



Eco-Learning and Coastal Resilience: Community-Based Mangrove Rehabilitation in Response to Coastal Abrasion

Ayu Azkiyah

Universitas Islam Negeri Walisongo Semarang, Indonesia

DOI: <https://doi.org/10.61987/ljce.vii.237>

Article History:

Received: 15 January 2026

Revised: 18 March 2026

Accepted: 15 April 2026

Keywords:

Participatory Action
Research, Mangrove
Rehabilitation, Local
Ecological Knowledge,
Coastal Conservation

Abstract:

Coastal abrasion, mangrove degradation, and land-use conversion threaten the ecological stability of coastal communities and increase the need for participatory ecosystem rehabilitation. This community engagement activity aimed to document coastal environmental conditions, identify locally recognized disturbances affecting mangrove seedlings, implement collaborative mangrove planting, and document associated biodiversity through a Participatory Action Research (PAR) approach. The activity involved Biology Education students and a local environmental activist. Data were obtained through participatory observation, local knowledge identification, field documentation, and direct implementation of mangrove rehabilitation. The intervention included the preparation of planting sites, establishment of planting holes in muddy substrates, planting of 1,000 *Rhizophora* sp. seedlings, and installation of bamboo stakes secured with tying ropes. Field diagnosis identified approximately 30% mangrove-area damage associated with abrasion and land conversion. Local ecological knowledge identified three disturbance factors, termed “3W”: *Wideng* (crabs), *Wedus* (goats or livestock), and *Wong* (human activities). Field observations documented *Rhizophora apiculata*, *Rhizophora mucronata*, and *Periophthalmus* sp. The activity demonstrates the potential of PAR to integrate local ecological knowledge, collaborative restoration, biodiversity observation, and experiential biology education within community-based coastal rehabilitation.

INTRODUCTION

Coastal ecosystems are essential to environmental stability and the livelihoods of communities living near the sea. In Indonesia, extensive mangrove forests provide shoreline protection, habitat, biodiversity support, and blue-carbon functions that connect local ecological conditions with broader climate mitigation efforts. Mangrove conservation is therefore not only an environmental concern but also a community development priority, particularly where coastal settlements face simultaneous ecological and socioeconomic pressures. Sidik et al. (2023) describe blue carbon as an important paradigm for mangrove conservation in Indonesia, while Arifanti et al. (2022) identify sustainable management as a continuing challenge. These perspectives indicate that protecting mangroves

*Email Correspondence: ayuazkiyah1212@gmail.com

requires actions that connect ecological restoration with local participation. Consequently, community-based rehabilitation can provide a practical pathway for addressing coastal vulnerability while strengthening local involvement in maintaining coastal ecosystems and supporting longer-term environmental resilience over time coastal areas.

The importance of mangrove rehabilitation becomes greater where coastal degradation directly affects the physical environment inhabited by communities. Coastal abrasion can progressively alter shorelines, while mangrove loss may reduce the vegetation available within coastal protection systems. Irsadi et al. (2022) documented abrasion and accretion dynamics requiring mitigation and environmental adaptation, and Rahadian et al. (2022) emphasized that mangrove rehabilitation should consider coastal typology and ecological dynamics. Recent reviews likewise identify abrasion, erosion, climate change, and human activities as interconnected challenges requiring integrated mitigation approaches (Rusadi et al., 2024; Haslimin et al., 2026). These findings establish that coastal rehabilitation is relevant beyond individual planting events. Therefore, interventions that respond to locally observed degradation while involving community actors are important for translating broader coastal-management principles into practical actions within vulnerable coastal villages and strengthening community capacity for environmental stewardship contexts.

Kartikajaya Village, Patebon District, Kendal Regency, represents a concrete local context in which these coastal pressures are visible. Field information documented approximately 30% mangrove-area damage associated with abrasion and land conversion to ponds and residential areas. During the participatory activity, local ecological knowledge also identified three disturbance factors affecting mangrove seedlings: Wideng, referring to crabs; Wedus, referring to goats or livestock; and Wong, referring to human activities. These observations indicate that rehabilitation is undertaken within a setting where physical coastal change and direct local disturbances coexist. The field activity therefore involved Biology Education students from UIN Walisongo and Mr. Wasito, a local community figure and environmental activist, in diagnosing conditions and implementing planting activities. The documented setting provides a relevant basis for examining community participation, local knowledge, ecological observation, and practical mangrove rehabilitation within one community-based activity during the intervention.

Previous studies have demonstrated the value of community participation in mangrove restoration and coastal conservation. Kusumadewi et al. (2024) synthesized evidence on community-based mangrove restoration, while Damastuti et al. (2022) showed its relevance for biodiversity conservation in Central Java. Sathiyamoorthy and Sakurai (2024) also reported evidence concerning community participation in mangrove restoration, and Lhosupasirirat et al. (2023) highlighted stakeholder perceptions in community-based ecological restoration. Research further emphasizes collaboration and co-creation in addressing coastal challenges (Raha et al., 2024) and the inclusion of local knowledge in conservation planning (Djosetro & Behagel, 2024). However, much of this literature focuses primarily on restoration effectiveness, stakeholder participation, or conservation planning as separate concerns. The present activity

addresses this gap by integrating participatory diagnosis, local ecological knowledge, collaborative planting, and biodiversity observation within a PAR-based community intervention with local actors.

The ecological dimension of mangrove rehabilitation also requires attention to species identification and field-based biodiversity observation. Research has examined the ecological distribution and conservation relevance of *Rhizophora apiculata* and *Rhizophora mucronata* under changing climate and sea-level conditions (Samal et al., 2023), while Ngernsaengsaruy et al. (2024) emphasized taxonomic differentiation within *Rhizophora*. Studies in Indonesia have also examined biomass characteristics of these species (Ledheng et al., 2022) and their genetic variation (Widyasari et al., 2026). Nevertheless, restoration activities conducted through community engagement are not always presented together with systematic field observations that connect planted vegetation and associated intertidal organisms. In Kartikajaya, observation documented *R. apiculata*, *R. mucronata*, and *Periophthalmus* sp. alongside the planting activity. This integration contributes a place-based record linking restoration action, species recognition, and biodiversity observation within participatory field-based biology education in a locally documented coastal context for local conservation.

The specific problem addressed by this community engagement activity is the combination of mangrove degradation, coastal abrasion, land conversion, and disturbances that may threaten newly planted seedlings in Kartikajaya Village. Approximately 30% of the mangrove area was identified as damaged, while local knowledge documented the “3W” disturbance factors: Wideng, Wedus, and Wong. The community therefore requires practical rehabilitation activities that respond to observed coastal conditions and recognize locally identified threats to seedlings. At the same time, Biology Education students require opportunities to apply marine-biology concepts through direct observation and environmental action. The problem is consequently not limited to the absence of mangrove vegetation, but also concerns the connection between ecological conditions, local knowledge, participatory action, and biological learning. This community engagement initiative addresses these interconnected needs through participatory diagnosis, collaborative planting, and field observation conducted with community involvement jointly.

This community engagement activity aims to implement participatory mangrove rehabilitation in Dusun Bleder, Kartikajaya Village, through the PAR stages of co-diagnosis, collaborative action, and field observation. The activity specifically seeks to document local coastal conditions and disturbance factors, implement the planting of 1,000 *Rhizophora* sp. seedlings using locally appropriate planting supports, and identify mangrove and intertidal organisms observed during the activity. The scope involves Biology Education students of UIN Walisongo and Mr. Wasito as a local community figure and environmental activist, with activities conducted on 16 May 2026. The initiative connects the environmental needs of the community with students' field-based biology learning by combining ecological observation and practical rehabilitation in one setting. Its contribution is the integration of community knowledge, participatory environmental action, and biodiversity documentation as interconnected components of a place-based coastal rehabilitation activity and community engagement locally.

RESEARCH METHODS

This community service activity employed a Participatory Action Research (PAR) approach to integrate participation, ecological learning, and direct environmental action. PAR was selected because it emphasizes collaboration among participants, local stakeholders, and facilitators in identifying environmental issues, developing practical responses, implementing actions, and reflecting on the process (Cornish et al., 2023; De Oliveira, 2023). The activity was conducted on Saturday, 16 May 2026, involving Biology Education students from the 2023 cohort. The activity was directly guided by Mr. Wasito, a local community leader and coastal environmental activist. Before planting, participants received technical guidance concerning coastal conditions, mangrove characteristics, and appropriate planting procedures. This participatory orientation enabled students to contribute actively to mangrove restoration while gaining contextual understanding of coastal environmental management.

The activity was conducted in the coastal area of Jalan Purnawirawan Raya, Dusun Bleder, Kartikajaya Village, Patebon District, Kendal Regency. The site was selected because the coastal environment requires continued ecological attention and provides a relevant setting for community-based mangrove restoration. Local guidance introduced participants to the coastal landscape and several mangrove species, including *Rhizophora mucronata*, *Rhizophora apiculata*, and *Avicennia* sp. Participants also learned about local environmental pressures, commonly described as the “3W” threats: *Wideng* (crabs), *Wedus* (goats), and *Wong* (human activities that show limited environmental awareness). Integrating local ecological knowledge into conservation activities can strengthen community participation and contextualize restoration planning (Djosetro & Behagel, 2024; Dhyani et al., 2023). The local setting therefore supported both practical restoration and experiential biological learning.



Figure 1. *Rhizophora* sp. seedlings prepared for planting

Data were collected through participant observation, informal interviews, field documentation, and reflective field notes. Participant observation was conducted throughout the preparation and planting processes to document student participation, interactions, planting procedures, and responses to local environmental conditions. Informal interviews with Mr. Wasito provided contextual information concerning the coastal environment, local mangrove conditions, and community-based environmental practices. Photographs and field documentation were used to record the preparation of seedlings, transportation

activities, and planting processes. During implementation, 1,000 *Rhizophora* sp. seedlings were planted on muddy coastal substrate. Students worked in groups to transport and plant the seedlings by preparing planting holes, positioning the seedlings, backfilling the soil, installing bamboo supports, and securing the seedlings to prevent displacement by tidal water. Such participatory restoration activities are consistent with community-based approaches that emphasize active involvement and collaborative action (Sathiyamoorthy & Sakurai, 2024; Moore & Kumble, 2024).



Figure 2. Participatory Mangrove Planting Activity

The collected information was analyzed descriptively through an iterative process of organizing field observations, interview information, documentation, and reflective notes; identifying recurring patterns; and interpreting the relationships among local ecological knowledge, mangrove planting practices, student participation, and experiential learning. The analysis followed the participatory orientation of PAR by connecting field experiences with reflection and action rather than treating participants solely as sources of information (Cornish et al., 2023; Snapp et al., 2023). Data validity was strengthened through source and technique triangulation. Source triangulation involved comparing information obtained from the local community leader with observations of the coastal environment and student activities, while technique triangulation compared observation, informal interviews, documentation, and reflective notes. This procedure was used to establish a more consistent interpretation of the activity and strengthen the credibility of the reported findings.

RESULTS AND DISCUSSION

Results

Results of Participatory Co-Diagnosis and Problem Mapping

The participatory diagnosis was conducted in Dusun Bleder, Kartikajaya Village, Patebon District, Kendal Regency, on Saturday, 16 May 2026. The activity involved Biology Education students from UIN Walisongo and Mr. Wasito, a local community figure and environmental activist. Field observations identified approximately 30% mangrove-area damage, which was associated with coastal abrasion and land conversion. The observed condition included areas with reduced mangrove vegetation and exposed muddy coastal substrates. Coastal abrasion was also identified as a major environmental threat affecting the condition of the mangrove area in Kartikajaya.

The participatory mapping process also documented local ecological knowledge concerning factors that may damage newly planted mangrove seedlings. Mr. Wasito identified three locally recognized sources of disturbance, referred to as “3W,” namely *Wideng*, *Wedus*, and *Wong*. *Wideng* refers to crabs that may disturb or damage seedlings, *Wedus* refers to goats or livestock that may enter the planting area, and *Wong* refers to human activities that may physically disturb the mangrove area. These three factors were identified during the field activity as potential sources of disturbance to planted seedlings. The identification of the “3W” was recorded as part of the local knowledge documented during the participatory diagnosis stage.

Implementation of Collaborative Mangrove Planting Action

The collaborative intervention consisted of planting 1,000 mangrove seedlings of *Rhizophora* sp. in the muddy substrate of the coastal area. The planting activity was carried out jointly by Biology Education students of UIN Walisongo and Mr. Wasito as the local environmental activist accompanying the activity. Before planting, holes were prepared in the muddy substrate at the designated planting points. Each seedling was positioned in the prepared substrate and supported using a bamboo stake.

The bamboo stakes were installed adjacent to the seedlings and connected using tying ropes to provide physical support for the planted seedlings. The planting procedure therefore consisted of preparing holes in the muddy substrate, positioning the *Rhizophora* seedlings, installing bamboo stakes, and securing the seedlings with tying ropes. The participants were organized into collaborative work groups during the implementation of the planting activity. The group-based arrangement enabled the participants to carry out the preparation, planting, staking, and securing of seedlings collectively at the designated rehabilitation area.



Figure 3. *Rhizophora* plant commonly observed along the road leading to the coast (Personal documentation, 2026).

The field observation of mangrove vegetation along the access route to the coast documented morphological characteristics consistent with *Rhizophora apiculata*, as shown in Figure 3. The observed plant had relatively narrow and glossy leaves, visible stilt roots, and a relatively tall and straight stem. The plant was recorded as one of the *Rhizophora* species observed in the Kartikajaya coastal area. The scientific classification of the observed species is presented in Table 1, while its field identification was based on the visible morphological characteristics documented during the observation.

Table 1. Scientific Classification and Morphological Characteristics of *Rhizophora apiculata*

Taxonomic Level	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Malpighiales
Family	Rhizophoraceae
Genus	<i>Rhizophora</i>
Species	<i>Rhizophora apiculata</i>



Figure 4. *Rhizophora* plant observed in front of residents' houses (Personal documentation, 2026).

Another *Rhizophora* plant was observed in front of residents' houses within the village area, as shown in Figure 4. The plant was characterized by relatively broad and thick leaves, pointed leaf tips, and visible stilt roots. Based on these observable morphological characteristics, the plant was identified as *Rhizophora mucronata*. The scientific classification of the observed plant is presented in Table 2. The observation documented the occurrence of this species within the residential surroundings of Kartikajaya Village.

Table 2. Scientific Classification and Morphological Characteristics of *Rhizophora mucronata*

Taxonomic Level	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Malpighiales
Family	Rhizophoraceae
Genus	<i>Rhizophora</i>
Species	<i>Rhizophora mucronata</i>



Figure 5. Field observation of intertidal biota in the mangrove area.



Figure 6. Mudskipper observed in the coastal area during low tide (Personal documentation, 2026).

The field observation also documented the presence of mudskippers (*Periophthalmus* sp.) in the coastal area during low tide, as illustrated in Figures 5 and 6. The observed fish had prominent eyes positioned above the head and strong pectoral fins that enabled movement across the muddy substrate. The fish was observed in the intertidal muddy area associated with the mangrove environment. The scientific classification and observed characteristics of the mudskipper are presented in Table 3. These morphological and habitat characteristics were recorded as part of the biodiversity observations conducted during the field activity.

Table 3. Scientific Classification and Observed Characteristics of *Periophthalmus* sp.

Taxonomic Level	Classification
Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Gobiiformes
Family	Gobiidae
Genus	<i>Periophthalmus</i>
Species	<i>Periophthalmus</i> sp.

Discussion

The finding of approximately 30% mangrove-area damage in Kartikajaya, associated with coastal abrasion and land conversion, indicates a coastal degradation pattern consistent with previous studies in Indonesian coastal areas. Irsadi et al. (2022) documented abrasion and accretion dynamics in Demak and emphasized the need for mitigation and environmental adaptation in vulnerable coastal zones. Similarly, Arifanti et al. (2022) identified land-use pressure and

environmental change as important challenges for sustainable mangrove management in Indonesia. However, the Kartikajaya findings add a locally specific dimension by documenting the damage condition through participatory field diagnosis rather than relying solely on spatial or secondary environmental assessments. This provides a site-level empirical basis for understanding coastal degradation within a community-based rehabilitation activity.

The identification of the local “3W” threat—*Wideng* (crabs), *Wedus* (goats), and *Wong* (human activities)—demonstrates that local ecological knowledge contributed specific information about disturbances affecting mangrove seedlings. This finding corresponds with Djosetro and Behagel (2024), who emphasized the importance of incorporating local knowledge into conservation planning, and Dhyani et al. (2023), who demonstrated the value of participatory stakeholder assessment for identifying drivers of mangrove loss. The Kartikajaya finding differs in its highly contextual formulation, because the threats were organized through a locally recognized “3W” concept. Thus, the contribution lies in documenting how community knowledge can translate general environmental pressures into concrete, locally understandable categories of disturbance relevant to post-planting conditions.

The planting of 1,000 *Rhizophora* seedlings represents the principal collaborative action generated through the PAR process. The use of bamboo stakes, tying ropes, and planting holes in muddy substrates reflects a practical intervention adapted to the physical conditions encountered during the field activity. This approach is consistent with community-based restoration literature emphasizing direct participation and locally implemented restoration practices (Kusumadewi et al., 2024; Moore & Kumble, 2024). Lewis et al. (2025) similarly reported community-based mangrove restoration involving active local participation following environmental disturbance. Nevertheless, the Kartikajaya activity contributes a distinct educational dimension because university students participated directly alongside a local environmental actor. The novelty therefore lies in integrating participatory coastal rehabilitation with experiential biology education within a single field-based intervention.

The collaborative structure observed in Kartikajaya also corresponds with evidence that stakeholder engagement is important in coastal restoration and conservation. Lhosupasirirat et al. (2023) found that stakeholder perceptions influence the implementation of community-based ecological mangrove restoration, while Sathiyamoorthy and Sakurai (2024) reported evidence of the role of community participation in mangrove restoration. Raha et al. (2024) further emphasized collaboration and co-creation when addressing complex challenges in coastal communities. The Kartikajaya activity extends these findings by positioning local ecological knowledge and student participation within the same action process. Rather than treating the community solely as a recipient of a rehabilitation program, the activity documented collaboration between students and a local environmental actor from problem identification through implementation. This provides a practical PAR-based model linking academic participation with community knowledge.

Field observations identified *Rhizophora apiculata* and *Rhizophora mucronata*, distinguished by differences in leaf morphology and other visible characteristics. The occurrence of both species is relevant to previous research

documenting their ecological distribution and characteristics. Samal et al. (2023) specifically examined the potential distribution and conservation areas of *R. apiculata* and *R. mucronata* under climate and sea-level fluctuations. Ngernsaengsaruy et al. (2024) also demonstrated the importance of careful taxonomic differentiation within the genus *Rhizophora*. The Kartikajaya observation contributes field-level documentation of these two species within a community rehabilitation setting. The observation of mudskippers (*Periophthalmus* sp.) further records associated intertidal fauna, complementing the vegetation observations. These findings establish biodiversity documentation as an integrated component of the rehabilitation activity rather than focusing exclusively on planted seedlings.

The findings also have implications for biology education because the activity connected direct species observation with ecological restoration practice. Students encountered mangrove morphology, intertidal fauna, muddy substrates, coastal disturbance, and restoration techniques within the same field setting. This is consistent with Nwokocha (2024), who identified field trips as a means of developing practical skills in biology education, and Stanfield et al. (2022), who reported that restoration-based field experiences can support systems thinking among biology students. Hernández et al. (2023) likewise demonstrated the broader professional relevance of biology field-course experiences. The distinctive contribution of the Kartikajaya activity is its combination of field biology learning and participatory environmental action. Accordingly, the activity produced not only restoration outputs but also an experiential learning context in which biological observations were directly connected with an actual coastal environmental problem.

Overall, the Kartikajaya activity contributes a PAR-based community-university rehabilitation model that integrates participatory diagnosis, local ecological knowledge, direct restoration action, and biodiversity observation. Existing studies have separately emphasized community-based restoration (Kusumadewi et al., 2024), stakeholder participation (Cioffi et al., 2024; Jennings et al., 2024), local knowledge (Djosetro & Behagel, 2024), and field-based biology education (Stanfield et al., 2022). The novelty of this activity is the integration of these elements within one documented intervention in Kartikajaya, with 30% observed mangrove damage, identification of the locally defined “3W” threats, and planting of 1,000 *Rhizophora* seedlings. This integration provides a concrete example of how PAR can connect ecological rehabilitation with community participation and higher-education field learning in a coastal setting.

CONCLUSION

The most important finding of this community engagement activity is that participatory mangrove rehabilitation can connect local ecological knowledge, environmental action, and field-based Biology learning within a coastal community context. The main lesson learned is that environmental rehabilitation becomes more meaningful when communities actively participate in identifying ecological problems and implementing solutions, as demonstrated by the identification of approximately 30% mangrove-area damage, the locally recognized “3W” disturbance factors—*Wideng* (crabs), *Wedus* (goats), and *Wong* (human activities)—and the collaborative planting of 1,000 *Rhizophora* sp. seedlings. The

implication of these findings is that mangrove conservation should integrate community participation, local ecological knowledge, and contextual field-based learning to strengthen environmental stewardship and ecological education. The scientific contribution lies in integrating participatory diagnosis, local knowledge, mangrove rehabilitation, and biodiversity observation within a PAR-based community engagement framework while providing contextual learning for Biology Education students. However, the activity was limited by its single-site and short-term implementation, absence of quantitative seedling survival monitoring, and lack of systematic biodiversity assessment. Future research should conduct longitudinal monitoring of seedling survival and growth, quantitatively assess biodiversity and habitat recovery, and examine sustained community participation to evaluate the long-term outcomes of participatory mangrove rehabilitation in Kartikajaya.

ACKNOWLEDGEMENT

In this section, authors formally express their gratitude to all individuals and institutions that have contributed to the completion of the research. This includes, but is not limited to, financial support from funding agencies, guidance and supervision from academic mentors, technical assistance, and access to research facilities or datasets. Authors are advised to mention only those parties who have made a substantive contribution to the study. Funding sources should be cited with full agency names and grant numbers to ensure transparency and proper recognition. Personal dedications or informal acknowledgments should be avoided to maintain a professional and scholarly tone.

CONFLICTS OF INTEREST

The author declares no conflict of interest related to this study.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

During the preparation of this manuscript, AI-assisted technology was used to support language refinement, structural organization, and academic writing improvement. All generated content was carefully reviewed, revised, and validated by the author. The author takes full responsibility for the scientific accuracy, originality, and integrity of the final manuscript.

REFERENCES

- Arifanti, V. B., Sidik, F., Mulyanto, B., Susilowati, A., Wahyuni, T., Yuniarti, N., ... & Novita, N. (2022). Challenges and Strategies for Sustainable Mangrove Management in Indonesia: A Review. *Forests*, 13(5), 695. <https://doi.org/10.3390/f13050695>
- Cioffi, G., Sanabria, J. G., Sansolo, D. G., Pegorelli, C., & de Andrés, M. (2024). Assessing Stakeholder Participation in Coastal Zone Management: Methodological Proposal and Its Application in a Case Study from Cádiz Bay, Andalusia (Spain). *Ocean & Coastal Management*, 255, 107214. <https://doi.org/10.1016/j.ocecoaman.2024.107214>

- Cornish, F., Breton, N., Moreno-Tabarez, U., Delgado, J., Rua, M., de-Graft Aikins, A., & Hodgetts, D. (2023). Participatory Action Research. *Nature Reviews Methods Primers*, 3(1), 34. <https://doi.org/10.1038/s43586-023-00214-1>
- De Oliveira, B. (2023). Participatory Action Research as a Research Approach: Advantages, Limitations and Criticisms. *Qualitative Research Journal*, 23(3), 287–297. <https://doi.org/10.1108/QRJ-08-2022-0101>
- Dhyani, S., Shukla, J., Kadaverugu, R., Dasgupta, R., Panda, M., Kundu, S. K., ... & Hashimoto, S. (2023). Participatory Stakeholder Assessment for Drivers of Mangrove Loss to Prioritize Evidence-Based Conservation and Restoration in Bhitarkanika and Mahanadi Delta, India. *Sustainability*, 15(2), 963. <https://doi.org/10.3390/su15020963>
- Djosetro, M., & Behagel, J. (2024). Including Local Knowledge in Conservation Planning: The Case of the Western Coastal Protected Areas in Suriname. *Ecosystems and People*, 20(1), 2361683. <https://doi.org/10.1080/26395916.2024.2361683>
- Haslimin, H., Desi, N., & Chaerul, M. (2026). Concept of Coastal Abrasion Disaster Risk Management. *Journal La Lifesci*, 7(2), 182–201. <https://doi.org/10.37899/journallalifesci.v7i2.3268>
- Hernández, L. M. A., Mittan-Moreau, C. S., Lamb, T., Holmes, K. D., McDonald, C. A., Zamudio, K. R., & Ballen, C. J. (2023). A Half Century of Student Data Reveals the Professional Impacts of a Biology Field Course. *BioScience*, 73(1), 59–67. <https://doi.org/10.1093/biosci/biac103>
- Irsadi, A., Martuti, N. K. T., Abdullah, M., & Hadiyanti, L. N. (2022). Abrasion and Accretion Analysis in Demak, Indonesia Coastal for Mitigation and Environmental Adaptation. *Nature Environment and Pollution Technology*, 21(2), 633–641. <https://doi.org/10.46488/NEPT.2022.v2i02.022>
- Jennings, V., San Antonio, K. M., Brown, M. J., Choice, L., Simpson, Q., Ford, I., ... & Robinson, D. M. (2024). Place-Based Conservation in Coastal and Marine Ecosystems: The Importance of Engagement with Underrepresented Communities. *Sustainability*, 16(22), 9965. <https://doi.org/10.3390/su16229965>
- Kusumadewi, S. D., Purnomo, H., Nadhira, S., & Putrizulfan, R. (2024). Systematic Review on the Implementation of Mangrove Community-Based Restoration in Indonesia and Beyond. *IOP Conference Series: Earth and Environmental Science*, 1315(1), 012052. <https://doi.org/10.1088/1755-1315/1315/1/012052>
- Ledheng, L., Naisumu, Y. G., & Binsasi, R. (2022). The Estimation of Biomass in *Rhizophora apiculata* and *Rhizophora mucronata* in Tuamese Village, North Central Timor Regency, East Nusa Tenggara Province. *Jurnal Sylva Lestari*, 10(1), 39–48. <https://doi.org/10.23960/jsl.v10i1.555>
- Lewis, J. P., Giery, S. T., Rossin, K. A., Rossin, K. A., Cissell, J. R., Steinberg, M. K., ... & Layman, C. A. (2025). Community-Based Mangrove Restoration Following a Catastrophic Hurricane in The Bahamas. *Wetlands Ecology and Management*, 33(4), 46. <https://doi.org/10.1007/s11273-025-10053-4>
- Lhosupasirirat, P., Dahdouh-Guebas, F., Hugé, J., Wodehouse, D., & Enright, J. (2023). Stakeholder Perceptions on Community-Based Ecological Mangrove Restoration (CBEMR): A Case Study in Thailand. *Restoration Ecology*, 31(5), e13894. <https://doi.org/10.1111/rec.13894>

- Moore, A. C., & Kumble, S. (2024). Community-Based Conservation and Restoration in Coastal Wetlands: A Review. *Wetlands*, 44(5), 62. <https://doi.org/10.1007/s13157-024-01818-3>
- Ngernsaengsaruy, C., Chanton, P., Leksungnoen, N., Uthairatsamee, S., & Mianmit, N. (2024). A Taxonomic Revision of *Rhizophora* L. (Rhizophoraceae) in Thailand. *PeerJ*, 12, e17460. <https://doi.org/10.7717/peerj.17460>
- Nwokocha, G. C. (2024). The Influence of Fieldtrip as a Practical Skill Acquisition Technique in Biology Education. *Asian Journal of Education and Social Studies*, 50(6), 269–279. <https://doi.org/10.9734/ajess/2024/v50i61413>
- Raha, D., Davies-Vollum, K. S., Hemstock, S. L., Boateng, I., Islam, M. T., & Pierce, C. A. (2024). We Need Collaboration and Co-Creation to Address Challenges Facing Coastal Communities. *Nature Human Behaviour*, 8(5), 814–822. <https://doi.org/10.1038/s41562-024-01875-y>
- Rahadian, A., Kusmana, C., Setiawan, Y., & Prasetyo, L. B. (2022). Adaptive Mangrove Ecosystem Rehabilitation Plan Based on Coastal Typology and Ecological Dynamics Approach. *HAYATI Journal of Biosciences*, 29(4), 445–458. <https://doi.org/10.4308/hjb.29.4.445-458>
- Rusadi, S., Mulyawan, R., Suwaryo, U., & Yuningsih, N. Y. (2024). Bibliometric Analysis of Abrasion and Erosion Disaster Mitigation: Trends, Key Themes, and Potential for Global Policy Development. *Cogent Social Sciences*, 10(1), 2430451. <https://doi.org/10.1080/23311886.2024.2430451>
- Samal, P., Srivastava, J., Charles, B., & Singarasubramanian, S. R. (2023). Species Distribution Models to Predict the Potential Niche Shift and Priority Conservation Areas for Mangroves (*Rhizophora apiculata*, *R. mucronata*) in Response to Climate and Sea Level Fluctuations Along Coastal India. *Ecological Indicators*, 154, 110631. <https://doi.org/10.1016/j.ecolind.2023.110631>
- Sathiyamoorthy, S., & Sakurai, T. (2024). Effectiveness of Community Participation in Mangrove Restoration: The Evidence from Northern Sri Lanka. *Environmental Economics and Policy Studies*, 26(4), 759–779. <https://doi.org/10.1007/s10018-024-00397-1>
- Sidik, F., Lawrence, A., Wagey, T., Zamzani, F., & Lovelock, C. E. (2023). Blue Carbon: A New Paradigm of Mangrove Conservation and Management in Indonesia. *Marine Policy*, 147, 105388. <https://doi.org/10.1016/j.marpol.2022.105388>
- Snapp, S. S., Bezner Kerr, R., Bybee-Finley, A., Chikowo, R., Dakishoni, L., Grabowski, P., ... & Kanyama-Phiri, G. (2023). Participatory Action Research Generates Knowledge for Sustainable Development Goals. *Frontiers in Ecology and the Environment*, 21(7), 341–349. <https://doi.org/10.1002/fee.2591>
- Stanfield, E., Slown, C. D., Sedlacek, Q., & Worcester, S. E. (2022). A Course-Based Undergraduate Research Experience (CURE) in Biology: Developing Systems Thinking through Field Experiences in Restoration Ecology. *CBE—Life Sciences Education*, 21(2), ar20. <https://doi.org/10.1187/cbe.20-12-0300>
- Widyasari, A. S., Chasani, A. R., Prihatini, I., Atmoko, T., Adman, B., & Sitepu, B. S. (2026). Microsatellite-Based Genetic Variation in *Rhizophora apiculata* and *Rhizophora mucronata* from East Kalimantan. *BIOTROPIA*, 33(2), 169–180. <https://doi.org/10.11598/btb.2026.33.2.2715>