Empowering communities in mangrove ecotourism: a pathway to sustainability and climate resilience in Bengkulu City

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Abstract. This study examines how empowering local communities contributes to the planning, utilization, and management of Bhadrika Mangrove Ecotourism Park in Bengkulu City, advancing sustainability and climate resilience. Using a descriptive quantitative approach, 27 household heads from RT 08 Lingkar Barat were surveyed to assess their participation. The results indicate substantial community involvement in planning (73.03%), utilization (72.27%), and management (74.48%), all categorized as "good." This active engagement promotes sustainable ecotourism, environmental preservation, and socio-economic development. However, issues such as limited infrastructure and low public awareness persist. Enhancing community roles through education, innovative approaches, and sustainable resource utilization is crucial to fully realize the ecological and social potential of mangrove ecotourism. The findings underscore the importance of community-driven initiatives in achieving ecosystem sustainability and climate change resilience.

1 Introduction

Mangroves play a crucial role in the global carbon cycle, serving as significant carbon sinks. These ecosystems sequester carbon at rates of 6 to 8 Mg CO_2e/ha annually, which are approximately two to four times higher than those observed in tropical forests [1–3]. Despite their immense ecological importance, mangrove ecosystems are under constant threat due to human activities and climate-related factors, leading to a global loss of 3363 km² of mangroves between 2000 and 2016 [4]. In addition to carbon sequestration, mangroves contribute significantly to climate resilience by stabilizing shorelines, reducing

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erosion, and protecting coastal communities from storm surges. Community participation in the management of mangrove ecosystems, particularly through ecotourism, is vital for ensuring their sustainability. Previous studies have shown that community engagement fosters a sense of ownership and responsibility, thereby enhancing biodiversity conservation and economic benefits [5]. However, regional variability in their carbon storage capacity limits the accuracy of localized estimates [6]. In addition to carbon storage, mangroves are vital in mitigating climate change impacts. They stabilize shorelines, shield coastal communities from erosion and storm surges, and enhance climate resilience. Their remarkable ability to sequester carbon in biomass and sediments underscores their role in global climate mitigation efforts [7]. Despite their value, mangroves face multiple threats. Between 2000 and 2016, global mangrove cover declined by 2.1% (approximately 3,363 km²), primarily due to human activities [2]. Challenges include eutrophication, overfishing, and harbor development impacting nearby seagrass ecosystems [9-10], as well as reclamation, invasive species, and rising sea levels degrading saltmarshes [10].

Sustainable mangrove management heavily relies on community engagement. Local communities are crucial in ensuring the conservation and sustainable utilization of mangroves, often acting as stewards of these vital ecosystems. Community-based initiatives the positive effects on biodiversity and ecosystem health [7]. Effective participation involves an emotional and mental commitment to decision-making, fostering responsibility for implementing those decisions [12]. While awareness of mangrove restoration's importance is relatively high, community participation in coastal restoration efforts remains moderate [13]. Strengthening local communities is vital for achieving sustainable outcomes and enhancing ecological resilience [14].

Mangrove in Bengkulu City have been partially converted into ecotourism destinations, but poor management practices have reduced their appeal. According to Srifitriani [15], the Bhadrika Mangrove is a prime example of a privately operated ecotourism site, demonstrating how dedicated management and a focus on conservation can create a desirable ecotourism experience. The Bhadrika Mangrove Ecotourism Park attracts more visitors during holidays than weekdays. However, the park's inability to charge entrance fees limits its revenue generation, which restricts its capacity to maintain infrastructure and upgrade facilities. Additionally, the absence of a systematic visitor tracking mechanism makes it difficult to evaluate visitor numbers and plan improvements effectively. These limitations impact the quality of services and infrastructure offered to tourists.

The involvement of the local community in ecotourism management is minimal, largely due to a lack of understanding about the significance and benefits of such activities. Many residents near the Bhadrika Mangrove do not engage in its management, reflecting broader challenges in fostering community participation for sustainable development. Strengthening community involvement is vital for the sustainable management of mangrove ecotourism. However, this requires building awareness and addressing the perception that ecotourism management offers limited immediate benefits. Developing the Bhadrika Mangrove Forest as an ecotourism destination will require tackling these issues effectively.

Research on community engagement in managing mangrove ecotourism is essential to address these challenges. This study addresses critical challenges, including limited community awareness, inadequate infrastructure, and the absence of sustainable revenue models, by offering actionable strategies to enhance local participation in ecotourism management. Additionally, it presents a localized perspective on the dual role of mangroves as essential carbon sinks and natural buffers against climate impacts, positioning

community-driven ecotourism as a scalable solution for climate change mitigation and adaptation. Furthermore, this research introduces an innovative framework that integrates the social, ecological, and economic dimensions of mangrove conservation, making it particularly relevant for policymakers and practitioners committed to advancing sustainability and resilience in coastal regions around the world.

2 Methods

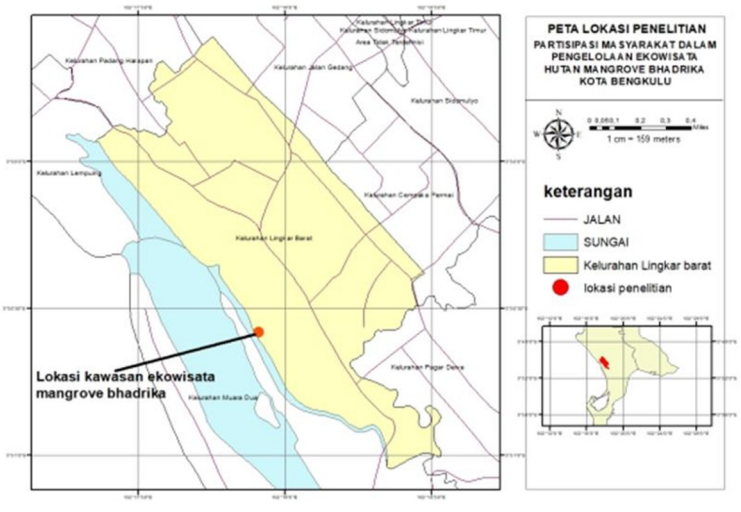

Fig. 1. Location of the Badrika Mangrove Ecotourism area

This study employed a descriptive quantitative approach to evaluate community participation in the Bhadrika Mangrove Ecotourism Park, located in Lingkar Barat Subdistricts, Bengkulu City. The area was selected due to its heterogeneous population and the critical state of its mangrove ecosystem. A total of 27 household heads were surveyed using a structured questionnaire. The questionnaire focused on three key dimensions of participation: planning, utilization, and management. Responses were measured on a 4-point Likert scale, and data validity and reliability were ensured through preliminary testing. Descriptive statistics were used to calculate participation levels in each dimension, expressed as percentages. Findings were categorized as “poor,” “satisfactory,” “good,” or “very good” based on established criteria. Additionally, the study aims to contribute valuable insights for formulating policies that can enhance the sustainability of mangrove ecotourism management in the area.

$$n = p\,x\,N \quad (1)$$

Explanation:
n = the number of samples taken
p = The proportion that is extracted from the sample, which is either 25% or 0.25
N = 108 is the number of people = 0.05 x 108 = 27

The study utilized a sample size calculation formula to select 27 households from Lingkar Barat Subdistricts, Bengkulu City. To assess community involvement in the management of Bhadrika Mangrove Ecotourism, a Likert-scale questionnaire was employed. This instrument featuring a graded response system, was designed to effectively gather data on the community's level of participation in various aspects of mangrove ecotourism management. Specifically, the questionnaire aimed to evaluate:

Table 1. Community level of participation (positive statement)

Strongly Agree	Score 4
Agree	Score 3
Disagree	Score 2
Strongly Disagree	Score 1

Table 2. Community Level of Participation (Negative Statement)

Strongly Agree	Score 1
Agree	Score 2
Disagree	Score 3
Strongly Disagree	Score 4

In this study, the uncertain response score was excluded, as it did not provide meaningful insights into respondents' answers. The development of the research instrument followed a systematic process, which included the following steps:

1. Designing a grid based on the variable indicators.
2. Formulating questions that align with the specified indicators.
3. Conducting a rational analysis to ensure the questions were consistent with the indicators.
4. Evaluating the linguistic accuracy of the questionnaire items.
5. Conducting a validity test.

The validity test was employed to assess the accuracy of the questionnaire items. In this study, the validity of each item was determined by comparing the calculated correlation coefficient with the critical value at a degree of freedom (df) equal to n-2. An item was considered valid if the calculated r was greater than the critical r value, while an item was deemed invalid if the calculated r was smaller than the table value. The validity test was conducted at a significance level of 5% (0.05) [16]. The distribution of the questionnaire was carried out during the data collection process by providing explanations to each sample that would be taken and handing over the questionnaire by visiting each respondent, in order to ensure the validity and accuracy of the data from external interventions. In this study, the researcher established the head of the household as the criterion for respondents selected as the research sample. The data obtained through the questionnaire is processed, analyzed, and interpreted according to the research objectives to be achieved. The data collected for this study is processed through several stages of processing as follows.

Data analysis followed a three-step process:

1) Descriptive Statistics: Scores from the Likert-scale responses were averaged for each dimension (planning, utilization, and management) and expressed as percentages. These percentages were then categorized into achievement levels, ranging from Very Poor to Very Good.
2) Correlation Analysis: Pearson’s correlation was employed to examine relationships between the dimensions of participation (planning, utilization, and management). This

analysis aimed to determine whether involvement in one dimension influenced engagement in others.

3) Data Visualization: Scatter plots were utilized to depict the relationships between dimensions visually. These plots highlighted patterns in community engagement and helped identify outliers or trends in the data.

$$M_{\times} = \frac{\sum X}{N} \quad (2)$$

Explanation:
$M_{\times}$ = Average score
$\sum X$ = Individual scores
N = Total number of respondents

Pearson's correlation coefficient (r) was computed to measure the strength and direction of relationships between variables using the formula:

$$r_{xy} = \frac{n\sum y_i r_i - (\sum x_i)(\sum y_i)}{\sqrt{\{n\sum x_i - (\sum x_i)2\}(\sum y_i)2\}}} \quad (3)$$

The collected data is processed to achieve the desired results through the following methods: Editing or rechecking, is the first step in data processing. This is done to determine whether the data collected is good enough and ready for the next stage of analysis. Editing is very important to make the information in the questionnaire clear, easy to read, relevant, and accurate. It is hoped that this will improve the quality of the data to be processed and analyzed. Coding is providing codes to facilitate data processing the codes will be given in the form of standard measurement scores. Tabulating which means organizing responses into groups. The research data is analyzed using descriptive data analysis. This analysis is to obtain an overview of the frequency of the data, the normal tendency, and the level of achievement of the respondents. To determine the level achievement of respondents in each variable, the formula [17] is used:

$$\text{Percentage Achievement} = \frac{Average\ Sore}{Maximum\ Score}\ x\ 100\ \% \quad (4)$$

Table 3. Level achievement of respondents

Score Range	Criteria
81 - 100%	Very Good
61 - 80%	Good
41 - 60%	Satisfactory
21 - 40%	Poor
0 - 20%	Very Poor

3 Results and discussion

The active involvement of local communities in ecotourism significantly contributes to environmental sustainability by mitigating pollution, enhancing ecosystem services, and conserving natural resources. This participation is crucial in achieving sustainable and

environmentally friendly tourism destinations. Local community engagement plays a vital role in reducing pollution within ecotourism sites. Communities involved in ecotourism activities are generally more aware of environmental preservation and are more likely to implement sustainable practices, such as waste minimization, energy efficiency, and the use of eco-friendly transportation. These measures collectively lead to a significant reduction in pollution levels in ecotourism areas [19].

Community participation also enhances ecosystem services in tourist destinations by improving habitat quality, biodiversity, and ecological functions. Through direct involvement in ecotourism management, local stakeholders develop a heightened sense of environmental stewardship and actively work to preserve natural ecosystems [20]. Moreover, the conservation of natural resources is strongly supported by community participation in ecotourism. Local communities recognize forests, rivers, and marine ecosystems as essential assets for the continuity of ecotourism and are motivated to protect these resources to ensure long-term sustainability [21].

The sustainability of ecotourism practices can be assessed through studies that examine the role of community participation in management. Previous research highlights local community involvement as a fundamental component of sustainable ecotourism management. These studies often evaluate critical aspects, such as the carbon footprint and resource utilization of ecotourism practices. Carbon footprint analyses provide insights into the environmental impact of activities such as visitor transportation, energy use in facilities, and waste management [23-24]. Additionally, assessments of resource utilization covering water, timber, and land can identify opportunities to adopt more efficient and sustainable practices [24-25]. Involving local communities in these research efforts provides valuable perspectives on existing practices and offers actionable recommendations for enhancing sustainability [25-26]. This participatory approach underscores the indispensable role of local communities in fostering sustainable ecotourism, emphasizing their contribution to achieving both environmental and social sustainability goals.

The implementation of ecotourism management can involve several forms of community participation. The goal of the community participation stages is to understand the involvement of the community in the planning, utilization, and control of ecotourism in the management of the mangrove ecotourism in Bengkulu City. The phases of community participation in planning consist of several activities, including involvement in planning the development of mangrove ecotourism, participation in the formulation of plans and policies for mangrove ecotourism, voicing opinions and being heard during the planning process of mangrove ecotourism, community involvement in planning the management of ecotourism products to ensure the sustainability of the surrounding environment, and receiving education in the planning of mangrove ecotourism development.

3.1 Community participation in planning

Community involvement in planning scored 73.03%, indicating a good level of engagement and a commendable level in formulating policies and planning for ecotourism management. Many respondents reported participating in policy discussions, ecotourism strategies, and mangrove conservation efforts. While 55.6% felt involved, 7.4% strongly agreed with dissatisfaction. However, there is potential to enhance inclusivity by engaging a wider range of stakeholders and improving access to relevant information. This highlights the need for more inclusive approaches, such as opportunities for dialogue and improving access to information. Engaging the community in planning can help ensure their voices are

heard and their needs are addressed, as supported by findings in [6]. Community participation in the planning phase primarily revolves around involvement in policy formulation and the development of ecotourism products. Although the participation rate is categorized as good, approximately 37% of respondents expressed dissatisfaction or disagreement with certain aspects of the planning process.

3.2 Community participation in utilization

Community engagement in utilizing mangrove ecotourism products reflects active involvement in product development. Nonetheless, further improvements in economic incentives and tangible benefits are necessary to ensure sustained and broader participation. The utilization phase scored 72.27%, also categorized as good. Communities participated in creating ecotourism products and contributed to conservation efforts. A majority (63%) felt involved, and 11.1% strongly agreed. However, some respondents expressed dissatisfaction due to limited direct benefits or a lack of economic incentives. These results indicate a need for a balance between environmental conservation and tangible economic benefits to enhance enthusiasm and participation. This aligns with insights from [7], which emphasize the importance of linking conservation efforts to economic sustainability. Community engagement in utilizing and developing environmentally friendly and appealing ecotourism products is evident. However, 22.2% of respondents indicated limited agreement with this aspect, which may stem from minimal direct benefits or a lack of economic incentives to encourage participation.

3.3 Community participation in management

The management phase recorded the highest participation level (74.48%), showcasing the community's strong commitment to conservation and maintenance efforts. This result highlights growing awareness and proactive involvement in safeguarding mangrove ecosystems. Activities included preserving mangrove ecosystems, maintaining facilities, and ensuring security. A significant 55.6% of respondents agreed they were involved, and 18.5% strongly agreed, showcasing the community's strong commitment to conservation. This phase demonstrates a growing understanding of the importance of protecting the mangrove ecosystem. However, challenges such as inadequate infrastructure and limited technical knowledge remain. Addressing these issues can help communities sustain and enhance their role in ecotourism management, as noted by [8]. Participation in management activities is higher compared to planning and utilization, reflecting an increased awareness among the community regarding the importance of conservation and facility maintenance. Despite this, challenges such as inadequate infrastructure and limited technical knowledge persist, requiring targeted interventions to address these gaps.

The overall score indicates a high level of community participation in managing mangrove ecotourism. However, challenges such as limited infrastructure and insufficient community education remain, requiring strategic interventions for sustainable and effective management. With an overall score of 77.47%, the findings underscore the significant role of local communities in mangrove ecotourism. However, challenges remain, including gaps in infrastructure and awareness. By addressing these issues, ecotourism has the potential to serve as a more effective tool for conservation and economic development. Enhancing

community participation and ensuring that local populations realize the benefits of their involvement will be crucial in establishing a sustainable and inclusive ecotourism model for the future. The findings suggest that enhancing community awareness and integrating innovative practices can improve the sustainability of ecotourism. Future research should focus on refining community-based ecotourism models to optimize conservation and socioeconomic benefits.

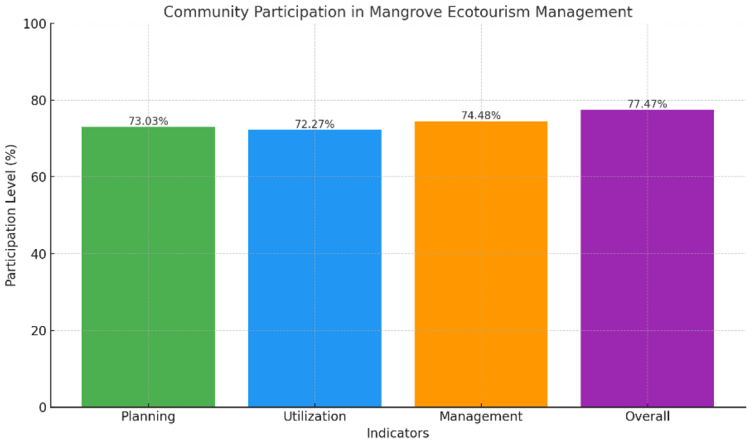

Fig. 2. Graph of community participation in mangrove ecotourism management

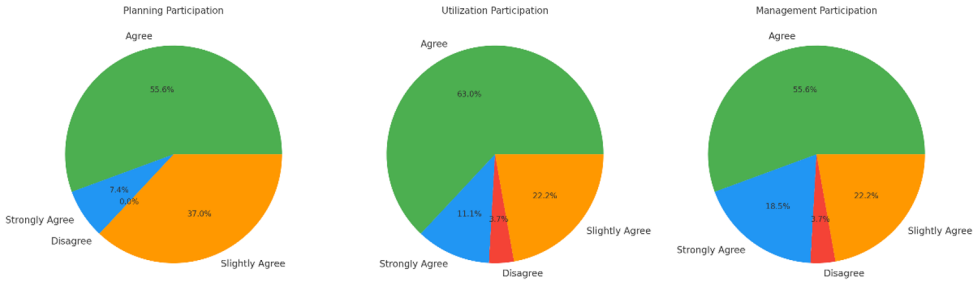

Fig. 3. Distribution chart of respondents answer categories for three community participation indicators

The slightly agree category is quite high on all indicators, especially in the planning aspect. This shows that despite involvement, some community groups feel that they are not fully engaged or get enough information. The improvement strategy carried out is to strengthen the community consultation mechanism in the planning stage, providing economic incentives directly at the utilization phase. And Expand training and education to improve technical understanding at the management phase.

Research findings indicate that community participation in managing mangrove ecotourism is effective, with respondents achieving a "good" understanding level of 77.58%. A questionnaire of 27 participants confirmed this classification. This aligns with previous research by [29], which demonstrates that community engagement in Bunaken, Manado Regency, positively influences mangrove ecotourism management. Furthermore, this participation aids in developing ecotourism products, promoting sustainable natural resource management, and enhancing environmental education regarding the importance of mangrove preservation.

Current research indicates that engaging local populations in ecotourism can yield significant environmental benefits [24] [30] [31]. When residents are involved in the development of ecotourism, they are often more motivated to protect the environment and its resources. This participation can lead to reduced pollution and improved management of natural areas. Moreover, when communities benefit directly from ecotourism initiatives, they are more likely to adopt sustainable practices. Involving local populations in management and decision-making fosters a sense of stewardship over natural resources. However, challenges such as power imbalances and limited local capacities can hinder meaningful participation. Addressing these barriers and ensuring equitable distribution of economic benefits are essential for maximizing the environmental advantages of community involvement.

4 Conclusion

This study examines the management of mangrove ecotourism, with a strong emphasis on planning and community participation. With a participation rate of 77.47%, the findings underscore the importance of active community engagement in fostering sustainable ecotourism in Bhadrika, Bengkulu City. Such involvement in environmental conservation also fosters socio-economic development. Despite these positive outcomes, several challenges persist. Issues such as inadequate infrastructure, limited public awareness, and a shortage of technical skills present obstacles that must be addressed. These challenges through infrastructure improvements, enhanced education and training initiatives, and the implementation of innovative technologies to ensure long-term sustainability and community engagement. The research highlights the necessity of integrating ecological, social, and economic considerations into ecotourism management. Policymakers and stakeholders can leverage these insights to develop participatory frameworks that align community objectives with conservation goals. Future research should focus on adaptive, community-driven ecotourism models that further support biodiversity conservation, climate resilience, and the improvement of local livelihoods.

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