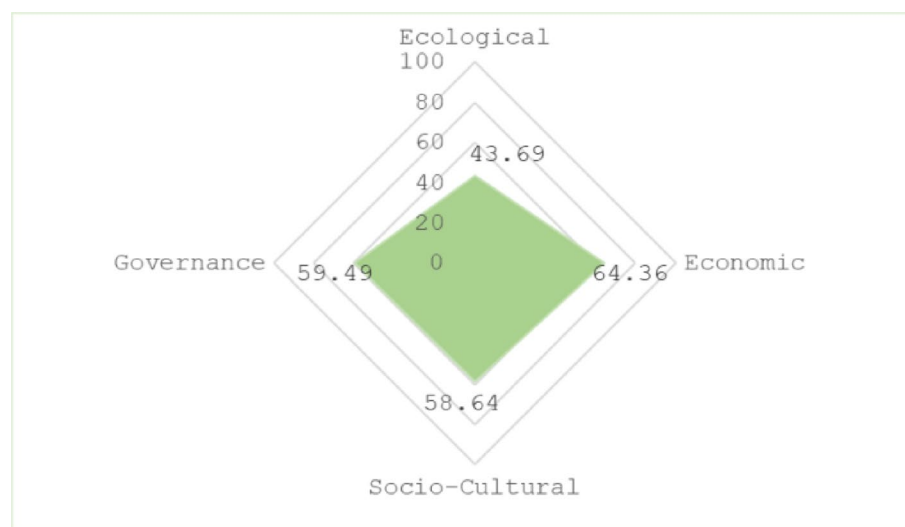


Fig. 8 Multidimensional sustainability of mangrove tourism

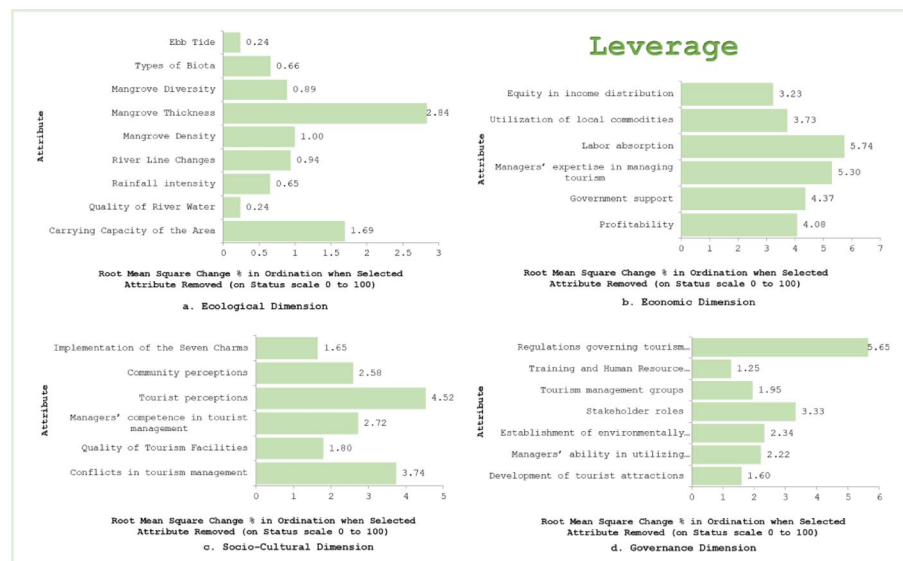


Fig. 9 Leverage of mangrove tourism

Table 10 Value of MDS, MC, stress and RSQ

Dimensions	MDS	MC	Difference	Stress	RSQ (%)
Ecology	43.692	43.819	0.127	0.246	92.84
Economic	64.362	63.669	0.694	0.178	95.95
Socio-cultural	58.639	58.078	0.562	0.221	94.45
Governance	59.490	59.033	0.456	0.233	93.72

0.25 or 25% indicates low accuracy in the results of the Multidimensional Scaling (MDS) calculation [44]. The S-stress value for the four dimensions of sustainability is below 0.25, with a squared correlation (RSQ) value nearing 1.00, namely within the range of 0.92 to 0.95. Consequently, it can be inferred that all variables employed in the investigation of the sustainability of Mandar Village mangrove tourism have proven beneficial, since they elucidate the four dimensions examined.

4.3 Interaction of Social-Ecological Systems in Mangrove Tourism in Mandar Village

Centrality is one of the most widely used concepts in social network analysis. A centrality measure scores each node in the network in terms of its structural importance [5]. The mangrove (Mangrv) and nature tourism (NatTouri) in Mandar Village have the highest degree centrality value of 10 (Fig. 10), indicating that their presence has the greatest influence on other nodes.

Betweenness—the share of times that a node is passed through in order to complete the connection between pairs of nodes via the shortest path [50]. Betweenness indicates the node that serves as a link between two other nodes in a network, hence influencing the positioning of further nodes. The primary node, determined by betweenness, is mangrove (Mangrv), associated with nature tourism (NatTouri), with values of 144.5 and 74, respectively. Additionally, the river node (River) exhibits water quality (Klts_Air) values of 60 and 56, respectively. The actor node yielding the highest value is mangrove, establishing it as a pivotal player in mangrove tourism in Mandar Village (Fig. 11).

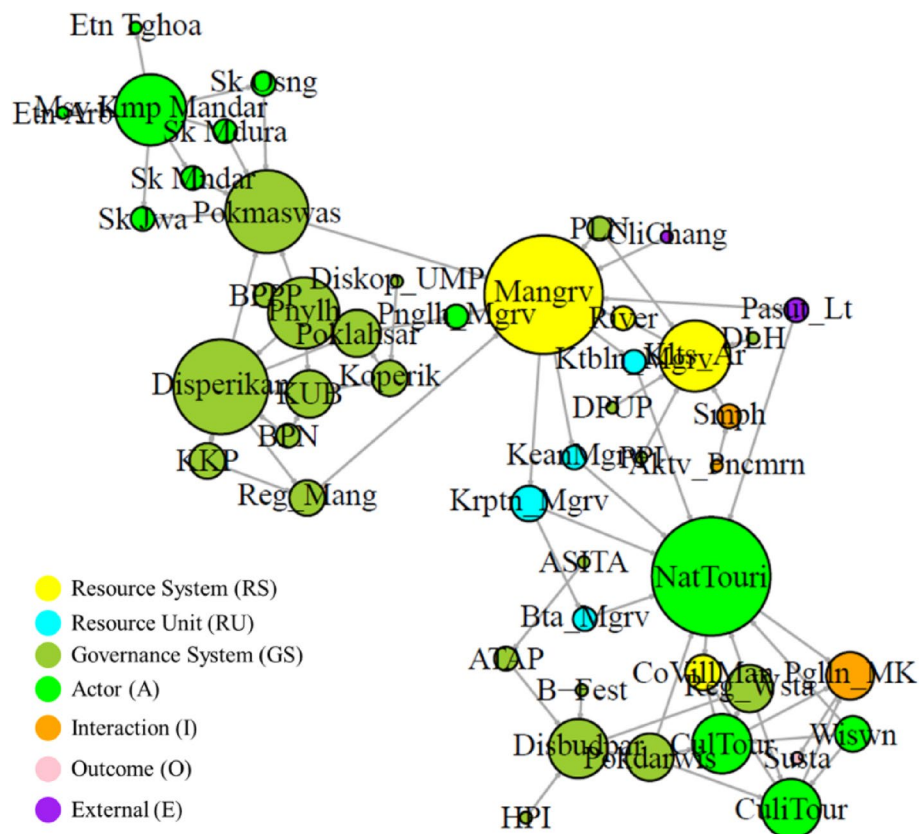


Fig. 10 Interaction of the social-ecological system of mangrove tourism in Mandar Village

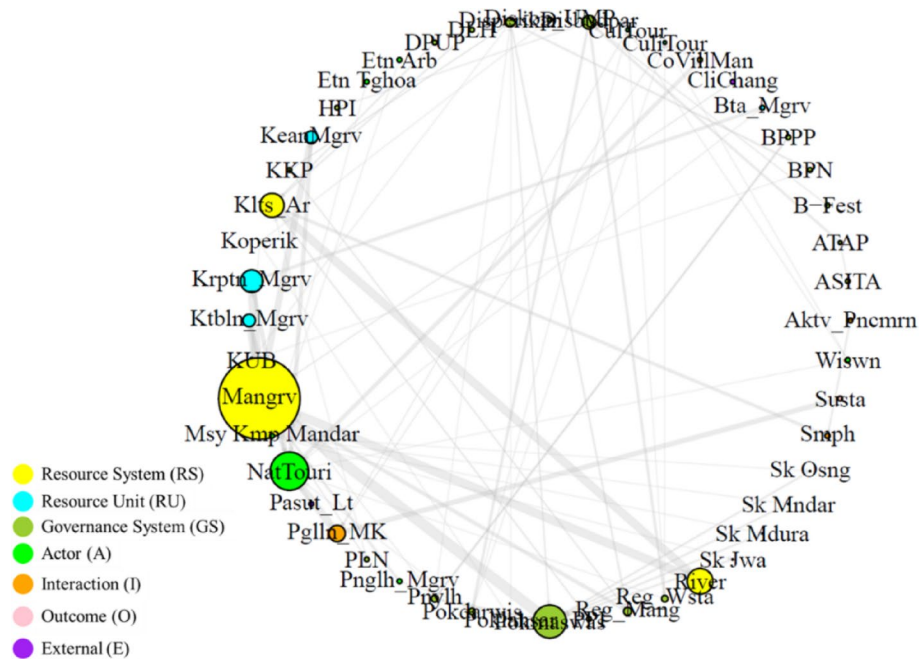


Fig. 11 Betweenness centrality mangrove ecotourism in Mandar Village

Cluster analysis is a set of techniques for assigning items into groups or classes based on the similarities or distances between them. Typically, these groups are mutually exclusive, forming a partition [5]. Clustering is grouping nodes with commonalities as a cohesive force within a community (Fig. 12).

5 Discussion

The Mandar tribe's migration to Banyuwangi in the eighteenth century originated from the historical connections between the kingdoms of Sulawesi and Blambangan, which subsequently established the social and cultural foundation of the coastal population in Banyuwangi. The arrival of Datuk Karaeng Puang Daeng Kapitan Galak and his forces not only provided military might but also maritime expertise and political connections that fortified Blambangan's stance against external threats such as Mataram and the Dutch, while also promoting the dissemination of Islam in the easternmost region of Java. Blambangan's allocation of coastal territory to the Mandar group acknowledged the strategic contributions of the Mandar tribe, creating an extensive territorial expanse from Tanjung to Pakis. Subsequently, the Mandar ancestors in Kampung Mandar experienced acculturation by intermarriage with Arab, Chinese, Madurese, and Osing ethnic groups, resulting in a dynamic and flexible multicultural society. The existence of the Mandar in Banyuwangi is not simply a migration event, but a fundamental aspect of the political, military, and cultural evolution of the coastal region. The Mandar identity, which integrates while preserving its marine characteristics, has generated a distinctive

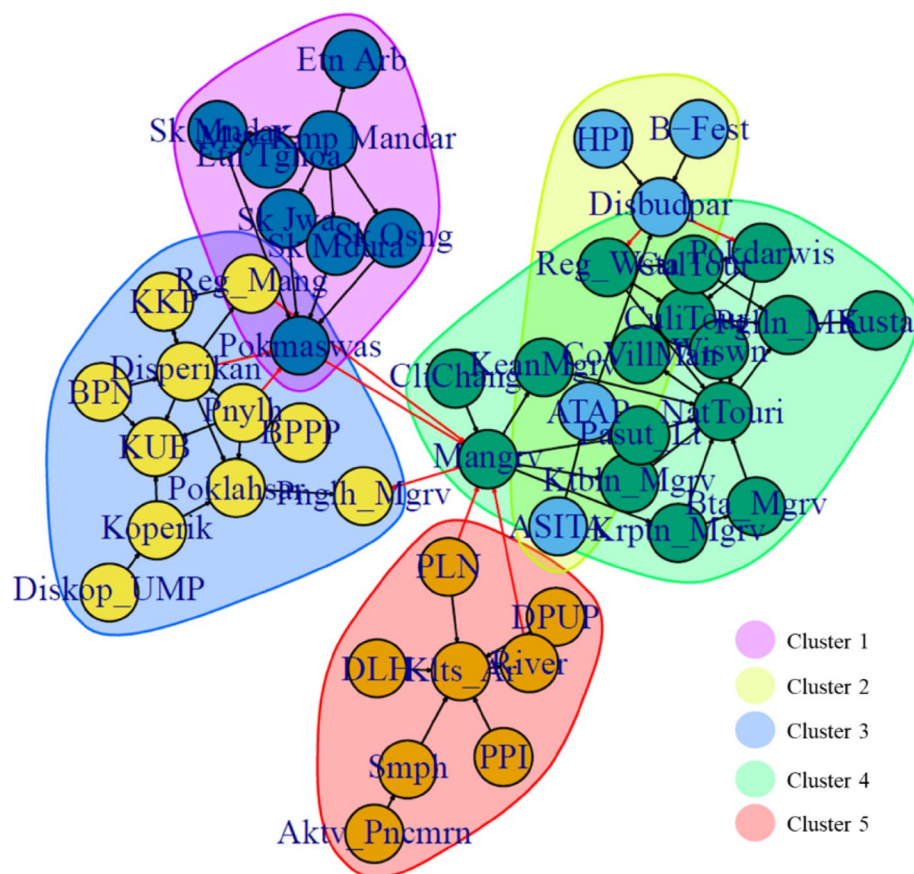


Fig. 12 Mangrove tourism cluster in Mandar Village

cultural heritage that may be used as tourist attractions, including historical sailing narratives, Bugis-Mandar rituals, coastal food, and community-based ecotourism.

Prior to 2009, the riverside region of Kampung Mandar was predominantly characterized by mangrove trees, which played a crucial role in sustaining the stability of the coastal ecology. Mangroves provide natural protection against erosion, act as carbon sinks, and provide as habitats for many aquatic organisms (Fig. 13). According to Alongi [1], mangrove forests are among the most effective ecosystems for carbon absorption and storage, primarily retaining carbon stocks in the soil and roots. Moreover, mangroves offer coastal protection by mitigating erosion and safeguarding terrestrial regions from sea waves, rendering them a crucial element of coastal ecosystem services.

From 2010 to 2011, road development involved the transformation of mangrove land into embankments. The procedure commenced with landfilling, pile installation, and the erection of concrete structures. Road development persisted in 2012–2013 utilizing concrete materials. In 2014, a breakwater was constructed to mitigate the effects of ocean waves. During the period from 2010 to 2017, the Fish Market region, once an estuary, transformed into a body of water as a result of alterations in water flow and sediment deposition. In 2017, the water pool was closed, and in 2018, direct access to the sea through Boom Beach was restricted due to the construction of a bridge.

The changes aimed to mitigate environmental impact while simultaneously altering the spatial configuration of the area. The alteration of the Fish Market use plan in 2019–2020 from a fish market to a culinary space indicates a transition from fishing operations to tourism-focused activities. In 2024, the Kampung Mandar river underwent dredging to alleviate silting that impeded fishing operations. The construction of embankments and breakwaters has maintained the river's width at approximately 50 m; nevertheless, this alteration has also influenced the velocity of water flow and silt deposition in the area.

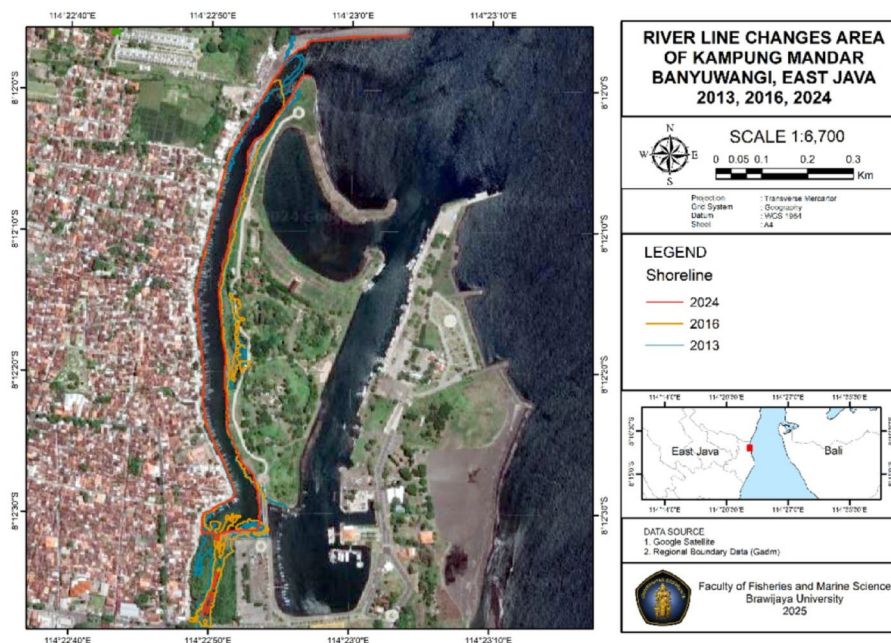


Fig. 13 River line changes area of Kampung Mandar Banyuwangi

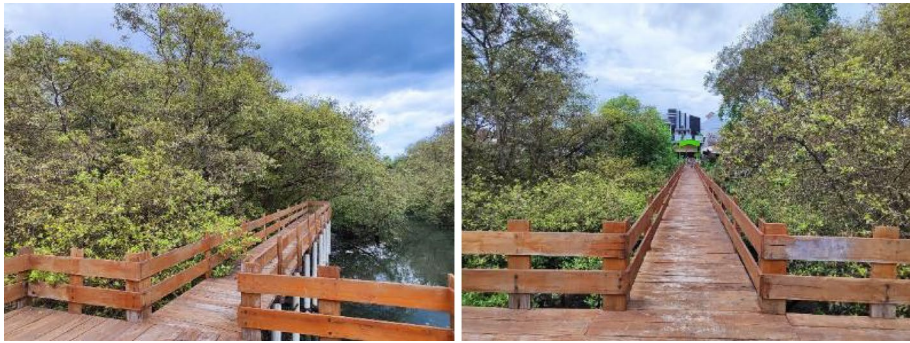


Fig. 14 Mangrove tourism in Mandar Village

Table 11 Suitability index for mangrove tourism in Mandar Village

No	Parameters	Weights	Observation station			
			1		2	
			Score	Value	Score	Value
1	Mangrove thickness	5	1	5	1	5
2	Mangrove density	3	2	6	2	6
3	Mangrove types	3	2	6	2	6
4	Tides	1	3	3	3	3
5	Biota objects	1	2	2	3	3
	Ni			22		23
	Value			56.41%		58.97%
	Category		Conditionally suitable		Conditionally suitable	

Mangrove tourism in Mandar Village (Fig. 14) was initiated in 2023 by the Ministry of Maritime Affairs and Fisheries through the establishment of the Mandar Village Youth Community Supervisory Group (*Pokmaswas*) Number: 188/KEP/429.501.13/2023, chaired by Muhammad Fathoni. The objective of developing mangrove tourism is to save the mangrove ecosystems in the Mandar Village region via tourist and economic initiatives centered around mangroves. The mangrove tourist site is situated between residential areas and Boom Beach tourism, adjacent to a river flow. The mangrove area of station 1 is 1.76 hectares, whereas station 2 encompasses 1.14 hectares [55] assert that the proximity of mangroves to residential areas subjects them to pressure from local residents’ activities, including illegal logging and trash.

The density of the mangrove forest serves as an attraction for tourists, as both overly dense and sparse mangroves are conducive to mangrove tourism. Mangroves exhibiting greater biodiversity will undoubtedly be more appealing to visitors. Moderate tidal conditions are conducive to safe mangrove tourism for guests. Mangroves with diverse biotic elements possess more aesthetic value for visitors [54]. The mangrove tourism suitability index at stations 1 and 2 in Mandar Village was 56.41% and 58.97% (Table 11 and Fig. 15), categorizing the mangrove tourism suitability as conditionally acceptable due to an index value ranging from 50–75%.

The promotion of mangroves as a tourism attraction is an appropriate strategy to ensure the sustainability of the mangrove environment while delivering economic advantages to coastal communities. Mangrove tourism can incentivize both the community and government to conserve and sustain the mangrove ecosystem due to its economic benefits. Tourists not only appreciate the natural beauty but also receive information on

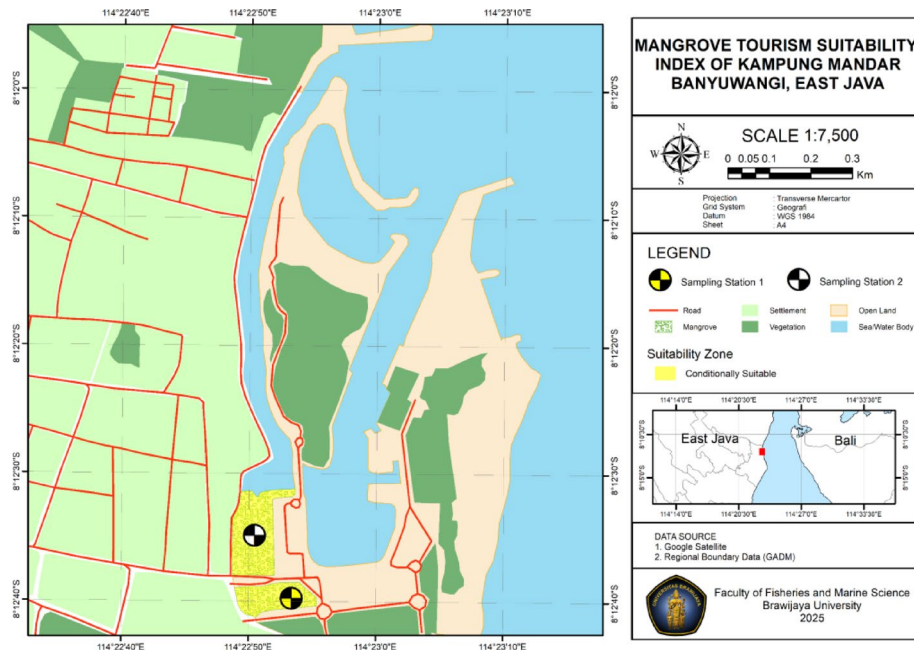


Fig. 15 Mangrove tourism suitability index of Kampung Mandar

the advantages of mangrove conservation to foster greater environmental consciousness. Furthermore, revenue generated from tourism activities may be designated for mangrove conservation and maintenance initiatives, including replanting and area restoration. The advancement of mangrove tourism serves as both a sustainable means to enhance community welfare and a strategic measure for preserving the integrity of the mangrove ecosystem.

Tourists' preferences for visiting mangrove tourism areas encompass the quality of attractions, pricing, comprehensiveness and safety of tourism, sustainability of mangroves, and hospitable service [13]. The mangrove ecosystem in Mandar Village offers economic benefits through mangrove tourism and processed items derived from mangroves. This region features three species of mangroves that naturally proliferate along the river, creating an ecosystem that is crucial for the stability of coastal zones and serves as a habitat for many marine organisms. The mangroves in the Mandar Village region are currently deemed unsustainable at 43.69% due to land degradation, erosion, and anthropogenic activities, necessitating mangrove reforestation initiatives to restore the ecosystem, enhance coastal protection, and promote environmental sustainability and the livelihoods of coastal communities. The findings of the study [11] indicated that the river water quality, in terms of salinity, pH, and temperature, at three sampling locations in Mandar Village usually conformed to the quality standards for river or sea water. Nonetheless, levels of nitrite, nitrate, and orthophosphate frequently exceed safe thresholds. This is largely attributable to the river's closeness to heavily inhabited regions, where inappropriate disposal of domestic garbage exacerbates contamination.

The mangrove environment of Mandar Village possesses economic potential as a natural tourism site and a source of processed mangrove-derived products, rendering mangrove tourism in Mandar Village very sustainable at 64.36%. The mangrove ecosystem serves as a tourist destination, showcasing distinctive natural beauty and a variety of flora and wildlife. Tourists can engage in activities such as trekking, birdwatching,

or boating, thereby enhancing their experience and augmenting local community revenue through tourism enterprises, including boat rentals, homestays, and souvenir sales. The study results [10] indicated that mangrove forests serve as a source of raw materials for various processed products, including syrup, nastar, kastengel, cookies, chocolate almonds, flowers, jam chopsticks, chocolate chopsticks, peanut cakes, and crispy brownies. These goods possess significant economic value and foster community innovation and entrepreneurship. The sustainable use of mangrove habitats can enhance economic welfare while preserving environmental sustainability.

Mandar Village is a multi-ethnic region comprising the Mandar, Osing, Javanese, Madurese, Chinese, and Arab ethnic groups. The mangrove ecosystem offers substantial social advantages for many ethnic groupings in the management of mangroves. The mangrove ecosystem not only sustains ecological life but also fortifies the social and cultural connections of the surrounding community, resulting in the classification of Mandar Village mangrove tourism as relatively sustainable at 58.64%. Mangrove conservation and management initiatives necessitate strong community engagement through planting, maintenance, and educational programs to foster a sense of belonging and cohesion between the community and organizations. Furthermore, the mangrove ecosystem serves as a platform for education and enhancing environmental consciousness among the youth through nature school initiatives or training programs. Managers can enhance partnerships and generate employment by collaborating with local people in the development of mangrove-based tourism or mangrove-processed industries. Consequently, the mangrove ecosystem not only sustains natural balance but also fosters harmony among ethnic groups and enhances community empowerment.

Efficient mangrove management necessitates the active participation of diverse stakeholders alongside explicit and stringent laws. The management of the mangrove environment in the Mandar Village region involves coordinated efforts to manage, maintain, and utilize mangroves, resulting in a sustainability classification of 54.49% for Mandar Village mangrove tourism. The government is crucial in formulating explicit policies and regulations, including the designation of protected areas, oversight of development activities, management of resource utilization, enforcement of stringent penalties for infractions, and provision of incentives for communities engaged in mangrove conservation. Local communities, as the stakeholders nearest to the mangrove environment, actively engage in the planting, maintenance, and responsible utilization of mangrove resources. Collaboration with non-governmental groups, academia, and the corporate sector is essential for delivering technical help, finance, and education.

The development of Mandar Village mangrove tourism, grounded in ecological dimensions, takes into account key features such as mangrove thickness, area carrying capacity, and mangrove density (Fig. 10a). The primary factor in the development of Mandar Village mangrove tourism is mangrove thickness. The growing density of the mangrove serves as an attraction and experience for travelers due to its aesthetic appeal. The density of the mangrove offers an optimal habitat for diverse biota, including birds, crabs, reptiles, and fish, so attracting tourists. Mangrove tourism necessitates control through tourist limitations, scheduled visits, and education on the advantages of conserving the mangrove ecosystem to achieve sustainable tourism. The carrying capacity of the mangrove tourism region refers to the mangrove ecosystem's capability to support tourism activities without inflicting environmental harm, which could diminish tourist

happiness. [2] highlighted that the carrying capacity of an area is assessed to restrict the number of tourists to preserve the sustainability of the mangrove environment.

The carrying capacity of the Mandar Village mangrove tourism area defines its capability to support tourism activities without leading to ecological deterioration or a decline in the quality of the visitor experience. The primary elements influencing carrying capacity are mangrove forest area, plant density, water depth, and infrastructural availability. An excess of visitors above optimal capacity can exert pressure on the mangrove ecosystem, resulting in damage to mangrove roots, disruption of aquatic biota, garbage accumulation, and infrastructure deterioration, so diminishing the area's aesthetic appeal and sustainability. The tourist accommodation capacity in Mandar Village is relatively low. This is attributable to multiple constraints, including the restricted width of the tracking path, inadequate supporting infrastructure, and the biological carrying capacity of the mangrove region, which necessitates proper protection. The inadequately developed track path restricts the simultaneous accommodation of tourists, hence posing a risk of ecosystem disruption during peak visitation periods. Moreover, there exists a scarcity of amenities such as rest spaces, informational displays, and tourist management systems. The role of the Mandar Village mangrove density is to preserve coastal ecosystem stability, safeguard rivers from erosion, and enhance biodiversity. The optimal mangrove density is essential for sustaining ecosystems and facilitating eco-friendly tourism activities. Mangrove tourism in Mandar Village is situated near the river, making it susceptible to alterations in river flow that may diminish the productivity of the mangrove ecosystem, decrease biodiversity, impair its ecological role as a protector against erosion, impact both aquatic and terrestrial habitats, disrupt ecosystem equilibrium, and further reduce biodiversity. Moreover, excessive sedimentation downstream can diminish water quality and threaten the survival of aquatic creatures.

The sustainability of mangrove tourism in Kampung Mandar is contingent upon management decisions being founded on quantifiable ecological indicators. A data-driven ecotourism planning methodology enables managers to sustain equilibrium between visitor attraction and ecological sustainability by monitoring mangrove thickness, measuring carrying capacity, and assessing vegetation density and hydrological conditions. The sustainability of tourism relies on tourist interest and the capacity of managers to continuously assess ecological data to preserve ecosystem functionality, which is the fundamental basis of mangrove tourism.

The primary factors in the economic aspect for achieving sustainable mangrove tourism in Mandar Village are labor absorption, management's capability to operate tourism, and governmental support (Fig. 10b). The mangrove ecosystem significantly contributes to the economy, particularly for employment opportunities. The conservation of the mangrove environment has ecological advantages and serves as a source of income for coastal people through the harvesting of economically valuable biota. The processing of mangrove-derived goods creates business opportunities for local populations. Mangrove ecosystem-based tourism also facilitates employment opportunities, including tour guides, homestay managers, and food vendors. Effective management of mangrove tourism is a crucial asset for enhancing the appeal and sustainability of tourist destinations based on mangrove ecosystems. Proficient managers can create appealing tour packages, including ecotourism, environmental education, and various tourism activities, to educate tourists on the significance of mangrove conservation while ensuring

their comfort and satisfaction. Managers' comprehension of efficient destination promotion via social media or partnerships with relevant entities to access a broader market. Government support for the development of mangrove tourism substantially influences the economic, ecological, and social viability of coastal communities. Government contributions to the advancement of mangrove tourism typically involve the construction of supporting infrastructure, provision of financial assistance to local communities for the development of mangrove-based products, delivery of tourism management training, environmental education, and technical support to enhance community capacity for professional and sustainable tourism management.

Sustainable development of mangrove tourism in Kampung Mandar necessitates economic planning grounded in labor data analysis, managerial capacity, and the efficacy of governmental backing. A data-driven tourism management strategy allows managers to discern economic growth prospects, assess the effects of tourism on community revenue, and develop focused economic empowerment strategies. Consequently, mangrove tourism serves as both a conservation strategy and a catalyst for sustainable, inclusive, and community-oriented local economies.

Mangrove tourism in Mandar Village can achieve sustainable development through socio-cultural dimensions by addressing factors such as tourist perceptions, conflicts in tourism management, and the competence of managers in tourism operations (Fig. 10c). The opinion of tourists regarding mangrove tourism attractions is crucial in influencing their pleasure and intention to return. An engaging experience for tourists fosters opportunities for them to endorse the destination to others. Consequently, tourism managers are encouraged to persist in enhancing the quality and diversity of attractions while ensuring sufficient facilities to maintain favorable tourist impressions and promote the sustainability of mangrove tourism. Conflicts between conservation concerns and economic exploitation of mangroves can adversely affect the growth of mangrove tourism. Regional development that neglects mangrove ecosystems, natural attractions, and biodiversity may lead to a deterioration in the quality of key mangrove tourism destinations. Conflicts among local communities, government, and the business sector can impede the construction of suitable tourism amenities and diminish community involvement in sustaining the mangrove ecosystem. Managers with a profound comprehension of mangrove ecology can facilitate the development of sustainable and instructive tourism initiatives. Furthermore, expertise in tourism management encompassing facilities management, marketing, and visitor services can enhance the overall experience for travelers. Managers should comprehend the principles of sustainability to mitigate the adverse effects of tourism activities on the mangrove ecosystem. The involvement of the multicultural community in Mandar Village, comprising Mandar, Osing, Javanese, Madurese, Chinese, and Arab ethnicities, has established a distinctive collaborative framework for managing mangrove tourism rooted in local wisdom through: complementary role distribution in ecosystem management, innovation of tourist attractions that integrate multiethnic cultural elements, and a conflict resolution mechanism based on inter-ethnic deliberation.

The sustainability of a destination is primarily influenced by managers' capacity to analyze tourist perception data, resolve stakeholder conflicts, and enhance multicultural collaboration via a community-based tourism strategy. This data-driven approach suggests that tourism success relies not alone on the ecosystem's aesthetic appeal but also

on a social framework that fosters peace, cultural innovation, and constructive interactions among management, communities, and tourists.

The main governance components in the development of mangrove tourism include regulatory frameworks for tourism management, stakeholder involvement, and the promotion of sustainable tourism practices (Fig. 10d). Regulations governing the utilization of mangrove habitats as tourism attractions are essential to guarantee ecological, economic, and social viability. Explicit laws governing tourism activities can mitigate harm to mangrove ecosystems, disrupt animal habitats, and reduce environmental pollution from waste or refuse. Effective laws will establish limitations on visitor numbers, designate permissible places for visitation, and outline allowable tourism activities to mitigate pressure on the mangrove habitat. Moreover, rules might guarantee that tourism revenue is designated for the conservation and upkeep of mangroves. The involvement of stakeholders in the development of mangrove tourism is essential for fostering synergy and ensuring sustainability in destination management. The government, in its regulatory capacity, is tasked with formulating policies and regulations that promote mangrove conservation and facilitate the development of tourism infrastructure. Local communities, as the entities nearest to the mangrove ecosystem, play a crucial role in preserving environmental sustainability and are the primary participants in tourism activities. The private sector can participate by investing in and innovating facilities and promoting destinations. Furthermore, non-governmental organizations (NGOs) and scholars can offer technical assistance, teaching, and research to facilitate sustainable tourist management. Creating sustainable facilities by constructing pathways from materials that do not harm mangrove roots, utilizing solar panels for illumination, and implementing designated waste receptacles to mitigate pollution. Moreover, educational institutions such as information centers or interpretive signage regarding the mangrove ecosystem might enhance tourist awareness.

The viability of mangrove tourism in Kampung Mandar is predominantly contingent upon the capacity of the government, community, and managers to establish a data-driven governance framework. Robust rules necessitate quantitative evaluation procedures; stakeholder participation demands the delineation of roles and communication pathways; and eco-friendly facilities should be underpinned by regular environmental impact evaluations. Utilizing a data-driven governance framework, the advancement of mangrove tourism can be oriented towards establishing a destination that serves not only as a recreational site but also as a paradigm of sustainable, transparent, and adaptive coastal governance in reaction to evolving ecological and social dynamics.

Mangrove protection has ecological advantages for organisms and serves as a tourist attraction. Mangrove forests are crucial for sustaining coastal ecological equilibrium by preventing erosion, sequestering carbon, and providing home for diverse kinds of fish, birds, and marine organisms. The diversity of mangrove and biota species renders it an appealing tourist destination. The Fisheries Service (Disperikan) plays a crucial role in advancing mangrove tourism, which has been operating at a consistent node of 8 degrees. Disperikan plays a crucial role in sustaining the Mandar Village mangrove through training and mentoring initiatives. In 2023, the Ministry of Marine Affairs and Fisheries (KKP) facilitated the transformation of Mandar Village mangrove into a natural tourism site. Water quality (Klts_Ar) and extension workers (Pnylh) exert an influence on the third position, characterized by a node of 6 degrees. Subpar water quality

resulting from environmental pollution diminishes aesthetic value, leads to organism mortality, and adversely affects the health of mangrove trees, potentially resulting in their demise. [40] explains that the volatility of these water quality factors would lead to a deterioration in quality and maybe the demise of mangroves.

Extension workers (Pnylh) play a crucial role in promoting the sustainability of the mangrove ecosystem through teaching, training, and support. Instruction delivered by extension workers enhances community awareness of the advantages of mangrove conservation, alongside technical instruction in planting and maintenance procedures to facilitate sustainable ecosystem management and mangrove-based processing for economic enhancement. Direct assistance aids the community in incorporating sustainability concepts into tourism activities, therefore mitigating adverse environmental impacts. The Department of Culture and Tourism (Disbudpar) is pivotal in the comprehensive development of mangrove tourism, serving not only as a natural attraction but also as an integral component of the gastronomic and cultural tourism of Mandar Village. The collaboration between extension workers and Disbudpar in integrating ecological considerations with tourism development exemplifies an effective multistakeholder strategy, using environmental conservation as a foundation for sustainable development.

The mapping of the Social-Ecological System of Mangrove Tourism in Kampung Mandar indicates that the Fisheries Department (Disperikan), Extension Workers (Pnylh), and the Culture and Tourism Agency (Disbudpar) are pivotal actors governing the flow of information, resources, and decision-making within the system. Disperikan serves as the principal governance center, connecting formal regulations (KKP, Reg_Mang) with diverse local stakeholder groups (KUB, Pokmaswas, Poklahsar, Koperik), hence acting as the primary catalyst for the integration of mangrove conservation and fishery exploitation. Pnylh functions as an operational broker, connecting Disperikan and central government policies with practical field applications via group support, innovation dissemination, and community feedback to the government; this role renders the efficacy of conservation and empowerment initiatives significantly reliant on extension capacity. Disbudpar serves as a tourism gatekeeper, linking ecosystem services (nature, culinary, and cultural tourism) with tourism industry stakeholders (Pokdarwis, HPI, ASITA, ATAP) through regulatory frameworks and promotional events (Reg_Wsta, B-Fest), thus influencing the balance between enhancing tourist arrivals and the sustainability of mangrove ecosystems. Enhancing the cooperation and capability of these three entities is a crucial leverage point for advancing the socio-ecological sustainability of the Mandar Village shoreline.

The presence of mangroves in Mandar Village offers ecological and economic advantages. Mangroves serve as natural coastal defenders against erosion, carbon sequestrators, and water quality regulators, while also providing home for diverse species of fish, crabs, birds, and other organisms. The economic management of mangrove ecosystems as nature-based tourism creates tourist attractions through activities such as river excursions, mangrove seedling planting, and wildlife observation. Local communities derive economic advantages from homestay enterprises, seafood gastronomy, and the selling of processed mangrove products, including syrup, handicrafts, and several other processed goods. The integration of environmental conservation and sustainable tourism fosters community revenue and enhances awareness of the significance of nature preservation.

Pokmaswas holds a pivotal role as an intermediary in preserving the sustainability of the mangrove ecosystem in Kampung Mandar. The Pokmaswas node is situated exactly between the management subsystem, the community, and the resource unit, hence serving as a connection between formal regulations and practical applications in the field. Socially, Pokmaswas comprises members from the Madurese, Javanese, and Mandar ethnic groups who collaborate closely with the diverse community of Kampung Mandar, which includes the Mandar, Madurese, Javanese, Osing, and other ethnicities, to establish community-based mangrove monitoring and protection systems. This diversity fosters social bridging capital, enhancing cross-ethnic collaboration and promoting joint efforts to save the coastal ecosystem.

The second intermediary entity positioned strategically inside the network is the Culture and Tourism Office (Disbudpar). This node links diverse tourism stakeholders—including nature tourism (NatTour), culinary tourism (CuliTour), cultural tourism (CulTour), and tourists (Wiswn)—with local institutions like Pokdarwis and tourism governance mechanisms such as Reg_Wsta and the B-Fest promotional agenda. This connectivity pattern illustrates Disbudpar's function as the primary conduit between the ecological significance of mangroves and their application in the tourism industry. Disbudpar plays a crucial role in aligning tourist development with mangrove environment conservation by regulating tourism standards, promoting destinations, and empowering tourism communities. Consequently, Disbudpar is instrumental in reconciling ecological and economic objectives within the socio-ecological framework of Kampung Mandar.

The Fisheries Service (Disperikan) serves as a third-party middleman, primarily connecting fisheries communities (KUB, Poklahsar, Koperik, Pnylh) with formal regulations and institutional support at both district and central levels. Disperikan enhances governance of mangrove and coastal resource exploitation through guidance, outreach, and policy coordination, while promoting knowledge dissemination and community economic empowerment initiatives. The amalgamation of these three intermediary entities, Pokmaswas, Disbudpar, and Disperikan, establishes a SES network framework that facilitates co-management between the government and diverse communities in the sustainable protection and utilization of mangroves.

Mangrove tourism in Mandar Village is categorized into five clusters:

- a. Cluster 1: The Multicultural Community of Kampung Mandar, the existence of a multicultural demographic in Kampung Mandar, comprising the Mandar, Madura, Osing, and Javanese ethnic groups unified under the Community Surveillance Group (Pokmaswas), constitutes critical social capital for the sustainability of the mangrove ecosystem. This cultural heterogeneity engenders distinct patterns of social interaction that bolster collaborative mechanisms in coastal resource management. Furthermore, the assimilation of local wisdom values from each ethnic group, specifically the spirit of gotong royong (communal cooperation), environmental stewardship, and a robust work ethic, contributes synergistically to the sustainable preservation of the mangrove habitat.
- b. Cluster 2 contains tourist management stakeholders, including the tourist Office, the Indonesian Tour Guide Association (HPI), and the Banyuwangi Festival, which play a pivotal role in advancement of mangrove tourism in Banyuwangi. The Tourism Office serves as a regulator and facilitator by developing integrated policies, supplying supporting infrastructure, and promoting mangrove locations via diverse

marketing platforms. The Indonesian Tour Guide Association (HPI) enhances the quality of tourism human resources by training local tour guides to deliver mangrove conservation education and enrich tourist experiences through engaging ecological interpretation narratives. The Banyuwangi Festival serves as a tourism attraction by incorporating mangrove tourism into the national event program, drawing tourists with nature and culture-based tour packages. Functions as a tour operator, serving a crucial role as an intermediary between mangrove areas and tourists, while also facilitating education and conservation efforts. In the realm of mangrove tourism, a meticulously organized trip not only offers an authentic natural experience but also enhances understanding of environmental sustainability.

- c. Cluster 3 serves as a stakeholder in mangrove management, with the government, as the regulatory authority, responsible for developing policies and regulations that promote the conservation and sustainable utilization of mangroves. The local populations residing in the Mandar Village mangrove region are the principal agents in the preservation and traditional utilization of resources, while applying indigenous knowledge. Non-governmental groups and scholars contribute through research, teaching, and rehabilitation initiatives to enhance awareness of the significance of mangroves. The private sector, including the tourist and fishing industries, adopts sustainable practices and endorses conservation initiatives. Stakeholder collaboration is essential for effective mangrove management, biodiversity preservation, climate change mitigation, and enhancement of community welfare. In the absence of collaboration among all stakeholders, mangrove conservation initiatives will not function effectively.
- d. Cluster 4 prefers to tourism management, where sustainable mangrove tourism necessitates a holistic approach that emphasizes equilibrium between ecosystem preservation and economic exploitation. The active involvement of local people as primary managers yields economic advantages from tourism and fosters awareness for the preservation of mangrove sustainability. Furthermore, it is essential to implement stringent regulations concerning visitor numbers, the advancement of sustainable infrastructure, and the restriction of harmful activities such as deforestation or pollution. The mangrove habitat, which offers both economic and ecological advantages for various organisms. The mangrove ecosystem serves to safeguard the coastline from erosion, sequester carbon, and provide habitat for diverse species of fish, birds, and marine organisms. At the same time, the mangrove ecosystem presents economic opportunities through tourism, including ecotourism, educational tourism, and nature tourism.
- e. Cluster 5 refers to water quality management; the oversight of the Mandar Village River's water quality by relevant stakeholders has markedly improved the area's water quality. Initiatives undertaken include regular monitoring, management of domestic trash, and the planting of buffer vegetation along riverbanks to mitigate pollution and enhance water quality. The deterioration of water quality within the mangrove ecosystem is attributable to contamination by domestic waste, industrial activities, and oil spills, adversely affecting the growth of mangrove plants. Toxic chemicals, including heavy metals, pesticides, and plastic trash, contaminate aquatic environments, alter ecological equilibrium, diminish dissolved oxygen levels, and harm marine organisms

integral to the mangrove food chain. Moreover, water contamination can diminish the appeal of tourism activities.

Managing mangrove tourism in Kampung Mandar through the lens of sustainability cannot be sufficiently comprehended merely as an endeavor to balance economic, social, and environmental dividends. Rather, it needs to be strategically reoriented towards the cultivation of an eco-surplus culture—a paradigm wherein human activities transcend mere damage mitigation to proactively generate ecological protection, restoration, and natural regeneration. Within this conceptual framework, the mangrove ecosystem is no longer relegated to a mere backdrop for recreational activities or an exploitable economic asset; instead, it is positioned as an intrinsic core value requiring imperative conservation. Consequently, the success of such tourism initiatives is no longer quantified solely by conventional metrics such as visitor footfall, revenue generation, or destination popularity. Rather, efficacy is evaluated based on the extent to which tourism activities fortify the health of the mangrove ecosystem, ameliorate coastal environmental quality, and foster a collective behavioral shift toward environmental stewardship.

The cultivation of an eco-surplus culture is profoundly anchored in the vibrant local cultural values embedded within the multicultural fabric of Kampung Mandar. The indigenous maxims of the Mandar community (*“Naruao lembong narua toa, tumbiringo’ona mallewaima, nyawa siandarang, cera silolongngi”*), the Madurese proverb (*“Jek ngalokae alam mon tak tero nak poto lokah”*), and the Javanese philosophical tenet (*“memayu hayuning bawana”*) collectively articulate an ethical framework that emphasizes social solidarity, intergenerational responsibility, and the harmonious coexistence between humans and the natural environment. These foundational values are imperative, as an eco-surplus culture does not emerge solely through formal policy directives or technical interventions; rather, it manifests through the profound internalization of attitudes, beliefs, and moral responsibilities that position nature as an integral component of collective survival. Consequently, the management of mangrove tourism in Kampung Mandar is expected to operationalize local wisdom not as a superficial cultural ornament for promotional leverage, but as a robust normative foundation. This foundation serves to orient both the community and tourism managers toward perceiving mangrove conservation as a binding collective obligation, rather than a mere programmatic option.

Reinforcing an eco-surplus culture is imperative, as the overarching vision of sustainability perpetually confronts a fundamental paradox: interventions explicitly designed to promote sustainability can inadvertently undermine it. While escalated tourism promotion, the proliferation of attractions, and surges in visitor influx may amplify economic dividends, the absence of stringent carrying capacity regulations, continuous ecological monitoring, and disciplined management can exacerbate anthropogenic pressures on mangrove vegetation, hydrological quality, critical habitats, and overall environmental sanitation. Under such circumstances, an eco-surplus culture serves as a profound structural corrective to the inherently growth-centric logic of conventional tourism development. This paradigm emphasizes that economic profitability should be inextricably linked to tangible contributions toward ecological restoration; consequently, the success of a destination cannot be justified if it is attained at the expense of the ecosystem’s regenerative capacity. In essence, an eco-surplus culture unequivocally dictates that economic benefits are only sustainable and justifiable when tourism operations simultaneously generate a substantive ecological value-add.

The governance of mangrove tourism in Kampung Mandar necessitates a profound sense of humility and compassion, directed toward both fellow human beings and the natural environment, particularly the mangrove ecosystem. Humility is imperative for stakeholders to acknowledge the inherent epistemic limitations of their knowledge regarding ecological complexities, tourist behaviors, and social dynamics. Consequently, management decisions need to be subjected to perpetual evaluation, recalibration, and an openness to novel learning paradigms. Compassion, conversely, is critical to ensuring that human-nature interactions are predicated not upon exploitation, but upon ecological stewardship, moral responsibility, and a commitment to safeguarding collective survival. It is through the synthesis of humility and compassion that an eco-surplus culture can flourish as both an ethical compass and a practical orientation. This ensures that tourism initiatives transcend mere economic viability to proactively restore the ecosystem, fortify multicultural social cohesion, and bequeath a pristine environment to subsequent generations. This paradigm is highly congruent with [29] framework of *Uncertainty-Absurdity Mutuality*, which posits that humility facilitates the recognition of knowledge limitations and cognitive fallibilities, thereby fostering greater receptivity to uncertainty. Furthermore, compassion mitigates egocentric interpretations of reality and encourages the assimilation of diverse perspectives. Synergistically, these virtues enable the unbiased processing of novel information, allowing for cognitive and managerial recalibrations that are both highly adaptive and profoundly sagacious.

The implementation of an eco-surplus culture in mangrove tourism management necessitates an approach capable of cohesively integrating cultural values, conservation practices, and community roles. This approach is actualized through the Sustainable Multicultural Community-Based Tourism (SMCBT) concept, which positions the community as the primary actor in preserving environmental sustainability. Local values are translated into tangible actions, encompassing cross-ethnic collaboration, tourism management, and mangrove conservation efforts. Cultural diversity serves as social capital that bolsters cooperation, elevates environmental awareness, and fosters the creation of an adaptive, inclusive tourism management framework that harmonizes with coastal ecosystem conditions.

The Mandar Village Tourism Working Group, comprising Mandar, Madurese, and Javanese ethnicities, is pivotal in achieving Sustainable Multicultural Community-Based Tourism (SMCBT) by integrating cultural values, environmental preservation, and community empowerment. In the context of sustainable and multicultural community-based tourism, the ethnic diversity in Kampung Mandar serves not just as a demographic characteristic but also as a social asset that enhances cooperation in the management of the mangrove ecosystem. The Mandar ethnic group, due to its closeness to marine culture and traditional knowledge of coastal dynamics, offers an ecological and cultural basis for mangrove conservation efforts. The Madurese ethnicity contributes social vitality through solidarity, mutual cooperation, and a collective work ethos that enhances mangrove rehabilitation efforts, whereas the Javanese ethnicity offers managerial organization, public communication, and a professional tourism service framework. The three ethnic groups collaborate to establish an inclusive, participatory, and sustainability-focused ecotourism management system.

Pokdarwis, from the perspective of SMCBT, are pivotal agents that integrate local cultural values, ecological requirements, and economic prospects for tourism. They

promote interethnic conversation to cultivate a collective vision for the future of mangrove ecotourism, ensuring that each culture group has the opportunity to contribute and feel a sense of ownership over the conservation initiative. This collaborative approach positions mangrove rehabilitation as both an environmental initiative and a means of reinforcing communal identity within a multicultural coastal community that fosters harmony between humanity and nature. The creation of culture-oriented tourism packages, including mangrove education, Madura and Mandar cuisine experiences, and traditional Javanese arts, establishes a tourism value chain that embodies cultural variety while promoting ecological equilibrium.

SMCBT techniques enable Pokdarwis to guarantee equitable distribution of tourism advantages among the three ethnic groups, while enhancing social cohesiveness and fostering environmental consciousness. This partnership has produced a sustainable, community-oriented conservation framework that engages all societal layers in the decision-making, execution, and oversight of the mangrove environment. The incorporation of multicultural principles in tourism bestows Kampung Mandar with a distinctive identity, establishing it as an ecotourism destination that provides not just natural beauty but also narrates a tale of cross-cultural peace. Pokdarwis serves not only as a tourism administrator but also as an advocate of multicultural cooperation, a facilitator of conservation, and a proponent of sustainability values. This synergy illustrates that the implementation of SMCBT in managing Kampung Mandar's mangrove tourism fosters successful integration of ecological, economic, and socio-cultural sustainability, hence reinforcing the community's identity as a resilient coastal ecotourism destination.

The development of ecotourism fosters responsible tourism that aids in the preservation of nature and local culture by adhering to the principles of ecotourism: preservation, education, economy, participation, and tourism [15]. The primary stakeholders in the development of Mandar Village mangrove tourism are those involved in mangrove management, mangrove ecosystems, and tourism management, as these three elements are essential for the ecological and economic sustainability of the region. Mangrove management stakeholders, including the Fisheries Service and fisheries extension workers, are essential in policy formulation, technical assistance provision, and the implementation of suitable conservation techniques. In the absence of appropriate regulation and enforcement, the pressures from tourism activities may jeopardize the sustainability of mangroves. The mangrove environment is the primary draw for tourism; the state of the mangrove vegetation, water quality, and biodiversity influence visitor comfort and the tourism value, hence enhancing the destination's competitiveness. Third, effective tourist management is essential to reconcile conservation efforts with economic exploitation, encompassing visitor regulation, facility support, and local community engagement in labor absorption. An integrated approach that fosters collaboration among stakeholders, regular ecosystem monitoring, and the establishment of environmentally sustainable, multi-ethnic community-based tourism is essential for the enduring viability of Mandar Village mangrove tourism. The advancement of Mandar Village mangrove tourism is predicated on the interplay of social-ecological systems that take into account appropriateness and sustainability, encompassing:

1. Development of mangrove tourism attractions in the form of elevated restaurants that offer culinary items (cakes) and beverages (syrup, tea, and coffee) derived from mangrove resources, as well as fish and crabs sourced from the mangrove region, by

implementing a minimum payment system, restricting visiting hours, and enforcing stringent regulations to preserve the sustainability of the mangrove ecosystem.

2. Enhancing managers' capacity to autonomously cultivate mangrove trees.
3. Extending the length of mangrove monitoring.
4. Research and development of processed mangrove derivatives.
5. Designing a secure and convenient parking facility for mangrove tourism patrons.
6. Developing instructional materials for the general populace or educational institutions concerning the roles and advantages of mangroves.
7. Implementing mangrove planting along the Mandar Village river on designated degraded land.
8. Executing the Environmental Service program via trash Management through the Banyuwangi Hijau initiative, enhancing TPS3R in Banyuwangi Regency, maximizing trash banks, and the Banyuwangi River Basin Care School (SEKARDADU).

Leveraging ethnic diversity to build culture-oriented mangrove tourism attractions.

6 Conclusion

Mangrove tourism in Mandar Village features three predominant species of mangroves: *Rhizophora mucronata*, *Sonneratia alba*, and *Avicennia marina*. The Tourism Suitability Index (TSI) for Mandar Village indicates that the area is conditionally appropriate for development as a mangrove tourism site, with values of 56.41% and 58.97%. This suggests that while the potential for mangrove tourism is substantial, numerous elements of the physical, social, and management settings require additional focus to enhance the area's appropriateness. The sustainability condition of the Mandar Village mangrove tourism area is classified as fairly sustainable, with a score of 56.55%, signifying that the management system is not yet optimal in balancing resource usage and ecosystem preservation. Factors influencing sustainability include the density of mangrove vegetation, local labor absorption, favorable community and tourist impressions, and the presence of management laws. The interactions within the socio-ecological system indicate that the primary influencing nodes in the dynamics of mangrove tourist management are the mangrove ecosystem, nature tourism, the Fisheries Service, water quality, and fisheries extension personnel. The mangrove environment plays a pivotal role in tourism by offering both ecological and economic services, whereas nature tourism exemplifies conservation-oriented use elements. The participation of the Fisheries Service and fisheries extension workers underscores the significance of institutions and policies in executing participatory and sustainable management. Water quality, as an environmental indicator, is a critical determinant of the mangrove ecosystem's carrying capacity for tourism activities. The presence of these pivotal actors underscores the necessity for stakeholder coordination and the integration of ecological, economic, and social dimensions to enhance the viability and sustainability of mangrove ecotourism in a cohesive and sustainable fashion. Recommendations derived from the findings of this study include enhancing managerial competencies in mangrove management, fostering community awareness through ongoing participation in mangrove cleanup initiatives, developing innovative educational mangrove tourism attractions, and promoting collaboration between the government and the community to bolster mangrove sustainability and economic prospects for community welfare.

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Author contributions

Mochammad Fattah: Conceptualization, methodology, data curation, formal analysis, investigation, visualization, writing—original draft. Luchman Hakim: Conceptualization, validation, supervision, writing—review and editing. Soemarno: Methodology refinement, resources, validation, supervision, writing—review and editing. Pudji Purwanti: Data interpretation, socio-economic analysis, validation, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to confidentiality and research participant privacy considerations but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study involved human participants and was conducted in accordance with the ethical research standards of the institutional review committee of Universitas Brawijaya. Ethical approval for this study was obtained from the Ethics Committee of Universitas Brawijaya under Certificate Number: 215/UN10/KERIS/05/2026. Informed consent to participate was obtained from all participants prior to the commencement of the study. All participants were provided with adequate information regarding the purpose, procedures, anticipated benefits, and potential risks of the study. Participants voluntarily agreed to take part in the research by providing written informed consent following a full explanation. This study did not involve animal experimentation, animal handling, invasive procedures, or collection of animal specimens. Therefore, approval from an animal ethics committee or an Institutional Animal Care and Use Committee (IACUC) was not required. All ecological observation activities were conducted non-invasively and caused no disturbance to the organisms or the mangrove habitat. Consent to participate was obtained from all participants prior to the conduct of the study. All participants were provided with adequate information regarding the objectives, procedures, and potential risks of the research and voluntarily agreed to take part by providing written informed consent.

Consent for publication

Written informed consent for publication was obtained from all participants.

Competing interests

The authors declare that they have no competing interests.

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