Mangrove Conservation and Ecotourism: Pathways to Sustainable Development

[1]Dr. Bindu V V, [2]Ms. Aleena P & Anju Pramod T V

[1]Associate Professor Department of Economics S.N. College, Kannur, Kerala, India

[2]B.A. Economics Students Department of Economics S.N. College, Kannur, Kerala, India

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ABSTRACT

Mangroves are one of the most productive and valuable coastal ecosystems, providing significant ecological, economic, and social benefits. In recent years, mangrove-based ecotourism has emerged as a sustainable approach to generate income for local communities while promoting environmental conservation. This project aims to study the potential of mangrove-based ecotourism in generating revenue among the local community while ensuring environmental sustainability. It also examines the major challenges faced by mangrove ecosystems due to human encroachment such as land reclamation, waste disposal, and unplanned developmental activities. Further, the study attempts to understand the role of the local community and government in the protection and conservation of mangroves. The study is based on both primary and secondary data. Primary data were collected through a structured questionnaire administered among local residents, while secondary data were gathered from books, journals, government reports, and official websites. The findings reveal that mangrove-based ecotourism has significant potential to enhance local livelihoods and create employment opportunities when managed sustainably. However, inadequate awareness, weak enforcement of regulations, and increasing human pressure pose serious threats to mangrove ecosystems. The study highlights the importance of community participation, government support, and effective policy implementation in achieving sustainable mangrove conservation. The project concludes that a balanced approach integrating ecotourism development and environmental protection is essential for the long-term sustainability of mangrove ecosystems and local economic development.

Keywords: Mangrove, shorelines, mitigation, sediments, filtering pollutants

INTRODUCTION

Mangrove ecosystems are among the most productive and economically valuable coastal habitats in the world. mangrove forests form a vital component of the coastal and wetland landscape. These ecosystems not only support rich biodiversity but also provide direct and indirect economic benefits to local communities. However, rapid urbanization, land reclamation, pollution, and unplanned development have resulted in significant degradation of mangrove habitats. In this context, integrating mangrove conservation with ecotourism presents a sustainable economic strategy that can promote environmental protection while enhancing local livelihoods.

Mangrove conservation is not merely an environmental concern; it has strong economic relevance. Mangroves function as natural protective barriers against coastal erosion, storm surges, and flooding. By stabilizing shorelines and reducing the impact of extreme weather events, they help to minimize economic losses associated with damage to infrastructure, agriculture and property. This natural disaster mitigation service reduces public expenditure on artificial coastal defences and rehabilitation measures. Therefore, conserving mangroves can be viewed as a cost-effective investment in long-term economic security.

Mangroves play a critical role in supporting fisheries, which are a major source of income for local communities. Mangrove ecosystems serve as breeding and nursery grounds for various fish species, crabs, prawns, and molluscs. These resources contribute directly to the livelihoods of fishermen and small-scale seafood traders. The productivity of nearshore fisheries is closely linked to the health of mangrove ecosystems.

Degradation of mangroves leads to a decline in fish populations, which in turn affects income levels and food security. Thus, conservation efforts can enhance fish stocks, stabilize incomes, and ensure sustainable economic returns over time.

Mangroves improve water quality by filtering pollutants and trapping sediments. This benefits aquaculture, agriculture, and drinking water sources in surrounding areas. Moreover, mangroves act as significant carbon sinks, storing large amounts of carbon in their biomass and soil. In the context of global climate change, this carbon sequestration potential may open opportunities for climate finance mechanisms and carbon credit initiatives.

Ecotourism emerges as a promising approach to link conservation with economic development. Unlike conventional mass tourism, ecotourism emphasizes environmental sustainability, community participation, and cultural preservation. Responsible tourism initiatives such as guided mangrove trails, canoe rides through backwaters, bird watching tours, photography excursions, and environmental education camps can attract visitors interested in sustainable travel experiences.

The economic benefits of ecotourism are multifaceted. First, it generates direct employment opportunities for local residents. Community members can work as tourist guides, boat operators, nature interpreters, homestay hosts, and small-scale entrepreneurs selling handicrafts and local products. Women and youth, in particular, can benefit from these opportunities, contributing to inclusive economic growth. Second, ecotourism stimulates indirect economic activities such as transportation services, local food supply chains, and small businesses. The multiplier effect of tourism spending can enhance overall income levels in the region.

Importantly, ecotourism can create a financial incentive for conservation. When local communities recognize that healthy mangroves attract visitors and generate income, they are more likely to participate actively in protecting these ecosystems. Revenue generated from tourism can be reinvested into conservation programs, such as mangrove replantation, waste management, awareness campaigns, and infrastructure maintenance. This creates a sustainable cycle in which conservation supports tourism, and tourism funds conservation.

Furthermore, integrating mangrove conservation with ecotourism aligns with Kerala's broader development model that emphasizes responsible and sustainable tourism. The state has already gained recognition for its eco-friendly tourism initiatives. By developing Kattampally as a model for mangrove-based ecotourism, local authorities and community organizations can enhance regional tourism networks and attract both domestic and international visitors. This can strengthen Kannur's position as a destination that balances economic development with environmental sustainability.

However, the economic success of such initiatives depends on careful planning and management. Unregulated tourism can lead to environmental degradation, disturbance to wildlife, and commercialization that undermines sustainability goals. Therefore, it is essential to implement clear guidelines, community-based management systems,

and environmental impact assessments. Capacity-building programs and awareness campaigns should be conducted to ensure that local stakeholders understand the principles of sustainable tourism and conservation.

REVIEW OF LITERATURE

The study develops with a background base from earlier studies, that are following:

Sathirathai (1997) showing community- managed mangrove resources often result in higher ecological and economic returns compared to state - controlled approaches. This work provided empirical evidence supporting decentralized resource Management and advancement in understanding the effectiveness of community involvement in mangrove conservation. The research delved deeply into how local communities, when given a participatory role in managing mangrove resources, can achieve superior ecological and economic outcomes compared to traditional, centralized, state-controlled.

Douglas J. Krieger (2001) examines the economic value of forest ecosystem services situates forests as multi-functional systems whose benefits extend beyond timber production to include regulating services (carbon sequestration, climate regulation, watershed protection, flood control), provisioning services (food, fibre, medicinal resources), supporting services (biodiversity maintenance, habitat provision), and cultural/recreational values (aesthetic, educational, spiritual uses). The study contributes to the growing empirical and theoretical literature that advocates integrating non-market values into policy analysis, highlighting methods such as stated and revealed preference techniques (e.g., contingent valuation, choice experiments, travel cost methods), avoided cost and replacement cost approaches, and benefit transfer as practical tools for valuing non-timber forest benefits. Overall, Krieger's contribution helps to frame forests not merely as sources of timber but as complex cost-benefit entities whose preservation often yields net social benefits, supporting arguments for policy instruments such as payments for ecosystem services, conservation prioritization, and integrated landscape planning.

Grace Mathew, R. Jeyabaskaran and D. Prema (2010), highlight that mangrove ecosystems in India are highly productive coastal forests that support rich biodiversity, provide nursery grounds for fisheries and protect shorelines, while also sustaining local livelihoods. The authors report that Indian mangroves are increasingly threatened by coastal development, conversion for agriculture and aquaculture, pollution and alteration of natural tidal flow, leading to habitat fragmentation and decline in species diversity. They further argue that although policy and regulatory frameworks exist, weak enforcement and limited institutional coordination reduce their effectiveness, and therefore stress the need for integrated, science-based and community-oriented conservation approaches for the long-term sustainability of mangrove ecosystems in India.

Piyashi. De. Roy and R. Jayaraman (2012), A study conducted in MGR Thittu village, near the Pichavaram mangroves of Tamil Nadu, explored the current status of mangroves, their perceived role in local livelihoods, and estimated their economic value. Data were collected from 41 experts and 120 local villagers, focusing on the fisherfolk's perception of mangrove services and the economic significance of the ecosystem. The study found that the primary perceived benefit of mangroves was their role in coastline protection against tsunamis, floods, and heavy winds. Other key benefits included support for fisheries and provision of firewood, highlighting both ecological functions and direct resource use. Using a Total Economic Value (TEV) framework, the study categorized the mangrove values into direct use values, indirect use values, and willingness to pay (WTP). The study underscores the importance of economic valuation tools in making visible the hidden ecological and protective functions of mangroves. It also reinforces the need for inclusive policy-making, engaging both local stakeholders and government bodies in the conservation and sustainable management of these vital coastal ecosystems.

Badola, Barthwal, and Hussain (2012) investigates how local communities perceive and respond to mangrove conservation in the Bhitarkanika Conservation Area on India's east coast, underscoring the crucial role of human attitudes in sustainable resource management. Drawing on questionnaire surveys from 36 villages, the authors found that most residents hold positive attitudes toward mangrove conservation largely because they recognize the direct benefits these ecosystems provide for their wellbeing, such as coastal protection, livelihood resources, and ecosystem

services. However, demographic and socio-economic factors influence these attitudes: for example, education levels and proximity to the forest affected willingness to adopt conservation practices and alternatives to forest resource use. The study highlights the importance of integrating community perceptions into conservation planning and suggests that strengthening livelihood options could reduce pressure on mangroves while enhancing local support for sustainable management.

K. Vidyasagaran and V. K. Madhusoodanan (2014) provides a systematic assessment of the distribution and plant diversity of mangroves along the west coast of Kerala highlighting both the present extent and the fragmented nature of these ecosystems. Based on extensive field surveys, the authors documented the spatial distribution of mangrove patches across coastal districts and estimated a total mangrove area of about 2,502 hectares, distributed between private and government ownership. The study revealed strong variation in species composition and structural characteristics among different sites, reflecting local environmental conditions and human disturbance. Importantly, Vidyasagaran and Madhusoodanan emphasized that most mangrove stands in Kerala are small, isolated remnants affected by land conversion, hydrological alteration, and developmental activities, and they stressed the urgent need for site-specific conservation and restoration strategies to protect the remaining mangrove diversity of the state.

Vaiga and Sincy (2016), their article aimed to identify the key mangrove species and understand their ecological roles and socio-economic importance in Kannur district. Their research found that specific mangrove species support fisheries, contribute to shoreline stabilization, and provide livelihoods for local communities. The study emphasized that conserving these species at all levels is essential to sustain ecological functions and socio-economic benefits, highlighting the interconnected nature of biodiversity and local economies. From an environmental economics perspective, the authors highlight the significant ecosystem services mangroves provide such as fish breeding, flood control, and water purification which carry non-market economic value and contribute to natural capital. These services reduce government expenditure on artificial infrastructure and support local income generation, thus reinforcing their economic relevance.

Kathiresan, K. (2018), in his article published in Current Science, provided a comprehensive overview of mangrove forests in India, highlighting their ecological uniqueness, biodiversity richness, and conservation status. The author reported that India possesses approximately 4,921 sq. km of mangrove cover, accounting for about 3.2% of global mangrove forests. The Sundarbans is identified as the largest mangrove ecosystem in the world and a globally significant biodiversity hotspot, while Bhitarkanika National Park is described as a “mangrove genetic paradise” due to its high species diversity. The study documented over 4,000 species of flora and fauna associated with Indian mangroves, emphasizing their role in coastal protection, fisheries support, and carbon sequestration. The author also analysed changes in mangrove cover based on data from the Forest Survey of India, noting an overall increase in mangrove area over three decades despite regional declines. The major threats identified include urbanization, aquaculture expansion, industrialization, hydrological alterations, and climate change impacts such as sea-level rise. The author concluded that sustainable management strategies including ecological restoration, legal protection, and participatory community-based conservation are essential to ensure the long-term survival and functionality of mangrove ecosystems in India.

Sarang, K. T. (2020), This study explores the symbiotic relationship between local communities and mangrove wetlands near the Kavvayi river basin in northern Kerala. Mangroves are acknowledged here as highly productive ecosystems, providing shoreline stabilization, protection from coastal hazards, filtration of pollutants, and essential breeding grounds for fish and shellfish.

Chitra K.P, Preetha K.V., Vikas P.A. (2021) - This chapter situates Kerala’s wetland conservation strategies within the global framework provided by the Ramsar Convention. It defines wetlands expansively, including marshes, peatlands, and even shallow marine zones, emphasizing their ecological importance and contribution to sustainable development goals. In Kerala, wetlands including mangroves provide critical ecosystem services like flood mitigation, water purification, carbon sequestration, and microclimate regulation.

Devaraj Asir Ramesh et al. (2022) –This study undertakes a comprehensive economic valuation of mangrove ecosystem services across India using the Millennium Ecosystem Assessment (MEA) framework, which classifies ecosystem services into four categories: provisioning, regulating, cultural, and supporting services. Provisioning services include timber, fuelwood, fisheries, and honey. Regulating services encompass storm protection, erosion control, and carbon sequestration. Cultural services involve ecotourism and spiritual significance, while supporting services include nutrient cycling and primary productivity.

Divya S. Rajan and Athira P.V.'s article (2023), This article sits within a broad and growing body of mangrove literature that emphasizes the indispensable ecosystem services mangroves provide—coastal protection, nursery habitat for fisheries, carbon sequestration, nutrient cycling—and the multiple, often synergistic threats they face from coastal development, aquaculture, pollution, and hydrological alteration.

Statement of the Problem

Mangrove ecosystems are among the most valuable coastal resources, providing environmental protection, supporting biodiversity, and safeguarding coastal communities from storms and erosion. However, despite their ecological importance, mangroves are often neglected and face threats due to environmental degradation and lack of awareness. At the same time, tourism has emerged as a promising opportunity for economic growth and community development in coastal regions.

When properly planned and managed, ecotourism can serve as a positive force that supports mangrove conservation while generating income and employment for local communities. It can also create awareness among visitors about the importance of protecting natural ecosystems. Therefore, the problem addressed in this study is to examine how mangrove conservation can be strengthened through sustainable ecotourism practices. The study seeks to understand how tourism can be promoted in a responsible and environmentally friendly manner that enhances economic benefits without compromising ecological sustainability.

METHODOLOGY

Based on a case study approach, the current paper examines Kattampally in Kerala, India's Kannur district. Based on both primary and secondary data, the study is analytical and descriptive in character. Primary data were collected through structured questionnaires, direct interviews with local residents, fishermen, tourism workers and visitors, along with field observation. Secondary data was sourced from published research articles, academic journals, government reports, policy documents, environmental studies, and official websites related to mangrove ecosystems and eco-tourism. The respondents were chosen using a convenience sample technique. Convenience sampling was used in the study, and participants were chosen based on their availability and desire to take part. The survey had 50 respondents in total. The number of respondents is limited due to fewer people are living closer to mangrove growing areas and the study was conducted in a short span of time frame. Field visits and self-administered questionnaires were used to collect data in order to guarantee the validity and applicability of the answers.

A contingency table was constructed by proportionally distributing responses across categories of perceived threats and preferred government measures. Categories were further grouped to satisfy chi-square test. The hypotheses tested are: H_0: No association between perceived threats and preferred government measures. H_1: There is an association.

Objectives

Mangrove ecosystems are vital coastal resources that provide environmental Protection, support rich biodiversity, and contribute to local livelihoods. Promoting mangrove conservation along with sustainable ecotourism can help Balance economic development and environmental protection.

1. To study the potential of mangrove-based ecotourism in generating revenue among the local community while ensuring environmental sustainability.
2. To identify the challenges faced by mangroves due to human encroachment.
3. To understand the role of local community and government in protecting mangroves.

LIMITATIONS

- The research depends largely on primary data, and accurate financial records regarding tourism revenue, employment generation, and conservation expenditure may not be fully accessible or officially documented.
- The sample size of tourists, local residents, and stakeholders may be limited, which may not completely represent the views of the entire population.
- Since the research focuses only on the Kattampally mangrove area, the findings may not be applicable to other mangrove regions in Kerala or India.
- While studying the revenue potential of mangrove-based ecotourism, accurate income estimation may be difficult because many tourism-related activities are informal and not officially recorded.
- The study is conducted within a limited time frame, so it may not fully capture seasonal variations in tourist inflow, biodiversity, and income generation.
- In identifying major threats to the mangrove ecosystem, the research may depend largely on respondents' opinions and secondary data, which may not provide complete scientific accuracy.
- Financial constraints, limited technical expertise, and restricted access to certain areas may also affect the depth of environmental sustainability assessment. Therefore, these limitations may influence the overall generalization and precision of the study findings.

RESULTS

Mangrove forests are vital coastal ecosystems that provide significant ecological and economic benefits, particularly in tropical regions. They act as natural barriers against coastal erosion, floods, and storms, while also supporting biodiversity and sustaining the livelihoods of local communities through fisheries, aquaculture, and related activities. In Kerala, mangrove ecosystems are closely linked with the backwater economy and eco-tourism development. Kattampally, situated in the Kannur district, is an important wetland area where mangrove forests contribute to both environmental protection and local income generation. In recent years, the promotion of eco-tourism in Kattampally has created new economic opportunities while increasing awareness about conservation. However, balancing economic activities with sustainable management remains a challenge. Therefore, studying the economic aspects of mangrove forest conservation and tourism in Kattampally is essential to understand how environmental sustainability and local economic development can be effectively integrated for long-term growth.

Table 1. Common products collected from Mangroves

Sl No	Common product collected from mangrove	No. of respondents	Percentage (%)
1	Crabs	6	12.0%
2	Firewood	4	8.0%
3	Fish	23	46.0%
5	Shellfish	4	8.0%
4	None	13	26.0%
	Total	50	100

(**Source:** Primary data)

Table 1 shows that fishing is the predominant activity associated with mangrove resources. Fish represents the largest category of products collected, accounting for 46% (23 out of 50) of the total count. This underscores the vital role mangroves play as a nursery and habitat for fisheries. Interestingly, the second-largest group consists of individuals

who collect "None" of the listed products, making up 26% (13 out of 50) of the sample. Among those who do extract biological resources, Crabs are the next most common at 12.0%, while Firewood and Shellfish are collected less frequently, each representing 8% of the total activities. The concentration of activity in fish and crab collection indicates that the area is likely a significant source of protein and income for the local population.

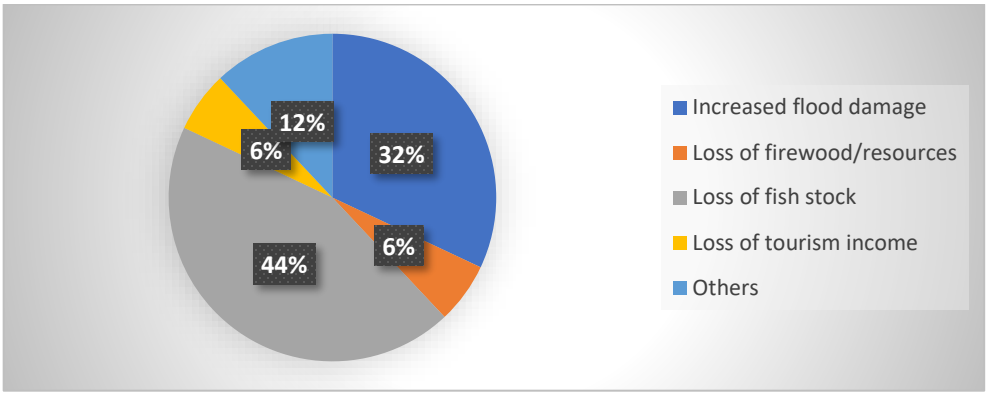
Table 2. Mangroves and fish populations

Sl No	Mangroves and fish populations	No. of respondents	Percentage (%)
1	Serve as nursery grounds (Which implies that root of mangroves helps the growth of fish)	14	28.0%
2	Provide shelter from predators	10	20.0%
3	Maintain water quality	9	18.0%
4	All of the above	17	34.0%
	Total	50	100

(**Source:** Primary data)

Table 2 presents the respondents' views on the role of mangroves in supporting fish populations. Out of 50 respondents, the highest percentage (34%) selected "All of the above," indicating that many people believe mangroves contribute to fish populations in multiple ways, including serving as nursery grounds, providing shelter from predators (means the animals that eat small fish), and maintaining water quality. About 28% of the respondents stated that mangroves serve as nursery grounds, showing that a significant number recognize their importance in the early growth stages of fish. Additionally, 20% believed that mangroves provide shelter from predators, while 18% felt that they help to maintain water quality. The distribution of responses suggests that awareness is fairly spread across different ecological functions, but the largest group understands that mangroves play a comprehensive and interconnected role in sustaining fish populations.

Figure 1. Major Economic Losses



(**Source:** Primary data)

Figure 1 shows the distribution of various economic impacts derived from primary data, highlighting a significant reliance on natural and environmental stability. The most prominent factor is the loss of fish stock, which dominates the chart at 44%, indicating that the depletion of aquatic resources is the primary driver of economic decline in this context. This is followed closely by Increased flood damage at 32%, suggesting that nearly a third of the economic burden is tied to environmental disasters and infrastructure vulnerability. The remaining categories represent a smaller portion of the total impact. "Others" accounts for 12% of the losses, while Loss of tourism income and Loss

of firewood/resources each contribute a minor 6%. When viewed holistically, the data reveals that over three-quarters (76%) of the economic losses are concentrated in just two areas: fisheries and flood-related damages. This suggests that the local economy is highly sensitive to ecological health and water management, making it particularly vulnerable to climate-related shifts or unsustainable resource extraction.

Table 2. Major threats to mangroves

S. No	Options	No. of respondents	Percentage (%)
1	Urbanization	12	24.0%
2	Pollution	17	34.0%
3	Aquaculture (prawn farms)	6	12.0%
4	Illegal cutting	6	12.0%
5	Climate change	5	10.0%
6	Others	4	8.0%
	Total	50	100

(**Source**: Primary data)

Table 2 shows the respondents opinions regarding the major threats to mangroves. Out of 50 respondents, the highest percentage (34%) identified pollution as the main threat, indicating that contamination of water bodies and surrounding environments is widely perceived as the most serious issue affecting mangrove ecosystems. Urbanization was the second most reported threat, with 24% of the respondents pointing to land development and infrastructure expansion as significant causes of mangrove destruction. Aquaculture (prawn farms) and illegal cutting were each identified by 12% of the respondents, suggesting that human economic activities and unauthorized exploitation also contribute notably to mangrove degradation. Additionally, 10% of the respondents recognized climate change as a threat, reflecting awareness of long-term environmental impacts such as rising sea levels and changing weather patterns. The remaining 8% selected other factors. Overall, the table indicates that human-induced activities, particularly pollution and urbanization, are considered the primary threats to mangroves, highlighting the need for stronger environmental protection and sustainable management practices.

Table 3. Causes of mangrove degradation

S. No	Causes of mangrove degradation	No. of respondents	Percentage (%)
1	Pollution	21	42.0%
2	Urbanization	16	32.0%
3	Conversion to aquaculture	8	16.0%
4	Natural disasters	5	10.0%
	Total	50	100

(**Source:** Primary data)

Table 3 presents the respondents' views on the main causes of mangrove degradation. Out of 50 respondents, the highest proportion (42%) identified pollution as the primary cause, indicating that waste disposal, industrial discharge, and water contamination are widely recognized as major threats to mangrove ecosystems. Urbanization was the second most reported cause, with 32% of the respondents pointing to land development, construction

activities, and expansion of human settlements as significant factors contributing to mangrove loss. Additionally, 16% of the respondents stated that conversion to aquaculture is a cause of degradation, showing awareness that transforming mangrove areas into fish or prawn farms can damage these ecosystems. A smaller percentage (10%) identified natural disasters as a cause, suggesting that while environmental factors like storms and floods play a role, human activities are perceived as more dominant causes.

Table 4. Groups benefiting from mangroves

S. No	Categories	No. of respondents	Percentage (%)
1	Local fishermen	28	56.0%
2	Women self-help groups	2	4.0%
3	Youth and guides	8	16.0%
4	Local businesses	10	20.0%
5	Government bodies	2	4.0%
	Total	50	100

(**Source**: Primary data)

Table 4 highlights the distribution of beneficiaries of mangrove eco-tourism based on primary data from 50 respondents. The findings show that local fishermen are the major beneficiaries, accounting for 56%, indicating that eco-tourism provides alternative income opportunities such as boating, guiding, and tourism-related fishing activities, thereby reducing pressure on mangrove ecosystems. Local businesses make up 20% of the beneficiaries, reflecting the growth of small enterprises like shops, food services, and homestays due to tourism. Youth and guides, representing 16%, indicate that mangrove tourism generates employment opportunities for young people while promoting environmental awareness and conservation practices. However, the participation of women self-help groups and government bodies remains minimal, with each accounting for only 4%. This limited involvement suggests that women's economic participation and institutional support in mangrove eco-tourism are still underdeveloped.

Table 5 Eco-tourism activities

S. No	Tourism activities	No. of respondents	Percentage (%)
1	Guided nature walks	15	30.0%
2	Bird watching	4	8.0%
3	Boating/Kayaking	28	56.0%
4	Photography tours	3	6.0%
	Total	50	100

(**Source:** Primary data)

Table 5 shows the distribution of eco-tourism activities related to mangrove areas, which indirectly reflects visitors' engagement with mangrove conservation initiatives. This indicates that boating and kayaking are the most preferred activities, reported by 28 respondents (56%), suggesting that tourists primarily experience mangrove ecosystems through water-based access and guided routes. Guided nature walks account for 15 respondents (30%), highlighting a significant interest in learning about mangrove flora, fauna and ecological functions through direct, low-impact

interaction. Bird watching is practiced by only 4 respondents (8%), while photography tours are the least preferred activity with 3 respondents (6%). Overall, the findings imply that experiential and mobility-based activities dominate mangrove tourism, while educational and conservation-oriented activities such as bird watching and photography tours receive comparatively lower participation. This indicates the need to strengthen awareness-driven programmes within mangrove eco-tourism so that conservation objectives are more strongly integrated with recreational use.

Table 6. Association between Perceived Threats to Mangroves and Preferred Government Conservation Measures

Threat Category	Economic/Legal	Awareness	Community	Total
Human activities	16	8	5	29
Resource use	6	2	4	12
Natural/Others	6	3	0	9
Total	28	13	9	50

(**Source:** Primary data)

Chi-Square Test

Component	**Value**
Null Hypothesis (H_0)	No association between perceived threats and preferred government measures
Alternative Hypothesis (H_1)	There is an association
Calculated χ^2 value	4.076
Degrees of Freedom (df)	4
Critical χ^2 value ($\alpha = 0.05$)	9.488
Decision Rule	Reject H_0 if χ^2 calculated > χ^2 critical
Result	4.076 < 9.488
Final Decision	**Fail to reject H_0**
Conclusion	No statistically significant association

Since the calculated chi-square value (4.076) is less than the critical value (9.488) at the 5% significance level, the result is not statistically significant.

This means the differences observed in the table could be due to random variation. There is no strong evidence to suggest a relationship between perceived threats to mangroves and preferred government conservation measures.

A large share of respondents (76%) belongs to the Below Poverty Line (BPL) category, suggesting that mangrove-dependent communities are economically vulnerable and rely on mangrove resources for livelihood support. For 86% of respondents, mangrove-related activities contribute less than 40% of monthly income, showing that mangroves function mainly as a supplementary income source. Fish collection is the most common mangrove-based activity (46%), followed by crab collection (12%), while 26% do not collect any mangrove products, indicating

partial dependence on mangrove resources. Loss of fish stock (44%) and increased flood damage (32%) together account for the major economic losses, highlighting the strong link between mangrove degradation and local economic insecurity. A high proportion of respondents (80%) agree that mangroves support endangered species, reflecting a positive level of ecological awareness. Pollution (34%) and urbanization (24%) are perceived as the major threats to mangrove ecosystems, followed by aquaculture and illegal cutting. A clear majority of respondents (76%) agree that mangrove-based eco-tourism contributes positively to local income. Boating and kayaking are the most preferred eco-tourism activities (56%), while bird watching and photography receive comparatively low preference. Natural scenery and biodiversity (44%) and a peaceful environment (30%) are the main motivations for visiting mangrove areas, while educational and adventure motives are limited. Employment opportunities are mainly confined to tourist guides (56%) and boat operators (36%), with very limited scope for conservation and hospitality-related jobs. Lack of awareness is identified as the biggest challenge to mangroves (46%), followed by limited funding for its conservation (22%). A very large majority of the respondents (90%) consider community involvement essential for mangrove conservation, and 78% support an active community role. A very high proportion of respondents (92%) support providing incentives to local communities for mangrove protection. Even though people identified different threats (human activities, resource use, natural causes), their preferences for government actions (economic/legal, awareness, community-based) do not significantly differ in a patterned way.

CONCLUSION

The study concludes that mangrove-based ecotourism has good potential to generate income for the local community while maintaining environmental sustainability. Tourism activities such as boating, bird watching, and nature walks can attract visitors and create employment opportunities for local people. This can improve the economic condition of the community and provide additional sources of livelihood. At the same time, ecotourism helps to increase awareness among tourists and residents about the ecological importance of mangrove forests and the need to protect them.

The study also reveals that mangroves face several challenges mainly due to human encroachment and other human activities. Land reclamation, construction, pollution, and unplanned development have reduced the area of mangrove forests in many regions. These activities disturb the natural habitat of many plants and animals and weaken the ability of mangroves to protect coastal areas from erosion and flooding. Therefore, proper conservation measures are necessary to protect these valuable ecosystems.

Furthermore, the study highlights the important role of both the local community and the government in protecting mangrove forests. The participation of local people in conservation activities such as mangrove planting, monitoring, and responsible tourism management can greatly support protection efforts. Government support through environmental policies, awareness programs, and proper management strategies is also essential for the sustainable development of mangrove ecosystems.

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