Jurnal Ilmiah Peuradeun
The Indonesian Journal of the Social Sciences
Journal Homepage:
https://journal.scadindependent.org/index.php/jipeuradeun

Vol. 14, No. 2, May 2026	**Copyright © 2026, is licensed under a CC-BY-SA**
Pages: 1185-1204	**Publisher: SCAD Independent**
DOI: https://doi.org/10.26811/peuradeun.v14i2.1797	**P-ISSN: 2338-8617 / E-ISSN: 2443-2067**

Collaborative Pentahelix Governance and Environmental Literacy Development in Mangrove Ecotourism

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Article Info

Received: August 5, 2024
Accepted: January 7, 2026
Published: May 30, 2026
Online First: May 30, 2026

Keywords

Pentahelix Synergy; Environmental Literacy; Mangrove Conservation; Collaborative Governance; Karangsong.

Abstract

Despite the ecological value of mangrove ecotourism, environmental degradation due to waste accumulation and intense anthropogenic pressures remains a critical challenge in Karangsong Beach, Indonesia. While the Pentahelix model is recognized for destination management, its potential as a pedagogical tool for behavioral change remains underexplored. This study investigates how the Pentahelix synergy fosters comprehensive environmental literacy. Employing a qualitative case study through interviews, observations, and document analysis, the findings reveal that synergy enhances awareness through functional roles: academics provide scientific validation, the private sector provides vital funding and infrastructure, the government ensures regulation, the community leads operations, and the media amplifies educational narratives. Crucially, this study reconceptualizes collaboration as a structured "pedagogical mechanism" that transforms abstract ecological knowledge into practical conservation behavior. This research presents the "Karangsong Model" as a scalable governance framework for the Global South, demonstrating that long-term, sustainable conservation requires a hybrid architecture that seamlessly integrates economic incentives and educational responsibilities.

A. Introduction

Mangrove ecosystems are among the most vulnerable coastal environments, highly susceptible to anthropogenic disturbances that can undermine their ecological functions and long-term sustainability (Wardhani, 2011). This challenge has become increasingly important as mangrove ecotourism expands globally as a strategy for integrating biodiversity conservation with local economic development (Santoso et al., 2025; Baloch et al., 2023; Zallesa, 2023). The Karangsong Mangrove Ecotourism area in Indramayu, Indonesia, reflects this paradox. Despite its ecological and tourism potential, the area continues to face encroachment and waste accumulation resulting from human activities, threatening ecosystem integrity and conservation outcomes (Saputro et al., 2026; Prihadi et al., 2018; Purnamasari et al., 2015). These conditions indicate a critical deficiency in environmental literacy among stakeholders, limiting their ability to understand ecological consequences and engage in sustainable environmental practices (Efata et al., 2026; Muhsin et al., 2024; Maesaroh et al., 2021).

Fostering environmental literacy in a tourism context encompasses more than cognitive understanding; it requires meaningful changes in attitudes and behaviors. In many developing regions, this challenge is intensified by socio-economic pressures, where local communities often perceive natural resources primarily as economic assets rather than ecological systems requiring long-term stewardship (Hilmi et al., 2025). Under such conditions, environmental literacy cannot be developed solely through top-down educational interventions. Rather, it must be embedded within the everyday economic and social practices of local communities. This condition necessitates a governance approach that distributes educational responsibilities across multiple stakeholders. Conservation values need to be reinforced simultaneously through economic incentives, regulatory mechanisms, and social norms. Without such structural support, environmental education initiatives in coastal tourism areas are unlikely to generate lasting behavioral change.

Building such literacy in a complex tourism area requires collaborative governance, specifically the Pentahelix synergy involving academics, business, government, community, and media. However, a critical research gap remains in the existing literature. Previous studies have primarily positioned the Pentahelix model as an operational tool for creating urban resilience or for tourism marketing (Buchari et al., 2024; Shalihah et al., 2024; Suroija et al., 2022). Meanwhile, research on mangrove management often highlights the challenges of fragmented governance (Du et al., 2025) or focuses on community livelihoods (Dulyakasem et al., 2026; Rahman et al., 2024). Furthermore, while

previous research has analyzed environmental literacy in coastal communities, it generally lacks a direct link to multi-stakeholder governance frameworks (Karingayi, 2025; Winoto et al., 2023). Existing models often treat governance and environmental literacy as separate analytical domains, leaving limited understanding of how multi-sectoral collaboration shapes environmental literacy and subsequently influences conservation behavior within ecotourism settings.

In contrast to previous studies that primarily position the Pentahelix model as a framework for tourism management, marketing, or stakeholder coordination, this study contributes to the literature by conceptualizing collaborative governance as a mechanism for environmental learning. Drawing upon the concept of social learning proposed by Galang et al. (2025), this study advances the argument that environmental literacy is not developed solely through formal educational interventions but can also emerge through structured interactions, participation, and shared responsibilities among multiple stakeholders. By linking governance processes with environmental learning outcomes, this study extends existing discussions on collaborative governance beyond managerial and operational concerns. Moreover, by providing empirical evidence from a community-based mangrove ecotourism setting, this study contributes a scalable governance perspective that may be relevant to coastal tourism destinations across the Global South, where sustainable environmental management often relies on collaborative action and community participation rather than state capacity alone (Barrera-Bello et al., 2025; Dulyakasem et al., 2026).

The novelty of this study lies in its interpretation of the Pentahelix synergy as a pedagogical mechanism that actively constructs environmental literacy. By examining the functional interactions among academics, government agencies, business actors, local communities, and media, this study explains how ecological knowledge is translated into conservation-oriented attitudes and behaviors within a mangrove ecotourism setting. By analyzing this synergy in Karangsong, the study shifts the focus from "managing tourism" to "educating through governance".

Therefore, this study aims to analyze the mechanisms through which Pentahelix collaboration strengthens environmental literacy within the Karangsong Mangrove Ecotourism area. Specifically, the study investigates how interactions among academics, government agencies, business actors, local communities, and media contribute to the development of environmental awareness, ecological responsibility, and conservation behavior in a community-based mangrove ecotourism setting.

B. Method

This study employed a qualitative case study design to investigate the collaborative governance of the Pentahelix synergy in Karangsong (Creswell & Poth, 2023). This design was specifically chosen to explore the complex interactions and roles among stakeholders within their real-life context. The study was conducted from January to June 2023 in the Karangsong Mangrove Ecotourism area, Indramayu Regency, West Java, as illustrated in Figure 1. The selection of this location was based on its status as a pilot project for community-based mangrove rehabilitation in Indonesia, which involves diverse actors from government, corporate, and local community sectors.

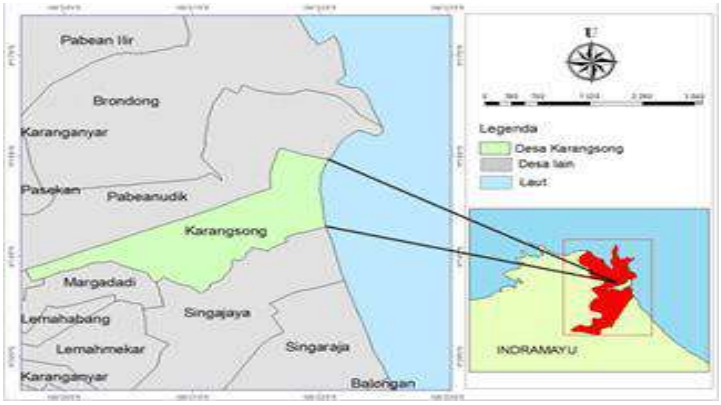

Figure 1. Research location map
Source: Potential of Karangsong Village, 2023

The primary data were collected through in-depth interviews and field observations. Informants were selected using a purposive sampling approach, focusing on actors with strategic roles and in-depth knowledge of mangrove management. A total of six key informants participated in this study, comprising three community leaders (including the administrator of the Pantai Lestari Group), one CSR representative from PT Pertamina Balongan (Business), one academic expert involved in local conservation research, and one local media practitioner. Semi-structured interviews lasting approximately 45-60 minutes were conducted to explore the roles and challenges of each stakeholder in fostering environmental literacy. Additionally, non-participant observations were carried out to document environmental conditions, waste management practices, and tourist behavior at the site. Secondary data were also gathered from relevant documents, including CSR reports, village regulations, and previous research publications, to support the empirical findings.

Data validity was ensured through source triangulation, with information cross-checked across interviews, observations, and documents to minimize bias. The data analysis followed the interactive model by Miles, Huberman, and Saldaña (Miles et al., 2014), comprising three streamlined stages. First, data condensation was performed, selecting, focusing, and simplifying raw data from interviews and field notes to identify key themes related to Pentahelix roles. Second, the data display stage presented the organized information in a narrative text to facilitate the understanding of synergy patterns. Finally, conclusion drawing and verification were conducted, during which initial findings were revisited and verified against valid evidence to formulate final conclusions on the effectiveness of the collaboration.

This study adheres to strict ethical research standards. Formal permission was obtained from the Karangsong Village Government and the Ecotourism Management Board prior to data collection. All participants provided informed consent and participated voluntarily, with the understanding that they could withdraw at any time. Furthermore, the identities of specific respondents have been anonymized or coded where necessary to ensure confidentiality and data privacy.

C. Results and Discussion

This section presents the empirical findings regarding the Pentahelix synergy in the Karangsong Mangrove Ecotourism area. The data were collected through interviews, observations, and documentation, focusing on the roles of five key stakeholders: Academics, Business, Community, Government, and Media. To ensure a comprehensive analysis, the interactions among these actors are examined to reveal how collaborative governance functions as a driver for environmental literacy. The findings are organized into four main thematic sections: the community as the core manager, business sector contributions, academic support, and the roles of government and media.

1. Results

a. The role of community as the core manager

The local community, represented by the Pantai Lestari Group, functions as the primary operator of the ecotourism site. Field observations indicate that this group manages the daily operations, focusing on ecosystem rehabilitation and infrastructure maintenance. The visualization of the managed area is presented in Figure 2.

Figure 2. Mangrove ecotourism area Karangsong Indramayu
Source: Researcher's personal document, 2023

Figure 2 provides visual evidence of the site's comprehensive management. The image on the left depicts a dense mangrove ecosystem along the river corridor, confirming the success of vegetative rehabilitation. Meanwhile, the image on the right shows the tracking path and entrance gate, illustrating the community's role in maintaining physical tourism facilities. This combination confirms that the community manages both the ecological assets and the tourism infrastructure. Interviews reveal that this awareness grew out of the urgency of coastal erosion. Regarding the necessity of collaboration, Mr. Eka, an administrator of the group, stated:

> "*To protect the damaged coastal environment so that it becomes ecotourism, up to now it cannot be done only by the Pantai Lestari group, but we also collaborate with other institutions, such as the government service PT. Pertamina Balongan, NGOs and academics from various universities in West Java.*" (Interview with Community Administrator, March 2023)

This statement highlights that, while the community is the core actor, it relies on external networks for sustainability. This acknowledgement indicates a strategic adjustment in the community's perspective. They position themselves as the operational leader requiring technical and material support from external parties. This mindset is a prerequisite for the effective implementation of the Pentahelix model, as it prevents the role ambiguity that often hinders multi-stakeholder projects.

However, the study also found operational challenges. Data from interviews reveal that financial independence remains a major hurdle for facility maintenance. As stated by the management of Karangsong Mangrove ecotourism:

> *"With the reduction of tourists who came during 2020-2022, there was damage to several facilities as a result of limited funds for maintenance, such as damage to tracking in the forest area made of bamboo, which has been an access for tourists to go around the mangrove forest."* (Interview with Management, April 2023).

The degradation of physical facilities mentioned above serves as a concrete indicator of the financial vulnerability inherent in this community-based model. Since the maintenance budget depends entirely on revenue from entrance tickets, any disruption to visitor flow immediately impacts the site's infrastructure. This finding underscores that while the community possesses strong social capital in the form of motivation and labor, it lacks accumulated financial capital to withstand external shocks. Consequently, this operational limitation necessitates the structural involvement of the business sector to ensure material sustainability.

b. Business sector contribution: Corporate Social Responsibility (CSR)

The business sector plays a role specifically in infrastructure development and community empowerment through CSR programs. Observations confirm that PT. Pertamina Balongan acts as a key partner in funding physical facilities that the community cannot afford independently. This commitment extends beyond supporting tourism infrastructure and includes efforts to promote environmental awareness among visitors. As explained by a representative of PT. Pertamina Balongan:

> *"We do not only support the development of tourism facilities, but also seek to create educational spaces that encourage visitors to understand the ecological importance of mangrove ecosystems and the need for their conservation"*. (CSR Officer, Interview, April 2023).

The interview findings indicate that environmental education constitutes an important component of the company's CSR strategy within the Karangsong Mangrove Ecotourism area. The business sector's contribution is therefore not limited to providing financial assistance or supporting tourism infrastructure. Rather, the CSR program is designed to integrate conservation values into visitors' experiences by creating facilities that simultaneously serve recreational and educational purposes. Through this approach, environmental learning becomes embedded within the physical environment, allowing visitors to encounter ecological information and conservation messages throughout their visit.

This educational orientation reflects the company's recognition that long-term ecosystem sustainability depends not only on physical conservation efforts but also on increasing public awareness and fostering environmentally responsible behavior. Consequently, the infrastructure developed through CSR initiatives incorporates elements intended to communicate scientific knowledge, environmental ethics, and conservation values to diverse groups of visitors. One manifestation of this commitment can be observed in the facilities installed throughout the ecotourism area, as presented in figure 3.

Figure 3. One form of corporate collaboration PT. Pertamina
Source: Researcher document, 2023.

Figure 3 illustrates the installation of educational signage along the mangrove tracking path. The visuals show that the infrastructure provided extends beyond physical bridges to include pedagogical tools as well. One board displays scientific taxonomic information about local fauna, specifically the Fiddler Crab (Uca vomeris), complete with its conservation status. Another board features an inspirational quote ("Let nature be your teacher") designed to frame the visitor's mindset toward conservation. The data indicate that this contribution functions as a "passive educational mechanism." By embedding scientific knowledge and philosophical values directly into the site's infrastructure, the CSR program enables a self-guided learning experience, ensuring visitors acquire environmental literacy even without a tour guide.

c. Academic support: Scientific validation and training

The academic sector serves a dual function: providing scientific validation of conservation strategies and facilitating capacity-building for local operators. Documentation data confirms that several higher education institutions, including Universitas Padjadjaran, IPB University, and Wiralodra Indramayu University, actively conduct community service programs in the area. These interventions are not limited to

theoretical research but involve direct technical transfers. As acknowledged by community members, Mr. Ali and Mr. Duloh, the impact of this presence is tangible:

> *"So far, we have also received counseling, training and technical guidance from several existing university lecturers. in West Java, such as from the Bogor Agricultural Institute and from Padjadjaran University, for example, regarding mangrove management, fisheries cultivation issues, environmental issues, tourism issues, etc."* (Interview with Community Members, May 2023).

This finding indicates that academics play a critical role in knowledge transfer. Often, scientific data regarding mangrove taxonomy or carbon sequestration is too technical for the general public. The intervention of academics in Karangsong effectively addresses this challenge. By translating complex ecological metrics into practical management modules spanning nursery techniques to marketing strategies, they ensure that the community possesses not only local wisdom but also the standardized technical competence required for professional site management. This scientific foundation is essential to prevent trial-and-error practices that could otherwise endanger the sensitive ecosystem.

d. Government and media roles

The government acts primarily as a regulator and provider of legal legitimacy. Documentation data confirms that the Ministry of Environment has designated the Karangsong mangrove area as a center for mangrove development in the Western region. This commitment is operationalized by the Indramayu Regency government through regulatory frameworks and tourism promotion. Meanwhile, the media functions as a dissemination agent that amplifies the educational value of the site. Based on interviews with local media practitioners in June 2023, the dissemination strategy relies heavily on local channels. Specifically, over 12 private radio stations, including Kijang Kencana FM, Best FM, and Elshanda FM, were identified as key partners in broadcasting conservation narratives, alongside the expanding reach of social media platforms. To visualize the comprehensive distribution of roles among all stakeholders, the structural mapping is summarized in table 1.

Table 1. The Role of stakeholders involved in ecotourism management in Karangsong

No.	Stakeholders	Role
1.	Pantai Lestari Group	Karangsong Mangrove Area Manager;
2.	Village Government	Authorities of Karangsong Mangrove Area;
3.	Community	Beneficiaries of the Karangsong mangrove area;

No.	Stakeholders	Role
4.	Department of Fisheries and Marine	Affairs Initiator of mangrove area policy, Manager of rehabilitation activities and empowerment of coastal communities;
5.	Department of Forestry and Plantation	Organizer of mangrove area forestry policies and activities;
6.	Pertamina	Organizer of ecosystem restoration activities, area and coastal community empowerment as part of the CSR program;
7.	Department of Youth, Sports, Culture and Tourism	Manager of tourism activities in the Karangsong tourism area;
8.	Environment Agency	Organizer of policies and activities to preserve the environment of the mangrove area;
9.	Regional Development Planning Agency	Organizer of development planning and development of the Karangsong Mangrove Area (Karangsong Mina-politan Area);
10.	DRPD of Indramayu Regency	The party that facilitates legislation, budgeting and supervision of the development of the Karangsong Mangrove area;
11.	Cimanuk-Cisanggarung River Basin Center	Management organizer of the Praja-gumiwang Karangsong River delta area;
12.	Department of Water Resources Management, Mining and Energy	Organizer of the management of the Praja-gumiwang Karangsong River delta area.

Source: Adapted from Gunawan et al., (2018) and verified through Primary Data Analysis (2023)

The data in Table 1 illustrates a distinct separation of duties. While the community holds the operational execution role ("Manager"), the government holds the authority role ("Regulator"), and other actors function as supporters ("Initiator" or "Organizer"). This structure confirms that the governance model is not centralized but distributive. The synergy among these actors results in a collaborative mechanism that actively fosters environmental literacy. The specific patterns of this synergy and its output on literacy are detailed in table 2.

Table 2. Pentahelix synergy in growing environmental literacy

No.	Component	Role in Environmental Literacy
1.	Academics	Implementation of Tri Dharma in higher education, especially community service and research activities. In an effort to foster environmental literacy, the academic group provides training, counseling, and research on sustainable tourism, fisheries and marine affairs, and mangrove ecosystems.
2.	Company	PT. Pertamina Balongan Indramayu is a State-Owned Enterprise engaged in petroleum exploration in West Java. In the context of environmental literacy, PT. Pertamina, through its Corporate Social Responsibility (CSR)

No.	Component	Role in Environmental Literacy
		activities, has provided various forms of assistance, including planting mangrove seedlings, improving facilities in mangrove forests, and collaborating with schools to provide free buses for students visiting the Karangsong mangrove ecotourism area.
3.	Government	The government component in this activity includes the regional government of Indramayu Regency and the government of Karangsong Village: the Indramayu Regency regional government and the Karangsong village government.
4.	Community	The Community Self-Help Group (KSM) Pantai Lestari Group manages the Karangsong ecotourism destination.
5.	Media	In Indramayu Regency, the media components supporting environmental literacy in the Karangsong ecotourism area include mainstream media such as radio and social media.

Source: Researcher data, 2023

The structural synergy detailed in Table 2 demonstrates a cohesive system of roles. Unlike fragmented management models, in which stakeholders work in isolation, the Karangsong model illustrates a complementary mechanism. The academic sector supplies the theoretical knowledge and technical skills, the business sector provides the necessary infrastructure and funding, the government ensures regulatory stability, and the media manages public communication.

This interdependence ensures that environmental literacy is not just taught theoretically but facilitated through physical access and public information. For instance, the knowledge produced by academics is applied by the community and funded by the business sector. Similarly, the government's regulations are enforced through community management and promoted through media coverage. This cycle creates a consistent educational environment where visitors are exposed to conservation messages through multiple channels, including signage funded by CSR, explanations from community guides, and pre-visit information from media outlets.

2. Discussion

This study shows that environmental literacy in Karangsong is produced through collaborative governance rather than through formal educational interventions alone. The interaction among academics, government institutions, business actors, local communities, and media organizations has transformed the mangrove ecotourism area into an integrated educational landscape where conservation values are continuously reinforced through everyday practices. This finding extends conventional views of ecotourism that emphasize

recreation and economic benefits by demonstrating its role as a pedagogical ecosystem. Similar patterns have been identified in collaborative environmental governance networks, where environmental outcomes emerge from collective action and shared responsibility rather than from individual actors operating independently (Wang, 2024; Saffanah et al., 2024). In this context, governance functions not only as a mechanism of coordination but also as a medium through which ecological knowledge and environmental awareness are socially constructed (Efata et al., 2026; Hakim, 2022).

The main theoretical contribution of this study lies in the reinterpretation of the Pentahelix model as a pedagogical mechanism. Previous studies generally describe Pentahelix as a framework for destination management, tourism marketing, or stakeholder coordination (Suroija et al., 2022). The Karangsong case reveals a different function. Academics strengthen the cognitive dimension through research and capacity building (Prihadi et al., 2019), communities cultivate affective engagement through direct conservation practices (Karingayi, 2025; Tufliha et al., 2019), and the business sector supports behavioral engagement through infrastructure and financial assistance (Sattayapanich et al., 2022). Together, these roles connect knowledge, attitudes, and action, which constitute the core dimensions of environmental literacy (Maesaroh et al., 2021). The findings therefore support arguments that environmental knowledge becomes meaningful when reinforced by participation and opportunities for action (Jo et al., 2024; Efata et al., 2026).

The evidence from Karangsong also challenges the dominant narrative that mangrove conservation is inevitably constrained by fragmented governance. Du et al. (2025) argued that conservation programs frequently suffer from institutional silos, overlapping authority, and weak coordination among stakeholders. A different pattern emerges in Karangsong. Government institutions maintain regulatory authority, while local communities assume operational leadership in rehabilitation, ecotourism management, and environmental maintenance. This arrangement creates a balance between institutional legitimacy and local ownership. The historical designation of Karangsong as a regional mangrove development center further reflects the importance of state commitment in establishing the foundations of conservation programs (Iswantoro et al., 2024; Susana et al., 2020). Consistent with Gunawan et al. (2018), government intervention remains important during the initial stages of rehabilitation, yet long-term sustainability appears to depend on the willingness of institutions to share authority and strengthen community participation.

Despite the successful collaboration, the findings reveal a form of asymmetric interdependence within the Pentahelix structure. The deterioration of facilities during the pandemic demonstrated that strong social capital alone cannot guarantee sustainability when financial resources become limited. Although the community retained its commitment to conservation, reduced visitor numbers weakened its ability to maintain infrastructure and support operational activities. Similar vulnerabilities have been reported in community-based tourism initiatives that remain highly sensitive to external economic shocks (Shalihah et al., 2024). These finding challenges romanticized assumptions regarding community self-reliance. Community participation remains essential, but it requires complementary institutional and financial support. Consequently, sustainability depends not only on local commitment but also on the capacity of governance arrangements to secure stable resources during periods of uncertainty.

This condition highlights the strategic importance of Corporate Social Responsibility within collaborative environmental governance. In Karangsong, CSR performs a function that extends beyond philanthropy. Financial assistance, educational facilities, and infrastructure development contribute directly to the continuity of conservation activities and environmental learning. The support provided by PT. Pertamina illustrates how corporate involvement can strengthen the material foundations of community-based conservation, particularly when market-driven funding mechanisms become unstable. Similar conclusions have been reported by Sattayapanich et al. (2022), who found that CSR can enhance community participation and environmental outcomes when integrated into local governance structures. The Karangsong experience therefore suggests that CSR should be understood as a structural component of conservation governance rather than merely as a charitable contribution. In this regard, corporate support functions as a safety net that helps sustain conservation efforts during periods of economic disruption (Kuhzady et al., 2025).

The implications of these findings extend far beyond the local context of Karangsong. Coastal regions across Southeast Asia, Africa, and Latin America continue to face interconnected challenges involving ecosystem degradation, climate vulnerability, limited institutional capacity, and constrained conservation funding (Baloch et al., 2023; Dulyakasem et al., 2026; Hernández-Blanco et al., 2022). Under such conditions, environmental literacy cannot be strengthened solely through formal educational programs or state-led interventions because environmental behavior is shaped by broader social, economic, and governance structures (Efata et al., 2026; Winoto et al., 2023). The

Karangsong experience demonstrates that environmental literacy becomes more sustainable when conservation, education, and governance are integrated within collaborative institutional arrangements. This finding supports growing evidence that community participation, stakeholder collaboration, and environmental learning are mutually reinforcing components of successful coastal conservation initiatives (Wang, 2024; Saffanah et al., 2024; Hakim, 2022).

A particularly important lesson concerns the role of Corporate Social Responsibility (CSR) as a corrective mechanism capable of linking environmental responsibility with community development objectives. The involvement of an oil company in supporting mangrove restoration illustrates how potential environmental tensions can be transformed into productive partnerships that generate ecological, educational, and social benefits simultaneously. Similar approaches have been observed in sustainable mangrove management initiatives in Thailand and Mexico, where conservation outcomes are closely associated with community participation, institutional collaboration, and cross-sector partnerships (Swangjang & Kornpiphat, 2021; Vargas-del-Río & Brenner, 2023; Jaelani et al., 2025). These findings reinforce broader international efforts to strengthen mangrove restoration and climate resilience through participatory governance and multi-stakeholder cooperation (Hernández-Blanco et al., 2022).

The broader significance of the Karangsong model can also be viewed through its contribution to global sustainable development agendas. Environmental literacy has increasingly been recognized as a critical foundation for fostering environmentally responsible behavior and supporting long-term sustainability transitions (Efata et al., 2026; Winoto et al., 2023). In this regard, the Karangsong experience contributes to SDG 4 (Quality Education) by embedding environmental learning within community-based conservation practices rather than limiting it to formal educational settings. The protection and rehabilitation of mangrove ecosystems simultaneously support SDG 13 (Climate Action) and SDG 14 (Life Below Water), given the important role of mangroves in strengthening coastal resilience, preserving biodiversity, and mitigating climate-related risks (Hernández-Blanco et al., 2022; Baloch et al., 2023). Equally important, the collaborative relationship among government institutions, communities, academics, businesses, and media reflects the principles of SDG 17 (Partnerships for the Goals), demonstrating how multi-stakeholder governance can address complex environmental challenges more effectively than single-actor approaches (Wang, 2024; Saffanah et al., 2024). The Karangsong model therefore illustrates how environmental literacy,

conservation, and collaborative governance can operate as mutually reinforcing pathways toward sustainable development.

Despite providing important insights into the role of collaborative governance in fostering environmental literacy, this study has several limitations. The study focuses on a single case, providing substantial contextual depth but limiting the transferability of conclusions to regions characterized by different institutional arrangements, socio-cultural conditions, and governance structures. In addition, the analysis relies primarily on qualitative evidence to understand the development of environmental literacy. Although this approach provides rich insights into stakeholder interactions and learning processes, it does not directly measure changes in visitors' environmental literacy levels or conservation behavior. The findings should therefore be understood as an explanation of how collaborative governance contributes to environmental literacy rather than as a direct assessment of its measurable outcomes.

D. Conclusion

This study concludes that the Pentahelix synergy in Karangsong Mangrove Ecotourism operates not merely as a destination management strategy but as a structured pedagogical mechanism for fostering environmental literacy. The synthesis of findings demonstrates that literacy is constructed through a functional division of labor: academics provide scientific validation, the business sector supplies educational infrastructure, the government ensures regulatory stability, the media amplifies the narrative, and the community infuses the site with local ecological wisdom. This integrated ecosystem effectively bridges the gap between abstract environmental knowledge and visitor behavior, challenging the fragmented governance models often found in coastal conservation.

The academic contribution of this study lies in reconceptualizing collaborative governance as an educational tool. Theoretically, it extends the Pentahelix framework by demonstrating that multi-stakeholder partnerships can serve as "social learning" systems that mitigate the financial fragility of community-based tourism. Practically, the "Karangsong Model" offers a scalable solution for the Global South, demonstrating how "corrective CSR" can transform potential industrial-environmental conflicts into productive pedagogical partnerships. This positions the engagement of extractive industries not as greenwashing, but as a necessary structural safety net for sustainable conservation in resource-constrained regions.

Based on these conclusions and the study's limitations, future research should move beyond single-case qualitative designs. Subsequent studies are recommended to employ comparative analyses across different socio-political contexts in Southeast Asia to test the model's replicability. Furthermore, scholars should integrate quantitative measurements to assess the actual correlation between specific Pentahelix interventions and visitors' environmental literacy levels.

The Karangsong experience illustrates that lasting conservation is achieved not only through ecological restoration but also through the cultivation of shared environmental responsibility. By bringing together state institutions, local communities, academic actors, and the private sector, governance becomes a space where learning and conservation reinforce one another. In this way, environmental literacy develops as a lived social practice that sustains conservation beyond projects, policies, and regulatory requirements.

Acknowledgments

Thank you to the Chancellor of Padjadjaran University; this study was funded by an internal UNPAD grant for the Padjadjaran University Lecturer Competency Research.

Declaration of Competing Interest

We hereby declare that all authors in this study have no conflict of interest.

Bibliography

Baloch, Q. B., Shah, S. N., Iqbal, N., Sheeraz, M., Asadullah, M., Mahar, S., & Khan, A. U. (2023). Impact of Tourism Development Upon Environmental Sustainability: A Suggested Framework for Sustainable Ecotourism. *Environmental Science and Pollution Research*, *30*(3), 5917–5930. https://doi.org/10.1007/s11356-022-22496-w

Barrera-Bello, Á. M., Rodríguez-Rodríguez, A., Palacios, A. M. V., Polanía, J., Riascos, J. M., Blanco-Libreros, J. F., Hugé, J., & Dahdouh-Guebas, F. (2025). Community-Based Mangrove Management in Sucre, Colombia: Stakeholder Perceptions, Land Cover Trends, and Challenges. *Economic Botany*. https://doi.org/10.1007/s12231-025-09640-6

Buchari, R. A., Abdillah, A., Widianingsih, I., & Nurasa, H. (2024). Creativity Development of Tourism Villages in Bandung Regency, Indonesia: Co-Creating Sustainability and Urban Resilience. *Scientific Reports*, *14*(1), 1381. https://doi.org/10.1038/s41598-023-49094-1

Creswell, J. W., & Poth, C. N. (2023). *Qualitative Inquiry and Research Design* (5th ed.). SAGE Publications, Inc.

Du, Y., Lin, L., & Su, J. (2025). Applying the Social-Ecological Systems (SES) Framework for Sustainable Mangrove Management: A Case Study of Quanzhou Bay, China. *Ocean & Coastal Management*, *269*, 107860. https://doi.org/10.1016/j.ocecoaman.2025.107860

Dulyakasem, R., Brooks, C., Lehnert, S. L., & Newton, P. (2026). Community-Based Natural Resource Management in Coastal Communities: The Contribution of Mangroves to Household Livelihoods in Southern Thailand. *Environmental Development*, *57*, 101340. https://doi.org/10.1016/j.envdev.2025.101340

Efata, A. C., Mawarini, R., Wardani, W. I., & Husain, M. I. (2026). Achieving Sustainable Ecological Justice through Land Transfer Regulation in Indonesia. *Journal of Sustainable Development and Regulatory Issues*, *4*(1), 138–162. https://doi.org/10.53955/jsderi.v4i1.275

Galang, E. I. N. E., Bennett, E. M., Hickey, G. M., Baird, J., Harvey, B., & Sherren, K. (2025). Participatory Scenario Planning: A Social Learning Approach to Build Systems Thinking and Trust for Sustainable Environmental Governance. *Environmental Science & Policy*, *164*, 103997. https://doi.org/10.1016/j.envsci.2025.103997

Gunawan, A. G., Hidayat, A., & Anggraini, E. (2018). Institutional Analysis of Mangrove Rehabilitation in Karangsong Indramayu West Java. *Sodality: Jurnal Sosiologi Pedesaan*, *6*(1), 1–7. https://doi.org/10.22500/sodality.v6i1.21203

Hakim, M. A. (2022). Strategi Pentahelix Pada Perencanaan Pariwisata di Desa Hegarmukti, Cikarang, Kabupaten Bekasi, Jawa Barat. *Destinesia: Jurnal Hospitaliti Dan Pariwisata*, *4*(1), 33–41. https://doi.org/10.31334/jd.v4i1.2561

Hernández-Blanco, M., Moritsch, M., Manrow, M., & Raes, L. (2022). Coastal Ecosystem Services Modeling in Latin America to Guide Conservation and Restoration Strategies: The Case of Mangroves in Guatemala and El Salvador. *Frontiers in Ecology and Evolution*, *10*(1), 1–12. https://doi.org/10.3389/fevo.2022.843145

Hilmi, N., Arruda, G., Broussard, D., Maria Benitez, B., Sauron, L., Lamaud, T., Jahan, N., & Hall Spencer, J. M. (2025). Blue Carbon as a Nature-Based Climate Mitigation Strategy for Mangrove Conservation in Bangladesh. *Journal for Nature Conservation*, *86*, 126885. https://doi.org/10.1016/j.jnc.2025.126885

Iswantoro, Saparwadi, & Triasari, D. (2024). The Role of District Governments in Handling Damage to National Roads in the Regional Autonomy. *Journal of Sustainable Development and Regulatory Issues*, *2*(1), 20–34. https://doi.org/10.53955/jsderi.v2i1.22

Jaelani, A. K., Kusumaningtyas, R. O., Sarjiyanto, & Sobirov, B. (2025). Sustainable halal tourism regulation based on local wisdom in indonesia and

uzbekistan. *Journal of Human Rights, Culture and Legal System*, *5*(1), 351–377. https://doi.org/10.53955/jhcls.v5i1.671

Jo, W., Lin, Y., Xue, P., & Joppe, M. (2024). Role of Deindividuation Between Perceived Crowding and Tourist Behaviors: Moderating Effect of Environmental Knowledge. *International Journal of Tourism Research*, *26*(5). https://doi.org/10.1002/jtr.2748

Karingayi, T. H. (2025). Islamic Political Thought and The Crisis of Global Governance: Towards a Non-Western Theory of Order. *International Journal of Islamic Khazanah*, *15*(1), 1–10. https://doi.org/10.15575/ijik.v15i1.49657

Kuhzady, S., Olya, H., & Han, H. (2025). Corporate Social Responsibility (CSR): A Contemporary Review of Practices, Impacts, and Future Directions. *International Journal of Contemporary Hospitality Management*, *37*(7), 2556–2579. https://doi.org/10.1108/IJCHM-08-2024-1150

Maesaroh, S., Bahagia, B., & Kamalludin, K. (2021). Strategi Menumbuhkan Literasi Lingkungan pada Siswa. *Jurnal Basicedu*, *5*(4), 1998–2007. https://doi.org/10.31004/basicedu.v5i4.1048

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (3rd ed.). SAGE Publications, Inc.

Muhsin, M., Kususiyanah, A., & Maksum, M. (2024). Religious Moderation in Indonesian Islamic Universities: Policy Implementation and Identity Formation at IAIN Ponorogo. *Ascarya: Journal of Islamic Science, Culture and Social Studies*, *4*(2), 54–66. https://doi.org/10.53754/iscs.v4i2.713

Prihadi, D. J., Pamungkas, W., & Riyantini, I. (2019). Penguatan Kelembagaan Pengelola Pariwisata Mangrove Karangsong Dan Kelembagaan Potensi Bird Watching Di Ekowisata Mangrove Karangsong Indramayu. *Dharmakarya*, *8*(3), 160–162. https://doi.org/10.24198/dharmakarya.v8i3.20943

Prihadi, D. J., Riyantini, I., & Ismail, M. R. (2018). Pengelolaan Kondisi Ekosistem Mangrove dan Daya Dukung Lingkungan Kawasan Wisata Bahari Mangrove Di Karangsong Indramayu. *Jurnal Kelautan Nasional*, *13*(1), 53–64. https://doi.org/10.15578/jkn.v1i1.6748

Purnamasari, R., Suprapto, D., & Purwanti, F. (2015). Pengembangan Ekowisata Mangrove Desa Karangsong, Kabupaten Indramayu. *Management of Aquatic Resources Journal (MAQUARES)*, *4*(4), 146–154. https://doi.org/10.14710/marj.v4i4.9793

Rahman, A., Barizi, A., Sumbulah, U., Buny, M., & Bahy, A. (2024). Global Citizenship Concepts Perspective Abdullah Ahmed An Naim, *14*(1), 61–69. https://doi.org/10.15575/ijik.v14i1.31300

Saffanah, T., Rasito, Putra, D. I. A., & Yuliatin. (2024). Strengthening Law Enforcement and Public Awareness to Combat Human Trafficking in Indonesia: Challenges

and Solutions. *Al-Ahkam: Jurnal Ilmu Syari'ah Dan Hukum*, *9*(2), 91–112. https://doi.org/10.22515/alahkam.v9i2.9686

Saputro, I. P., Wahyuningsih, S. E., Tampubolon, J. N. A. M., Tanjung, M. Z., & Soliman, M. (2026). The Effects of Deradicalization Standardized Policy in Advancing Human Security. *Journal of Human Rights, Culture and Legal System*, *6*(1), 147–181. https://doi.org/10.53955/jhcls.v6i1.906

Sattayapanich, T., Janmaimool, P., & Chontanawat, J. (2022). Factors Affecting Community Participation in Environmental Corporate Social Responsibility Projects: Evidence from Mangrove Forest Management Project. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 209. https://doi.org/10.3390/joitmc8040209

Santoso, A., Ristianawati, Y., Hartono, S., Farman, F., & Nusuki, I. (2025). Islamic Social Business: The Role of al-Qardul Hasan in Empowering Vulnerable Micro-Enterprises through Bankziska. *Ascarya: Journal of Islamic Science, Culture and Social Studies*, *5*(2), 197–210. https://doi.org/10.53754/19sqjj52

Shalihah, A. H. N., Prahita, B. N., & Budiati, A. C. (2024). Implementasi Pendekatan Pentahelix dalam Melihat Tantangan dan Strategi Pengembangan Wisata Alam Telaga Madirda. *Jurnal Noken: Ilmu-Ilmu Sosial*, *10*(1), 183–193. https://doi.org/10.33506/jn.v10i1.3419

Suroija, N., Asrori, M., & Nugroho, B. S. (2022). Strategi Pengembangan Ekowisata dengan Model Pentahelix Pada Karang Jahe Beach Kabupaten Rembang. *Prosiding Seminar Hasil Penelitian Dan Pengabdian Masyarakat Polines*, 849–857. https://jurnal.polines.ac.id/index.php/Sentrikom/article/view/3415/107840

Susana, M., Kusmana, C., & Arifin, H. S. (2020). Potential Attractions of Mangrove Ecotourism in Karangsong Village, Indramayu Regency. *Jurnal Penelitian Sosial Dan Ekonomi Kehutanan*, *17*(3), 193–208. https://doi.org/10.20886/jpsek.2020.17.3.193-208

Swangjang, K., & Kornpiphat, P. (2021). Does Ecotourism in a Mangrove Area at Klong Kone, Thailand, Conform to Sustainable Tourism? A Case Study Using SWOT and DPSIR. *Environment, Development and Sustainability*, *23*(11), 15960–15985. https://doi.org/10.1007/s10668-021-01313-3

Tufliha, A. R., Putra, D. M., Amara, D. M., Santika, R. M., Oktavian, S. M., & Kelana, P. P. (2019). Kondisi Ekosistem Mangrove di Kawasan Ekowisata Karangsong Kabupaten Indramayu. *Jurnal Akuatika Indonesia*, *4*(1), 11–16. https://doi.org/10.24198/jaki.v4i1.23494

Umam, K., Tjondro Winarno, S., & Sudiyarto, S. (2016). Strategi Pengembangan Ekowisata Mangrove Wonorejo Surabaya. *AGRARIS: Journal of Agribusiness and Rural Development Research*, *1*(1), 38–42. https://doi.org/10.18196/agr.116

Vargas-del-Río, D., & Brenner, L. (2023). Mangroves in Transition. Management of Community Spaces Affected by Conservation and Tourism in Mexico. *Ocean & Coastal Management*, *232*, 106439. https://doi.org/10.1016/j.ocecoaman.2022.106439

Wang, W. (2024). The Functioning Mechanism of a Collaborative Environmental Governance Network in a Coastal Zone: A Case Study of the Wenzhou Dongtou Coastal Zone. *Sustainability*, *16*(23), 10159. https://doi.org/10.3390/su162310159

Wardhani, M. K. (2011). Kawasan Konservasi Mangrove: Suatu Potensi Ekowisata. *Jurnal Kelautan*, *4*(1), 60–72. https://doi.org/10.21107/jk.v4i1.891

Wedha, Y. Y., Wijaya, I. M. H., Mukti, H., & Turymshayeva, A. (2025). Unraveling the Complex Policies Regulating Conflicts of Interest and Criminal Corruption. *Journal of Human Rights, Culture and Legal System*, *5*(1), 33–59. https://doi.org/10.53955/jhcls.v5i1.486

Winoto, Y., Damayani, N. A., Husodo, T., Khadijah, U. L. S., Shuhidan, S. M., & Septian, F. I. (2023). Environmental Literacy and Local Wisdom of Sindangkerta Beach Communities West Java Indonesia. *Migration Letters*, *20*(8), 111–126. https://doi.org/10.59670/ml.v20i8.5226

Zallesa, S. (2023). Penyuluhan Pemanfaatan Ekosistem Mangrove sebagai Kawasan Ekowisata oleh Masyarakat di Desa Cijulang Pangandaran. *Farmers: Journal of Community Services*, *4*(2), 6. https://doi.org/10.24198/fjcs.v4i1.46145