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Empowering Mangrove Ecotourism: Integrating Governance, Community, and Technology for Sustainable Coastal Development

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Abstract

This study uniquely explores the under-researched synergy between institutional governance, community engagement, and technology utilization in sustainable mangrove ecotourism, specifically in Pesisir Selatan Regency. Addressing gaps in the literature, it evaluates how institutional frameworks and local participation impact conservation amidst the rapid growth of tourism in the region. Using a quantitative approach, data were gathered from 395 respondents living near mangrove ecotourism sites. Structural Equation Modeling (SEM) revealed that robust governance and active community involvement significantly contribute to sustainable ecotourism. However, technological adoption remains constrained due to inadequate infrastructure and low digital literacy. The findings highlight the need to enhance technological infrastructure to maximize its conservation potential. This comprehensive analysis underscores the importance of harmonizing institutional policies and community involvement while leveraging technology to support conservation. The study's insights are not only relevant to the local context but also offer a framework for other coastal regions facing similar challenges. Empowering communities, reinforcing governance, and investing in technological advancements are essential steps toward sustainable ecotourism, fostering economic benefits while safeguarding coastal ecosystems for future generations.

Keywords: *Mangrove Ecotourism, Sustainable Tourism, Institutional Integration, Technological Advancements, Coastal Ecosystems.*

Introduction

Mangrove forest conservation ecotourism offers economic opportunities for the surrounding local communities, including those in the coastal areas of Pesisir Selatan Regency, West Sumatra Province. Mangrove forests along the coast have unique tourism potential because they provide an attraction for visitors. Tourists can enjoy the beauty of the mangrove forests by exploring the designated trails, offering a unique educational experience (Nugraha and Safei, 2023). The ecotourism potential requires the development of tourism site capacities to maintain a balance between community empowerment in tourism activities and environmental conservation. Marine tourism activities in Pesisir Selatan Regency need to consider the potential they have for regional development. Data on marine tourism in Pesisir Selatan Regency shows significant growth over the last five years, from 2018 to 2022. In 2018, the number of tourist visits to Pesisir Selatan Regency reached only 300,000. However, this number continued to increase each year, reaching 3.2 million in 2022 (www.diaspora.pesisisrselatankab.go.id).

The primary objective of this study is to assess the extent to which various factors such as institutional systems, community participation, and the utilization of technology can influence the development of mangrove forest conservation ecotourism. The study aims to provide insights that could address current challenges in the development of ecotourism in Pesisir Selatan, contributing to the literature on community behavior and offering relevant policy recommendations. The urgency of this research is underscored by the rapid growth of the marine tourism industry in Pesisir Selatan, which has led to significant increases in tourist visits from 300,000 in 2018 to 3.2 million in 2022 (www.diaspora.pesisisrselatankab.go.id). While this growth presents substantial economic opportunities, it also poses threats to the sustainability of the mangrove ecosystems if not managed properly. Conservation-oriented ecotourism has the potential to protect these critical environments from further degradation by promoting environmentally friendly practices, such as energy-efficient transportation and responsible waste management (Zvikonyaukwa, Musengi, & Mudzengi, 2023). Therefore, it is imperative to develop ecotourism capacities that balance

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community empowerment in tourism activities with environmental conservation, ensuring long-term benefits for both the local economy and natural resources.

Despite the recognized potential of ecotourism to promote both economic development and environmental conservation, several challenges persist in the effective development and management of ecotourism in Pesisir Selatan. These challenges include weak institutional systems, lack of clear regulations, inadequate infrastructure, and insufficient community awareness regarding the importance of environmental conservation. This study identifies these gaps and seeks to explore how strengthening institutional frameworks, increasing community involvement, and leveraging technology can overcome these obstacles (Zvikonyaukwa, Musengi, & Mudzengi, 2023). The novelty of this study lies in its comprehensive approach to examining the synergy between institutional systems, community participation, and technological utilization in the context of sustainable ecotourism development. Moreover, the integration of ecotourism into mangrove conservation strategies has been shown to enhance local community engagement and provide economic incentives for conservation (Afifah et al., 2023; , Kurniawati et al., 2022). Here is the novelty of the research presented through the Reference Network (VOSviewer).

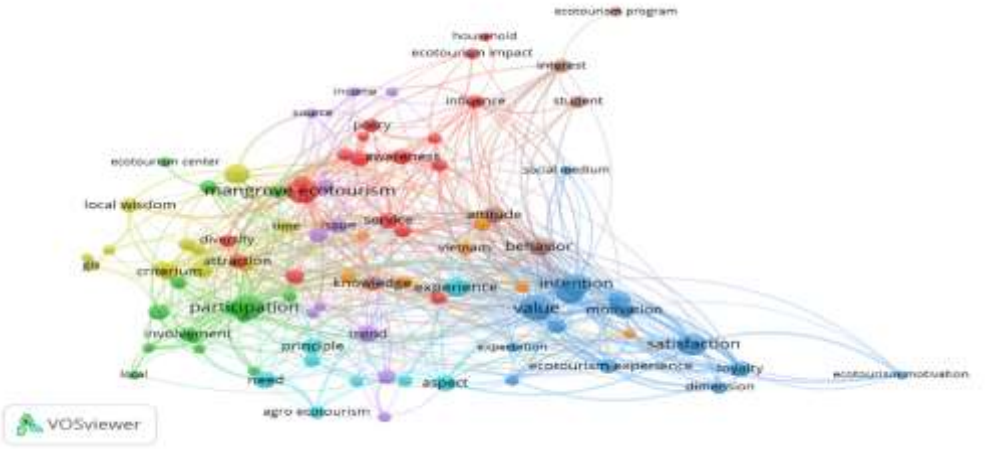

Figure 1. The References Network (VOSviewer)

This figure is a visualization of keyword networks related to ecotourism, generated using VOSviewer software. The colored nodes represent clusters of interrelated keywords, with the size of each node indicating the frequency of the keyword in the dataset. Key clusters include participation and local involvement (green), ecotourism awareness and policy (red), and values, intentions, and satisfaction in ecotourism experiences (blue). The connecting lines illustrate relationships or co-occurrences between keywords, with thicker lines indicating stronger connections, providing insight into how different concepts in ecotourism are interconnected.

The implications of the research conducted in Pesisir Selatan extend significantly beyond its immediate geographical context, offering valuable insights for sustainable tourism development in coastal regions facing analogous challenges. The findings advocate for a model of ecotourism that emphasizes community empowerment alongside environmental conservation, thereby contributing to the broader discourse on sustainable development. Such an approach not only enhances the economic well-being of local populations but also ensures the long-term preservation of vital natural resources, a sentiment echoed in various studies that highlight the interconnectedness of tourism, community welfare, and environmental sustainability. For instance, the study by emphasizes the importance of responsible environmental behavior among travelers at ecotourism sites, suggesting that increased awareness can lead to positive changes in attitudes and behaviors towards the environment (Handriana & Ambara, 2016). This aligns with the findings of , who posits that while ecotourists may not always prioritize sustainability, their motivations often stem from a desire to connect with nature, which can inadvertently promote sustainable practices among operators (Beaumont, 2011). Furthermore, the research by illustrates the critical balance between tourism

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development and environmental conservation, highlighting community attitudes as pivotal in shaping effective tourism strategies (Lee et al., 2020).

Given the complex challenges identified, such as weak institutional frameworks and insufficient infrastructure, this research highlights the urgency of fostering integrated collaboration among stakeholders, including government bodies, local communities, and tourism businesses. Effective coordination and clear role distribution among these parties are essential to avoid overlapping authorities and to streamline decision-making processes. This study will explore the dynamics of these relationships and propose strategies to enhance stakeholder synergy, which is crucial for achieving sustainable ecotourism development. Addressing these challenges not only improves the effectiveness of conservation efforts but also enhances the overall visitor experience, ultimately contributing to the long-term sustainability of mangrove ecotourism in Pesisir Selatan.

Theoretical Review

Building sustainable mangrove ecotourism along the southern coast necessitates a multifaceted approach that integrates institutional frameworks, technological advancements, and active community participation. Mangroves serve as vital ecosystems that provide numerous ecological, economic, and social benefits, making their conservation and sustainable management crucial for local communities and the environment.

Institutional Integration and Policy Frameworks

Effective governance is essential for the sustainable management of mangrove ecosystems. Policies that promote blue carbon tourism can enhance both local economies and environmental conservation efforts. For instance, local governments in China have developed detailed plans to utilize blue carbon resources, which include mangroves, for tourism development, thereby fostering the protection and restoration of these ecosystems (Xu, 2023). Similarly, the Integrated Coastal Zone Management Plan has been instrumental in setting objectives for mangrove protection and restoration, aiming to mitigate carbon emissions while enhancing tourism and fisheries (Arkema et al., 2023). This integrated approach not only supports biodiversity but also strengthens the resilience of coastal communities against climate change impacts such as sea-level rise and extreme weather events (Jones et al., 2020).

Effective governance structures are fundamental for the successful management of mangrove ecosystems and the promotion of ecotourism. Policies that prioritize the protection of mangroves while simultaneously promoting ecotourism can create a synergistic relationship between conservation and economic development. For instance, the establishment of clear regulations that govern the use of mangrove resources can help mitigate the negative impacts of tourism while ensuring that local communities benefit economically. Institutional reinforcement models that incorporate social-ecological assessments can facilitate better decision-making processes, connecting mangrove-dependent communities with policymakers (Purwanti et al., 2021). This approach ensures that the needs and knowledge of local populations are integrated into the management of ecotourism initiatives. Moreover, the role of local governments is pivotal in leading ecotourism development. Local authorities must align their development goals with sustainable practices that respect both the environment and the cultural heritage of the communities involved. This alignment can be achieved through participatory governance models that engage local stakeholders in the planning and implementation phases of ecotourism projects (Saragih et al., 2022). Such models not only enhance transparency but also foster a sense of ownership among community members, which is critical for the long-term success of ecotourism initiatives.

Technological Innovations in Ecotourism

Technological advancements play a pivotal role in enhancing the sustainability of mangrove ecotourism. The use of tools such as the CoastSat toolkit allows for effective monitoring of coastal dynamics, which can inform better management practices for mangrove ecosystems (Curoy et al., 2022). Additionally, the application of ecosystem service valuation methods can help quantify the economic benefits derived from mangrove tourism, thereby supporting policy decisions that favor conservation over degradation (Lin et al.,

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2022). Technologies that facilitate community engagement in tourism activities, such as mobile applications for ecotourism promotion, can also enhance visitor experiences while ensuring that local communities benefit economically from their natural resources (Ilieva, 2023).

Information and Communication Technologies (ICT) have emerged as essential tools for managing sustainable tourism development. They enable destination managers to mitigate the environmental impacts of tourism while enhancing visitor experiences. and Frew emphasize that ICT can facilitate better decision-making processes by providing destination managers with analytical tools to assess the sustainability of tourism practices (Ali & Frew, 2014). These technologies can democratize information, allowing stakeholders to make informed choices that align with sustainable tourism principles (Ali, 2022). Furthermore, the use of mobile applications and online platforms can enhance visitor engagement by offering real-time information about mangrove ecosystems, promoting responsible tourism behaviors, and facilitating bookings for ecotourism activities.

Community Participation and Empowerment

According to Gong et al. (2023), the influence of the planet within sustainable marketing on Community involvement is critical for the success of sustainable mangrove ecotourism. Empowering local communities through education and participation in conservation efforts can lead to more effective management of mangrove resources. For example, community-based tourism models have been shown to significantly contribute to mangrove conservation in Indonesia, where local residents actively participate in the management and restoration of mangrove forests (Nuraeni, 2023). Furthermore, initiatives that involve local communities in the production of mangrove seedlings and the promotion of ecotourism can create economic opportunities while fostering a sense of stewardship for the environment (Fauzan & Samputra, 2021). The success of such programs often hinges on shifting from top-down management approaches to more inclusive, participatory frameworks that recognize the knowledge and needs of local populations (Efendi, 2013).

Community participation is critical for the sustainable management of mangrove ecosystems. Local communities possess valuable traditional knowledge about their environment, which can significantly contribute to conservation efforts. According to , enhancing community understanding of the ecological and economic benefits of mangroves is vital for fostering active participation in conservation initiatives (Koda, 2023). This understanding can be achieved through government-supported training and awareness programs that emphasize the importance of mangrove ecosystems and the role of local communities in their preservation. Furthermore, economic incentives are pivotal in motivating community involvement. Providing financial benefits or income-generating opportunities related to mangrove conservation can lead to increased participation. For instance, highlight the need for integrated ecotourism development that creates a conducive atmosphere for community engagement, thereby encouraging active involvement in conservation activities (Priambodo et al., 2022). When communities see tangible benefits from their participation, they are more likely to commit to sustainable practices.

In conclusion, building sustainable mangrove ecotourism along the southern coast requires a comprehensive strategy that integrates institutional policies, technological innovations, and community participation. By leveraging the ecological and economic potential of mangroves through well-designed governance frameworks and active local engagement, it is possible to create a resilient and thriving ecotourism sector that benefits both the environment and local communities.

Research Method

This study adopts a quantitative research method to explore the relationships between institutional synergy, community participation, technology utilization, and the sustainability of mangrove ecotourism in Pesisir Selatan Regency. The quantitative approach was chosen because it allows for the systematic measurement and analysis of variables, providing objective and generalizable results. This method is particularly effective for testing hypotheses and examining the causal relationships between variables, which is essential for

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understanding the impact of institutional systems, community involvement, and technology on sustainable development.

This study was conducted among residents living in the mangrove ecotourism areas of Pesisir Selatan Regency. The population included both fishermen and non-fishermen residing within a three-kilometer radius of the mangrove ecotourism sites. A total population of 28,793 individuals was identified, spanning five districts: Ranah Pesisir, Lengayang, Sutera, IV Jurai, and Koto XI Tarusan. The sample size was determined using Slovin's formula, resulting in 395 respondents. The sampling technique employed was multistage random sampling, which involved multiple stages: defining the total population, allocating it by district, and further categorizing it by occupation (fishermen and non-fishermen). This technique ensured a representative sample across all key sub-populations.

Primary data was collected through a structured questionnaire distributed to the selected respondents. The questionnaire was systematically designed to gather accurate and relevant data related to the study variables, including indicators of ecotourism, mangrove conservation, institutional systems, community participation, and technology utilization. The questions were adapted and combined from previous research to ensure reliability and validity. Secondary data were also gathered from relevant archives, reports, and literature to support the logical arguments of this study. These documents included records on mangrove conservation efforts, institutional frameworks, and community involvement in the ecotourism sector.

The collected data was analyzed using Structural Equation Modeling (SEM) with Partial Least Squares (PLS) to test the hypotheses and evaluate the relationships between the variables. This model allowed for the measurement of both direct and indirect effects of institutional systems, community participation, and technology utilization on ecotourism and mangrove conservation. The analysis followed a rigorous process, including the evaluation of the measurement model (outer model) for convergent and discriminant validity, as well as the assessment of the structural model (inner model) for its predictive relevance using indicators like R-square and path coefficients. The statistical analyses were conducted using AMOS 26 software, ensuring that the results were robust and reliable.

Results and Discussion

Ecotourism in Pesisir Selatan Regency, West Sumatra, focuses on community-based tourism development through the conservation of mangrove forests spread across eleven districts. This initiative involves the local community in the management and maintenance of the mangroves, providing economic and educational benefits while also strengthening environmental conservation. With its rich biodiversity and the crucial role of mangroves as natural coastal protectors, this ecosystem serves as a major attraction for tourists. Support from local government, collaboration with NGOs, and effective promotional strategies are vital in establishing Pesisir Selatan as a sustainable ecotourism destination, while also enhancing the well-being of the local community.

Characteristics of Respondents

In addition to collecting data on the variables, the researchers also gathered demographic data about the respondents, who are the people living in the ecotourism conservation area of the mangrove forest in Pesisir Selatan. The demographics of the community living in the ecotourism conservation area in Pesisir Selatan include gender, education, and age. The demographics of the respondents are reported in Table 1.

Table 1. Respondent Characteristics

Characteristics	Sum	Percentage (%)
Gender		
Male	233	58.99
Female	162	41.01
Last Education		

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Characteristics	Sum	Percentage (%)
Elementary School	79	19.92
Middle School	74	18.8
High School	209	53.01
University	33	8.27
Age		
19-38 Years	138	34.95
39-58 Years	198	49.99
59-78 Years	59	15.5
Employment Status		
Fisherman	203	51.27
Non-fisherman	127	32.33
Unemployed	65	16.50
Business Ownership		
Yes	206	52.15
No	189	47.85
Number of Dependents		
1-2 People	91	23.25
3-4 People	230	58.14
5-6 People	74	18.61
Income		
< 1 Million IDR	6	1.51
1-2 Million IDR	192	48.62
> 2-4 Million IDR	176	44.55
> 4 Million IDR	21	5.32
Home Ownership Status		
Family-owned	171	43.29
Owned	182	46.08
Rented	30	7.59
None	12	3.04
Distance from Ecotourism Are		
< 1 KM	157	39.59
1-2 KM	190	48.32
2-4 KM	37	9.23
> 4 KM	11	2.86

Source: Processed Primary Data (2024)

This study provides a comprehensive overview of the socio-economic characteristics of communities living near ecotourism areas, with the majority of respondents being of working age (39-58 years) and having completed secondary education (high school). Most respondents are engaged in fishing, highlighting the community's economic dependence on the fishing sector, while others demonstrate entrepreneurial spirit by owning their own businesses. Additionally, the majority of respondents earn between 1-4 million IDR per month, indicating a certain level of economic stability despite limited access to higher education. The geographical proximity to ecotourism areas, with most respondents living within 1-2 KM, also suggests potential involvement in tourism-related economic activities. This research offers a novel perspective by linking the proximity of residences to ecotourism areas with various socio-economic factors, an aspect that has been relatively underexplored in existing literature. It contributes significantly to our understanding of how geographical location can influence the economic and social well-being of coastal communities. These findings are supported by previous studies that show a correlation between education and income, and that coastal communities often rely on small businesses for their livelihoods. Consequently, this study not only enriches the literature on the economics of coastal communities but also paves the way for further research into the impact of ecotourism on their lives.

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Analysis of Research Results

The latent variables that have passed the measurement model evaluation are those that have undergone selection and validation, ensuring that only valid and reliable indicators are used. Indicators that do not meet the standards will be removed from the model. The description of the latent variables includes the characteristics, dimensions, and relationships among the indicators within the construct being studied, aiming to provide a comprehensive understanding of the construct, including the interpretation of the analysis results related to these latent variables. The following are the results of the institutional variable description measured from five manifest variables.

Table 2. Descriptive Analysis of Variables

No	Manifest Variable	Mean	TCR	Description
Institutional				
1	Regulation Management	3.86	77.2	Fairly Good
2	Policy Implementation	3.82	76	Fairly Good
3	Resource Management	3.88	77.5	Very Good
4	Supervision	3.95	79.04	Fairly Good
5	Financial Sustainability	3.84	79.8	Fairly Good
Community Participation				
1	Community Perception	3.93	78.6	Good
2	Community Involvement	3.87	77.52	Good
3	Forest Product Utilization	3.86	77.2	Fairly Good
4	Forest Maintenance	3.84	79.8	Fairly Good
Technology Utilization				
1	Information and communication	4.15	83	Good
2	Waste Management	4.18	83.72	Good
3	Production Technology	4.24	84.84	Good
4	Transportation Technology	4.26	85.24	Good
5	Infrastructure Technology	4.20	84.14	Good
Mangrove Forest Conservation				
1	Mangrove Vegetation	3.93	78.72	Fairly Good
2	Mangrove Regeneration	3.98	79.76	Fairly Good
3	Environmental Sustainability	3.96	79.4	Fairly Good

Source: Processed Primary Data (2024)

The analysis of the table reveals that institutional factors and community participation in the management and conservation of mangrove forests are generally at a "Fairly Good" level, with some room for improvement, particularly in policy implementation and financial sustainability. On the other hand, the utilization of technology stands out with high performance, reflected in "Good" ratings across all related variables. This suggests that while institutional effectiveness and community involvement are crucial, the strategic use of technology can significantly enhance conservation efforts and overall management outcomes. The novelty of this study lies in its integrated approach, highlighting the critical role of institutional effectiveness in conservation outcomes and the influence of technology on community participation. By addressing these interconnected aspects, the research provides a holistic perspective on managing natural resources, particularly mangrove forests. The findings suggest that strengthening institutional frameworks and leveraging technology can lead to more effective conservation practices, fostering greater community involvement and ensuring the sustainability of these vital ecosystems.

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Before hypothesis testing, the reflective measurement model is evaluated to verify the manifest variables and constructs. The Outer Model assesses the validity and reliability through convergent and discriminant validity, as well as composite reliability and Cronbach's alpha. Convergent validity checks how well indicators measure the same construct, while discriminant validity ensures constructs are distinct. Reliable indicators are confirmed through composite reliability and Cronbach's alpha. The validity test, using Loading Factor (LF), determines whether indicators should be retained based on a loading value threshold of $\lambda > 0.5$.

Table 3. Loading Factor Variables

Exogenous Variables	Loading Factor Value
Institutional System	0.84
Community Participation	0.92
Technology Utilization	0.81
Mangrove Forest Conservation	0.97

Source: Processed by the researcher using Smart-PLS 3.0 (2024)

The analysis of the loading factor values shows that all exogenous variables Institutional System (0.84), Community Participation (0.92), Technology Utilization (0.81), and Mangrove Forest Conservation (0.97) are strong indicators of their respective constructs. Mangrove Forest Conservation and Community Participation exhibit the highest correlations, highlighting their significant influence in the model. Overall, the high loading factors confirm the reliability and validity of the constructs in the measurement model. Convergent validity measures the extent to which a construct has a positive relationship with other constructs (Hair et al., 2019). One way to assess convergent validity is by using the average variance extracted. AVE indicates how much of the variance in observed variables (manifest variables) is explained by the latent variable. The stronger this relationship, the better the latent variable explains the variance in the manifest variables. An acceptable AVE value is at least 0.50 or higher, meaning that the construct is able to explain at least 50 percent of the variance in the items that form it. Based on the results of the convergent validity test, the following findings were obtained:

Table 4. Convergent Validity Test Results

Variable	Average Variance Extracted (AVE)
Mangrove Forest Conservation	0.947
Community Participation	0.862
Technology Utilization	0.673
Institutional System	0.720

Source: Processed by the researcher using Smart-PLS 3.0 (2024)

The analysis of the table reveals that all the latent variables Mangrove Forest Conservation, Community Participation, Technology Utilization, and Institutional System have Average Variance Extracted (AVE) values above the minimum threshold of 0.5. Specifically, the AVE values range from 0.673 to 0.947, indicating a strong level of convergent validity across all variables. This means that each latent variable effectively explains a significant portion of the variance in its associated indicators, confirming that the constructs are well-represented by their respective indicators and are valid for further analysis in the model.

Table 5. Discriminant Validity Test Result

	Mangrove Forest Conservation	Community Participation	Technology Utilization	Institutional System
Mangrove Forest Conservation	0.895			
Community Participation	0.870	0.863		

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Technology Utilization	0.153	0.153	0.245	
Institutional System	0.834	0.742	0.855	0.212

Source: Processed by the researcher using Smart-PLS 3.0 (2024)

The analysis reveals that Mangrove Forest Conservation is strongly correlated with Community Participation (0.870) and Institutional System (0.834), indicating that these factors significantly influence conservation efforts. Community Participation also shows a strong relationship with Institutional System (0.742). In contrast, Technology Utilization has relatively low correlations with the other variables, suggesting it plays a less direct role in this context. The square root of the Average Variance Extracted (AVE) values for each variable exceeds their correlations with other variables, confirming good discriminant validity, meaning the constructs are well-defined and distinct from one another in the model.

Hair et al. (2012), when evaluating internal consistency, composite reliability is preferred over Cronbach's alpha in SEM analysis. Composite reliability does not assume equal weighting for each indicator, whereas Cronbach's alpha tends to provide a lower reliability estimate. Composite reliability is used to assess the reliability of latent variables by examining the correlation of all items. In contrast, Cronbach's alpha evaluates the average consistency of items within a variable and how well these items measure the same construct. Composite reliability is considered good if it exceeds 0.6. The results of the composite reliability test can be seen in Table 6 below, as follows:

Table 6. Composite Reliability Test Results

Variables	Cronbach's Alpha	Composite Reliability
Mangrove Forest Conservation	0.996	0.996
Community Participation	0.991	0.992
Technology Utilization	0.980	0.981
Institutional System	0.984	0.985

Source: Processed by the researcher using Smart-PLS 3.0 (2024)

The Composite Reliability Test results indicate that all variables—Mangrove Forest Conservation, Community Participation, Technology Utilization, and Institutional System demonstrate exceptionally high reliability. Both Cronbach's Alpha and Composite Reliability values for these variables are significantly above the acceptable threshold of 0.6, with scores ranging from 0.980 to 0.996. Mangrove Forest Conservation exhibits the highest reliability with a perfect score of 0.996 for both metrics, followed closely by Community Participation at 0.992, and Technology Utilization and Institutional System with values of 0.981 and 0.985, respectively. These findings confirm that the indicators for each variable consistently measure their respective constructs, ensuring the robustness and reliability of the data for further analysis.

The inner model tests the structural model to ensure it fits the data. It predicts relationships between latent variables and assesses the research hypothesis by analyzing t-statistics and p-values. A t-statistic over 1.96 and p-value below 0.05 indicate a significant relationship. Goodness of fit can be assessed using two indicators. First, the Standard Root Mean (SRMN) is considered adequate if below 0.1 and excellent if below 0.08. Second, the Normal Fit Index (NFI) ranges from 0 to 1, with values closer to 1 indicating better model quality. These indicators provide insight into the model's overall fit. Results from Smart PLS analysis is shown in Table 7 below:

Table 7. Results of GFI Test

	Saturated Model	**Estimated Model**
SRMR	0.074	0.074
d_ULS	30.558	30.558
d_G	8,708	8,708
Chi-Square	13007.700	13007.700

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NFI	0,789	0,789

Source: Processed by the researcher using Smart-PLS 3.0 (2024)

Path analysis measures the strength of influence between variables, both directly and indirectly. In this study, path analysis is essential to identify roles in enhancing ecotourism, enabling informed decisions for its development. The Direct Effect significance was evaluated using bootstrapping, with t-statistics compared to critical z-values 1.65 (10%), 1.96 (5%), and 2.58 (1%). A t-statistics value exceeding these indicates statistical significance. Here, the hypothesis was accepted at a 5% significance level (z = 1.96), with the estimated path coefficients as follows:

Table 8. Direct Effect of Exogenous Variables on Endogenous Variables

Construct	Coefficient	t-Statistics (O/STDEV)	Description
Institutional System -> Mangrove Forest Conservation	1.172	13.531	Accepted
Community Participation -> Mangrove Forest Conservation	0.234	2.470	Accepted
Technology Utilization -> Mangrove Forest Conservation	0.030	1.362	Rejected

Source: Processed by the researcher using Smart-PLS 3.0 (2024)

The Effect of Institutional Systems on Mangrove Forest Conservation in the Southern Coast

Changes or management within institutional systems can significantly impact mangrove forest conservation in the Southern Coast. Institutional systems encompass organizational structures, policies, regulations, and management mechanisms that govern the use and protection of natural resources, including mangrove forests. In the context of mangrove conservation, improvements or reforms in institutional systems can lead to substantial positive effects. The relationship between institutional systems and mangrove forest conservation can be described as follows: the more effective and efficient the institutional system, the greater the enhancement of mangrove conservation in the Southern Coast. This occurs because a strong institutional system provides a solid foundation for implementing conservation policies and programs.

An effective institutional system includes a clear organizational structure, well-defined roles and responsibilities among relevant institutions, and transparent and accountable decision-making mechanisms. This ensures good coordination among various stakeholders involved in mangrove conservation, such as government, non-governmental organizations, local communities, and the private sector. This aligns with previous findings that highlight the importance of institutional systems in preserving this valuable ecosystem. Effective local institutions play a crucial role in managing mangrove forests, as seen in the village of Pantai Bahagia Muara Gembong, where weak community institutions have led to ongoing mangrove forest degradation, resulting in flooding and economic disruption. This village serves as a tangible example of how vital strong institutional systems are in ensuring the protection and sustainable management of mangrove forests. The presence of effective local institutions can help coordinate conservation efforts, monitor harmful human activities, and enforce penalties for violations of conservation policies (Nugraha, Bambang, et.al, 2019).

In line with previous findings, institutional systems create new potential for mangrove forest conservation by efficiently and effectively coordinating conservation efforts (Ellison, 2014). With a clear organizational structure and transparent decision-making mechanisms, relevant institutions such as the government, non-governmental organizations, and local communities can collaborate in formulating and implementing coordinated conservation programs (Kodikara et al., 2017). This collaborative approach is essential for addressing the multifaceted challenges faced by mangrove ecosystems, which are increasingly threatened by both climate change and human activities (Kuenzer et al., 2011; Cahyaningsih et al., 2022). The primary impact of institutional systems lies in governance effectiveness, as strong institutions serve as a critical

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foundation. Strong institutions ensure consistent and fair enforcement of conservation policies and enable the sustainable management of mangrove forests while balancing ecological, social, and economic needs. For instance, multi-stakeholder forums involving government, local communities, and non-profit organizations can facilitate transparent and inclusive decision-making. Thus, robust institutional systems ensure that mangrove forest governance is conducted efficiently and responsibly, fostering a conducive environment for the sustainability of mangrove ecosystems and the well-being of the communities that depend on them.

The Effect of Community Participation on Mangrove Forest Conservation in the Southern Coast

The findings indicate that community participation has a significant impact on mangrove forest conservation in the Southern Coast. In the context of mangrove forest conservation, community participation plays a crucial role. Through active involvement in decision-making, the implementation of conservation programs, and environmental monitoring, local communities can act as effective agents of change in protecting and preserving mangrove ecosystems. With greater community involvement, as shown by this study's findings, mangrove conservation efforts are expected to become more effective and sustainable.

The findings indicate that community participation has a significant impact on mangrove forest conservation in the Southern Coast (Arfan, 2024). In the context of mangrove forest conservation, community participation plays a crucial role. Through active involvement in decision-making, the implementation of conservation programs, and environmental monitoring, local communities can act as effective agents of change in protecting and preserving mangrove ecosystems (Koda, 2023). With greater community involvement, as shown by this study's findings, mangrove conservation efforts are expected to become more effective and sustainable (Rumondang, 2024). Community engagement in mangrove conservation also brings additional positive outcomes, such as increased environmental awareness, the development of strong conservation values among the younger generation, and increased participation in sustainable ecotourism activities (Susilo et al., 2017). This aligns with the notion that empowering local communities through education and economic incentives can enhance their commitment to conservation initiatives (Locatelli et al., 2014).

Community participation in mangrove conservation in the Southern Coast has significant implications. This region has a mangrove ecosystem rich in biodiversity and serves as a vital natural resource for local communities. However, like many other coastal areas in Indonesia, the mangrove forests in the Southern Coast face various threats, including overexploitation, land conversion for development, and climate change. In this context, Community participation in mangrove conservation in the Southern Coast has significant implications. In this context, community participation is key to efforts aimed at protecting and restoring the mangrove forests (Fatimatuzzahroh et al., 2020). Engaging local communities in conservation initiatives not only enhances the effectiveness of these programs but also fosters a sense of ownership and responsibility towards the mangrove ecosystem (Arifanti et al., 2022). This phenomenon is reflected in various local initiatives in the Southern Coast, where communities have actively engaged in mangrove conservation activities, including reforestation, environmental monitoring, and sustainable resource management. For example, in several villages in the Southern Coast, such as Mandeh, Painan, Apiang Parak, Kambang, and Nyiur Melambai, communities have formed mangrove conservation groups that collaborate with government agencies and non-governmental organizations to protect mangrove ecosystems.

The findings align with previous research, which indicates that community participation in the Southern Coast plays a vital role in sustainable mangrove management. The Southern Coast is not only home to vast and diverse mangrove ecosystems but also serves as the economic and livelihood base for local communities. In this context, the traditional knowledge possessed by the community about mangroves becomes an invaluable asset. This knowledge, passed down through generations, includes a deep understanding of ecology, fish migration patterns, and sustainable fishing techniques. The importance of community involvement in mangrove management is not only reflected in the knowledge they possess but also in their participation in various stages of the management process. From planning to evaluation, local communities are actively involved in decision-making processes related to the management of their natural

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resources. They are part of decision-making forums that involve the government, non-governmental organizations, and local community representatives, where they can voice their interests and aspirations for mangrove conservation (Ramli & Author, 2023; Ahmed et al., 2023).

The novelty of this study lies in its detailed exploration of the relationship between community participation and mangrove conservation in the Southern Coast, offering a comprehensive understanding of how local involvement contributes to environmental sustainability. While previous research has acknowledged the importance of community engagement in conservation, this study provides new insights into how community-led initiatives, traditional knowledge, and cultural values specifically impact mangrove forest preservation in this region. Moreover, the study introduces a novel perspective on the socioeconomic benefits of community participation in mangrove conservation, particularly in relation to ecotourism development and sustainable resource management. This connection between community engagement and sustainable economic development provides a fresh understanding of how conservation efforts can be aligned with local livelihoods, thus ensuring both environmental and economic sustainability. The study's emphasis on active community involvement in decision-making forums also contributes to a deeper understanding of how participatory approaches can lead to more inclusive and effective conservation policies.

The Influence of Technology Utilization on Mangrove Forest Conservation in South Coast Areas

The findings indicate that there is no significant relationship between technology utilization and the development of mangrove forest conservation in the South Coast region. In this case, the limited technological infrastructure in the South Coast area is the main obstacle in utilizing technology for mangrove conservation efforts. The lack of adequate access to a stable internet network poses a serious challenge for the local community. Most coastal areas still face problems related to unstable or even non-existent internet connectivity. This hinders the community's ability to access information, communicate effectively, and use digital applications or tools that could support mangrove conservation efforts.

This result is in line with research conducted by Adani, N., et.al (2023), which also found that a lack of stable internet connectivity makes it difficult for local communities to access crucial information, hampers effective communication, and limits the use of digital tools for conservation purposes. This situation is exacerbated by the reality that many coastal areas still face unreliable or non-existent internet access. This significantly hampers the ability to apply technology-based solutions in mangrove conservation efforts. The limited infrastructure conditions are a serious obstacle to mangrove preservation efforts. The lack of stable and reliable internet access hinders the local community's ability to access knowledge and information about mangrove conservation and to participate in collaborative initiatives that utilize technology. For instance, without adequate internet access, it is difficult for the community to access environmental monitoring platforms or applications that assist in monitoring and reporting conservation activities.

Low digital literacy among coastal communities also complicates the utilization of technology. Limited knowledge and skills in using digital communication tools, such as computers or smartphones, as well as online applications and platforms, can reduce the effectiveness of conservation efforts involving technology. Communities with low technology skills tend to struggle with accessing information, collaborating online, or using digital tools for environmental monitoring. These limitations in infrastructure and digital literacy are real obstacles to harnessing the potential of technology for mangrove conservation in the southern coastal region. Greater efforts are needed to improve technology accessibility and increase the digital literacy of coastal communities so that they can effectively utilize technology in their mangrove preservation efforts. This could include providing better technological infrastructure, training, and education on technology use, as well as developing applications and technological solutions tailored to local needs and conditions. By doing so, coastal communities will be more capable of actively participating in mangrove conservation efforts and creating a more positive impact on their environment.

The limited digital literacy among the South Coast community poses a significant challenge in utilizing technology for mangrove forest conservation efforts. Studies in various countries, such as Bangladesh and Indonesia, highlight several relevant aspects in this context. In Bangladesh, research shows a high reliance

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on social media for disaster response, emphasizing the importance of technology adoption in emergency and critical situations. Meanwhile, in Indonesia, studies affirm the impact of weak institutional and community coordination in mangrove forest management, signaling the need to enhance community skills and knowledge in the context of conservation. Efforts to improve the skills and incomes of coastal communities align with the broader goal of enhancing livelihoods and promoting economic growth. Training and education on sustainable practices become crucial in this effort, enabling communities to better understand their role in environmental conservation and support the use of technology for this purpose (Neisser, Florian M, 2023).

The research focus on the relationship between technology utilization and mangrove forest conservation, particularly in the context of the South Coast area, which faces unique challenges such as limited infrastructure and low digital literacy. While previous studies have explored the role of technology in environmental conservation, this study highlights the specific obstacles faced by coastal communities in Indonesia, such as poor internet connectivity and digital literacy, that hinder the effective use of technology in conservation efforts. Additionally, the research suggests practical solutions such as improving technological infrastructure and providing tailored digital literacy training, which are crucial for empowering coastal communities in conservation efforts. This offers new insights into how localized, technology-driven solutions can support sustainable environmental practices.

Conclusion

This study explored the dynamics of building sustainable mangrove ecotourism on the southern coast of Pesisir Selatan Regency, focusing on the integration of institutional frameworks, community participation, and technology. It aimed to balance environmental conservation with economic benefits for local communities. The rapid growth of marine tourism in the region presents both opportunities and challenges, particularly concerning the protection of mangrove ecosystems. Key findings revealed that institutional systems, including governance and policy implementation, play a crucial role in supporting mangrove conservation. Additionally, community participation emerged as a vital element in successful ecotourism, as local knowledge and involvement in decision-making enhance conservation efforts. However, technological use, while promising, remains limited due to infrastructure and digital literacy challenges in the region. The study's novelty lies in its comprehensive approach, examining the interplay of institutional support, community engagement, and technology. It also introduces the concept of linking community proximity to ecotourism areas with socio-economic outcomes, offering new insights into fostering environmental stewardship through local involvement. The findings have important implications for sustainable tourism practices in coastal regions. The emphasis on institutional frameworks and community participation provides a model adaptable to similar contexts. Additionally, the limited role of technology highlights the need for improved infrastructure and digital skills to boost conservation efforts. Policymakers and tourism developers can use these insights to create more inclusive strategies, ensuring sustainable development without compromising environmental integrity.

Recommendation

Based on the study's findings, several recommendations are proposed to enhance sustainable mangrove ecotourism in Pesisir Selatan Regency. First, local governments should strengthen institutional frameworks by improving governance, creating clear regulations, and fostering collaboration between authorities, NGOs, and community groups to improve conservation efforts. Second, deeper community engagement is crucial and can be achieved through education programs and economic incentives that promote active participation in ecotourism. Third, enhancing technological utilization is essential, requiring investments in internet infrastructure and digital literacy to leverage technology in conservation efforts. Training communities in digital tools for environmental monitoring and sustainable tourism management will further empower them. Lastly, tourism developers should implement sustainable practices like eco-friendly transportation and waste management. The successful models identified in this study should be adapted for use in other coastal regions to promote responsible tourism and ensure both environmental protection and economic growth on a larger scale.

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