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A COMMUNITY-BASED MANGROVE REHABILITATION AND ENHANCEMENT IN THE CITY OF MATI, DAVAO ORIENTAL, PHILIPPINES – REGENERATING THE COAST OF PUJADA BAY

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ABSTRACT

Mangrove ecosystems play an integral role in coastal communities. They are crucial in mitigating climate change, supporting coastal ecosystems, and providing habitat for marine fauna, making them both ecologically and economically significant. The Regional Integrated Coastal Resource Management Center XI (RIC-XI) of the Davao Oriental State University, in collaboration with Mama Earth Foundation, Inc., Department of Environment and Natural Resources (DENR), Bureau of Fisheries and Aquatic Resources (BFAR), and the local government unit, has spearheaded the Community-based Mangrove Rehabilitation and Enhancement Project in Pujada Bay. This initiative aims to restore mangroves through reforestation while also providing livelihoods for Indigenous people and members of non-governmental organizations like the Women's Association of the City of Mati. The Mangrove Park, initiated by the Mama Earth Foundation, Inc., is a reforestation project that encourages active community participation in planning and implementing mangrove rehabilitation and development. The project goal is to plant 1,084,000 local species of mangrove present in their sites like Rhizophora stylosa, R. mucronata, R. apiculata, Avicennia marina, A. officinalis, Ceriops tagal, Sonneratia alba, and Bruguiera gymnorrhiza seedlings within coastal barangays of the City of Mati. Approximately 380-400 women participated in the Women's Association of nine coastal barangays. About 854,500 mangrove seedlings were planted as reported in 2023. Results indicated widespread recognition among the women's stakeholders and other local people of the social and economic benefits of the reforestation and enhancement of the mangrove park.

KEYWORDS: *Mangrove Ecosystems, Mangrove Species, Reforestation, Community Participation, Coastal Protection*

INTRODUCTION

Mangroves in the Philippines play a vital role in linking coastal ecosystem services to human well-being by providing a wide array of benefits that enhance both environmental health and community resilience. These ecosystems serve as natural barriers against storm surges and coastal erosion, significantly reducing the impact of extreme weather

events on coastal communities (Marquez & Olavides, 2024). They are critical habitats for numerous species, including fish and crustaceans, which are essential for local fisheries and food security ("Mangroves Sustaining Biodiversity, Local Livelihoods, Blue Carbon, and Local Resilience in Verde Island Passage in Luzon, Philippines", 2022). Additionally, mangroves store significant amounts of carbon, contributing to climate change mitigation efforts and enhancing local resilience to environmental changes ("Mangroves Sustaining Biodiversity, Local Livelihoods, Blue Carbon, and Local Resilience in Verde Island Passage in Luzon, Philippines", 2022).

Mangroves also support local economies by providing resources for fishing and tourism, with potential economic benefits estimated at billions of dollars if conservation efforts are optimized (Dabalà et al., 2023). Successful mangrove restoration projects often involve local communities, fostering ownership and sustainable management practices that enhance long-term benefits (Marquez & Olavides, 2024). However, anthropogenic pressures such as urbanization and industrialization have led to significant mangrove loss, jeopardizing the ecosystem services they provide. Prioritizing areas for conservation that maximize ecosystem services is essential for safeguarding both biodiversity and human well-being (Dabalà et al., 2023).

The study's primary objective was to conserve the country's remaining mangrove biological diversity and endangered habitats by mobilizing stakeholders to serve as effective partners while providing them additional income. Specifically, the study focused on bring back mangrove trees and vegetation in critic al and denuded areas using planned technical and management schemes; identify, train, and orient traditional mangrove users and other coastal resource dependents in effective community-based mangrove forest management; and rehabilitate traditionally depended upon/used mangrove forests and their associates through community-based mangrove forest management by creating additional livelihood programs. The integration of scientific and local ecological knowledge is crucial for effective mangrove management, ensuring that restoration efforts are sustainable and community-driven. Addressing the ongoing degradation of mangroves through integrated management and community involvement is critical for the future sustainability of these ecosystems in the Philippines.

MATERIALS AND METHODS

Study Sites

This project was conducted in the Malizia Mangrove Park in Pujada Bay, City of Mati, Davao Oriental, is a significant project focused on mangrove restoration and conservation. Pujada Bay is located in the City of Mati, Davao Oriental, Philippines (Figure 1). It is part of a larger coastal area known for its biodiversity and natural beauty. The park is part of a broader initiative to protect and enhance the coastal ecosystem of Pujada Bay, which includes several barangays such as Badas, Bobon, Dahican, Dawan, Lawigan, Luban, Macambol, Mamali, and Tamisan.

Mangroves in this region are crucial for coastal protection, carbon sequestration, and supporting marine life. However, they face threats from human activities like overfishing and coastal development. The Malizia Mangrove Park aims to restore mangrove ecosystems by planting native species, promoting community involvement, and enhancing local livelihoods. The project has already achieved significant milestones, including planting over one million mangrove seedlings as of early 2024 (Team Malizia, 2024; Mama Earth Foundation, 2023).

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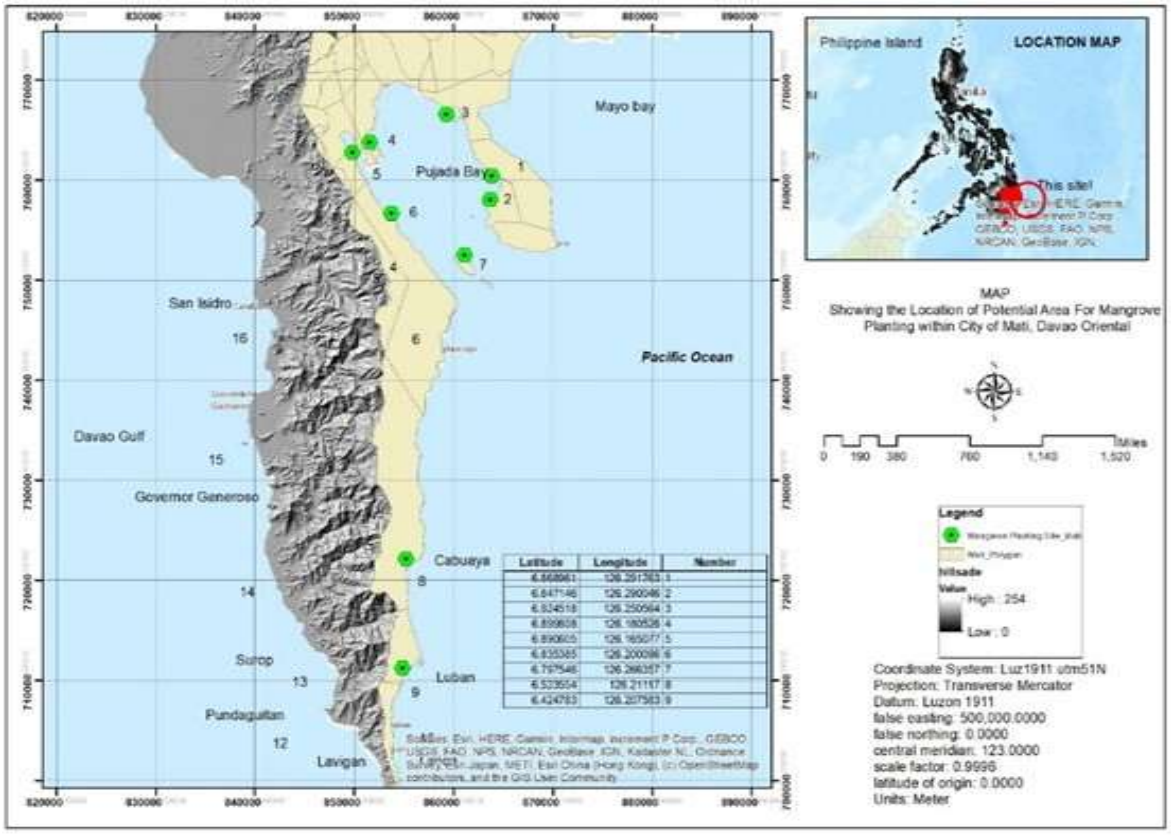

Community Engagement and Capacity Building for Sustainable Mangrove Management
Community-based mangrove management is crucial for the long-term conservation and sustainability of mangrove ecosystems. As shown in Figure 2, key methods for engaging communities and building their capacity include:

Entry Protocol in the Community
Establishing a respectful entry protocol is essential to build trust and rapport with local communities. This involves initial meetings with community leaders and stakeholders to discuss project goals and benefits.

Organize Community Team with Women's Association of the City of Mati
Engaging local women's associations can enhance community participation and ensure diverse perspectives. This partnership fosters inclusivity and strengthens community involvement in mangrove conservation.

Capacity Building
Providing training and workshops on mangrove ecology, nursery management, and sustainable practices empowers local communities to manage mangroves effectively. Capacity building activities should include leadership training and livelihood skills development.

Field Sampling Survey and Data Gathering
Conducting surveys and gathering data with community involvement helps in understanding local conditions and needs. This collaborative approach ensures that conservation strategies are tailored to the community's context.

Organize Community Monitoring Team Involving Women's Association
Establishing a community monitoring team that includes women's associations ensures ongoing oversight and maintenance of mangrove conservation efforts. This team can report on progress and address any challenges that arise.

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Strengthening Institutional Partnership in Policy, Research, and Advocacy

Collaborating with local governments, NGOs, and academic institutions is vital for developing effective policies and advocating for mangrove conservation. These partnerships can provide technical support, funding, and policy backing necessary for sustainable mangrove management.

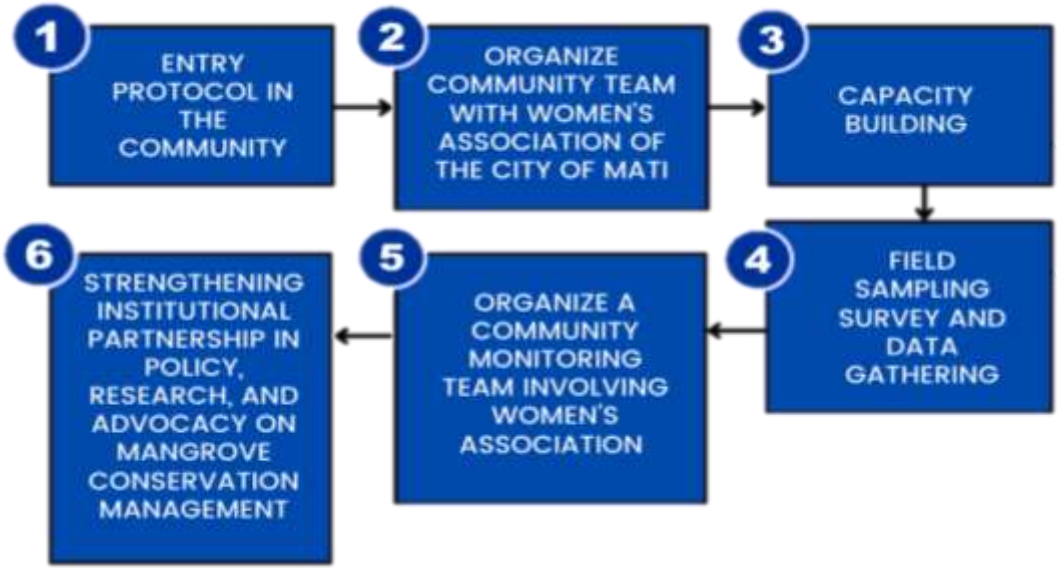

Figure 2. Methods for Community Engagement and Capacity Building for Sustainable Mangrove Management.

Mangrove Planting Scheme Guide

A successful mangrove planting scheme necessitates meticulous consideration of several critical factors. These include the type of soil substrate, which must support the specific needs of mangrove roots; the location, which should be protected from strong currents and have suitable tidal ranges; the area size, which needs to be sufficient to accommodate the growth of the mangroves and their ecological role; and the species selection, which must be appropriate for the local climate and environmental conditions to ensure the long-term viability and ecological balance of the mangrove ecosystem. Mangrove species that will be found in Pujada Bay in Landward and Seaward area are *Rhizophora stylosa*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia marina*, *Avicennia officinalis*, *Ceriops tagal*, *Sonneratia alba*, and *Bruguiera gymnorrhiza*.

Table 1. Mangrove planting scheme guide based on the type of soil substrate, location, area size, and species

SEDIMENT	SCHEME	ESTIMATED SEEDLINGS/HAS.	80% APPROXIMATE SEEDLINGS/HAS.
A. Muddy Seafloor	0.50 x 0.50	40,000	32,000
B. Ordinary/Normal	0.70 x 0.70	18,000	14,000
C. Hard Seafloor	1.00 x 1.00	10,000	8,000

Nursery Planting Stocks

Mangrove seedlings (3–6 months old) were cultivated in polypropylene bags (5’ x 8”) filled with fertile garden soil. Rhizophora species (including *R. stylosa, R. mucronata, and R. apiculata*) were selected for planting when they reached 3–4 leaves. The study focused on mangrove species in Pujada Bay, categorized into landward and seaward zones. Species identified included:

- **Rhizophora**: *R. stylosa, R. mucronata, R. apiculate*
- **Avicennia**: *A. marina, A. officinalis*
- *Ceriops tagal, Sonneratia alba, Bruguiera gymnorrhiza*

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RESULTS

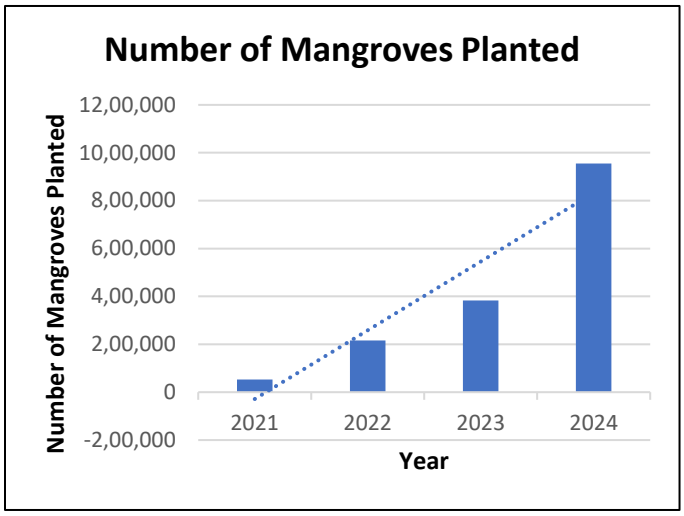

Figure 3. Number of Mangroves Planted from 2021 to 2024

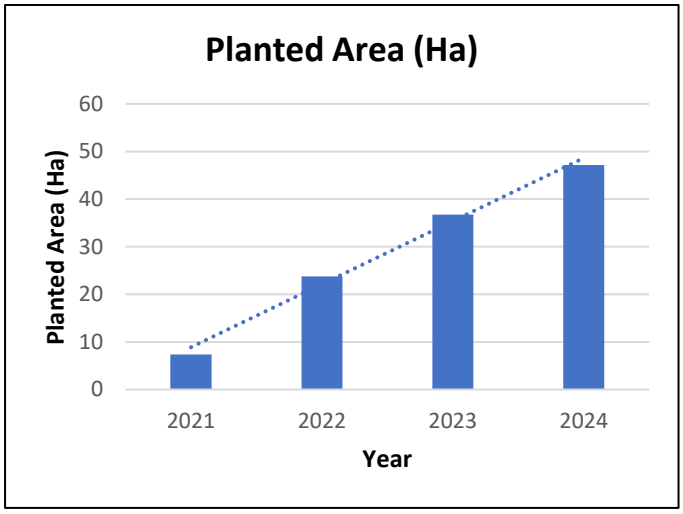

Figure 4. Planted Area (Ha) from 2021 to 2024

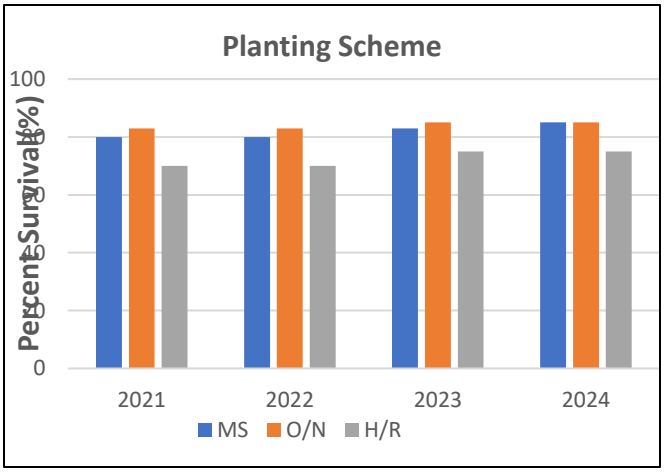

Figure 5. Percent Survival (%) from 2021 to 2024

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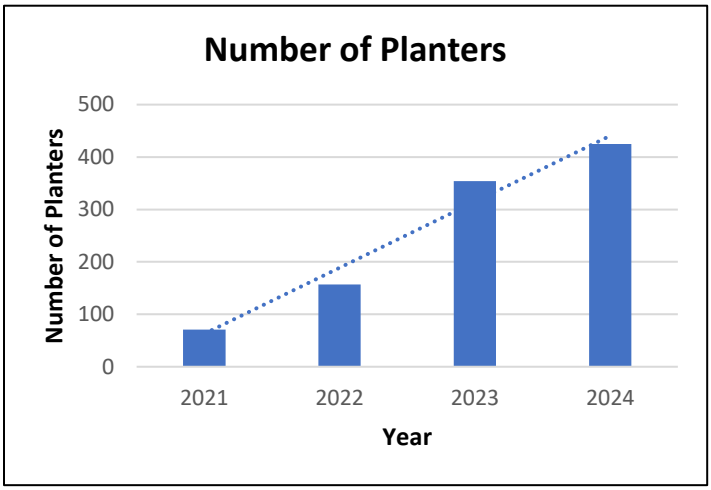

Figure 6. Number of Mangrove Planters from 2021 to 2024

DISCUSSION

Planting Scheme of Mangrove seedlings

A planting scheme (Table 1) ensures good mangrove growth and development and will guide the women planters for the optimal location, soil substrate, estimated seedlings per area, and conditions for certain species to grow. The 3–4 leaf criterion for seedlings ensured sufficient root development and photosynthetic capacity, reducing mortality risks in challenging coastal environments. Protocol adherence—particularly poly bag removal and substrate quality—enhanced soil-root interaction, critical for mangrove establishment.

Community incentives fostered sustained engagement, with phased payments aligning with project milestones. This approach not only ensured accountability but also incentivized long-term stewardship, addressing gaps in traditional mangrove restoration efforts.

Mangrove Planting Assessment (2021-2024)

The mangrove rehabilitation/enhancement in Pujada Bay have shown significant progress from 2021 to 2024 (Figure 3). In 2021, 53,500 mangroves were planted, including four species: *Rhizophora stylosa*, *Rhizophora mucronata*, *Rhizophora apiculata*, and *Avicennia marina*, with an average survival rate of 59%. By 2022, planting expanded to 216,550 hills across various sites, particularly in Sitio Guang-guang, with favorable habitat conditions and community involvement. The introduction of Ceriops tagal in this area achieved a higher survival rate of 80-85%. However, low survival rate of 35% at Sitio Interco due to pollution from nearby wastewater discharge, emphasizing the need for integrated management strategies. In 2023, a total of 382,700 mangroves were planted with minimal disturbances reported. Cumulatively, over 652,750 mangroves have been established from 2021 to 2023. In 2024, the project aims to reach nine out of ten coastal barangays around Pujada Bay, with a projected total of approximately 954,800 mangroves planted. These restoration efforts not only enhance biodiversity but also foster community engagement and resilience against climate change. Continued collaboration among local communities, researchers, and conservation organizations is essential for sustaining healthy coastal ecosystems in Pujada Bay.

Recent studies on mangrove ecosystems in the Philippines have revealed important insights into their structure, diversity, and carbon sequestration potential. Planted mangroves can achieve higher biomass and productivity compared to natural stands, though monospecific plantations may be more vulnerable to typhoon damage (Ogawa et al., 2022). Carbon stock assessments in various locations showed significant sequestration potential, with older plantations generally storing more carbon (Raga-as et al., 2022; Alimbon & Manseguiao, 2021). However, species diversity in some areas remains low, with *Avicennia marina* often dominating (Alimbon & Manseguiao, 2021). These findings highlight the importance of diverse species composition in mangrove restoration efforts, as well as the need for sustainable management practices to enhance carbon sequestration and ecosystem resilience (Ogawa et al., 2022).

Planted Area of Mangroves (2021-2024)

The rehabilitation/enhancement of mangrove areas in Pujada Bay have significant growth from 2021 to 2024 (Figure 4). Initially, 7.33 23.77 has, 36.73 has, and 47.18 has respectively. This increase is supported by collaborative initiatives, including a project led by Team Malizia and the Mama Earth Foundation, which has successfully planted over 800,000 mangrove seedlings in Pujada Bay (Philippine Morning Post, 2023). The increasing area planted with mangroves from 2021 to 2024 reflects a strong commitment to restoring coastal ecosystems in Pujada Bay.

Mangrove forests in the Philippines have experienced significant decline due to deforestation and conversion to aquaculture ponds (Samson & Rollon, 2011). Efforts to restore mangroves have been extensive, but often misguided, with plantings occurring in unsuitable areas like mudflats and seagrass meadows (Samson & Rollon, 2008). These plantings, primarily monospecific Rhizophora spp., have shown high mortality rates and stunted growth compared to natural mangrove sites (Samson & Rollon, 2008). However, successful plantations can achieve high biomass and net primary productivity, surpassing natural mangrove sites (Ogawa et al., 2022). To improve restoration efforts, it is recommended to focus on replanting in brackish-water aquaculture ponds, the original mangrove habitat (Samson & Rollon, 2008). Accurate mapping of mangrove extent is crucial for conservation efforts, with a study using Landsat imagery estimating approximately 256,185 hectares of mangrove cover in the Philippines circa 2000 (Long & Giri, 2011).

Percent Survival (2021-2024)

The 70–83% survival range highlight the interplay between substrate suitability, site-specific conditions, and environmental stressors such as Fertile garden soil in poly bags provided initial stability, but long-term survival depended on native soil compatibility post-transplantation; Seaward zones faced higher mortality due to frequent flooding and salt stress, whereas landward zones favored species like Avicennia and Sonneratia; and Storm surges and sediment burial disproportionately affected seedlings in exposed areas, highlighting the need for adaptive planting schedules.

Relationship Between the Number of Planters and the Number of Mangroves Planted

The number of women mangrove planters significantly increased in 2024, aligning with the highest number of mangroves planted during this period (Figure 5). This trend indicates a direct relationship between the number of planters and the volume of mangroves planted, supported by the expansion of project sites that encourage women's participation. Research shows that involving women in environmental initiatives enhances planting efforts and fosters community resilience. Collaborative projects in Pujada Bay, such as those by Team Malizia and the Mama Earth Foundation, have successfully engaged local communities, resulting in over 800,000 mangrove seedlings planted (Daily Tribune, 2023). These initiatives not only promote ecological goals but also empower women through active participation. However, an increase in planting does not guarantee a 100% survival rate for seedlings, as various environmental and human factors can affect outcomes. The increasing participation among women mangrove planters is crucial for enhancing restoration efforts in Pujada Bay.

Mangrove restoration efforts in the Philippines have faced challenges due to inappropriate planting locations and limited species diversity. Local planters often focus on Rhizophora species, resulting in monospecific plantations with high densities of small stems and limited regeneration of other species (Walters, 2000). Planting in non-mangrove areas like mudflats and seagrass meadows has led to high mortality rates and stunted growth (Samson & Rollon, 2008). Despite these issues, mangrove cover in the Philippines increased by 61% between 1998 and 2007, though field validation is needed (Samson & Rollon, 2011). To improve restoration success, experts recommend planting in appropriate elevations to reduce abiotic stress (Samson & Rollon, 2008) and incorporating facilitation theory, which emphasizes positive interactions among plants in harsh environments (Gedan & Silliman, 2009). A balanced approach considering exploitation, conservation, and restoration is suggested for sustainable mangrove management (Gedan & Silliman, 2009).

Factors Affecting Mangrove Survival

Reports from monitoring community organizers have identified several constraints negatively impacting the growth of mangrove seedlings in Pujada Bay. Key challenges include barnacle infestations, typhoon disturbances, and traditional fishing practices such as beach-seine fishing and gleaning, which disrupt coastal ecosystems (Ross & Underwood, 2006), while typhoons are a primary driver of mangrove loss (Mo et al., 2023). Additionally, pollution

from trash and microplastics poses significant threats to mangrove health. While mangroves are generally resilient, they are adversely affected by human-induced pollution (Wong et al., 2021). Effective monitoring and community awareness programs are essential to mitigate these threats. Addressing anthropogenic debris through regular clean-up initiatives is crucial for maintaining healthy mangrove habitats.

Impact of the Project on its Beneficiaries

The primary beneficiaries of the mangrove restoration project are the members of the Women's Association of the City of Mati. Around 1,000 women have been contracted as mangrove planters in Pujada Bay, providing them with job opportunities and empowering their roles in environmental stewardship. The project supported and assisted the mangrove nursery of the coastal communities manage by women's association. Other livelihood programs from the Local Government Units (LGUs) supports the community-based mangrove forest management such as Bamboo Basket Making, *Bangus* Deboning, *Malong* and Bag Making, Buko Pie Making, *Mandaya* Dress, Beads & Embroidery, Romblon Bags & Mats Making, Bamboo Furniture Making, and Candle Making. Research indicates that involving women in conservation efforts can significantly enhance project outcomes. Similarly, women's participation in mangrove restoration in Kenya leads to improved ecological conditions and community benefits (Nature Conservancy, 2021). The empowerment of women through participation in mangrove rehabilitation projects not only benefits ecological health but also strengthens community resilience. Continued support for women's involvement will be crucial for achieving sustainable outcomes in Pujada Bay and beyond.

CONCLUSION

The mangrove rehabilitation efforts in Pujada Bay demonstrate measureable ecological and social progress, highlight the efficacy of community-based conservation. In ecological milestones, Rhizophora species (e.g., *R. stylosa*, *R. mucronata*) and *Ceriops tagal* exhibited high survival rates in seaward zones, particularly under favorable substrate and salinity conditions. Seedlings achieved 70–83% survival, influenced by zonation (landward vs. seaward), substrate quality, and environmental factors like tidal patterns. Seedlings achieved 70–83% survival, influenced by zonation (landward vs. seaward), substrate quality, and environmental factors like tidal patterns. In Social Impact, over 1,000 women were contracted as mangrove planters, fostering economic empowerment and community resilience. Partnerships among local governments, NGOs (e.g., Mama Earth Foundation), academia, and coastal communities ensured participatory decision-making and long-term stewardship able ecological and social progress, highlight the efficacy of community-based conservation.

RECOMMENDATION

To ensure the long-term sustainability of mangrove rehabilitation in Pujada Bay, the researchers recommend:

1. Strengthening partnerships among local communities, youth, NGOs, and government agencies to pool resources and expertise;
2. Expanding women's roles from planters to decision-makers and providing further training;
3. Prioritizing adaptable seaward species like Avicennia and Sonneratia;
4. Optimizing conditions for *Ceriops tagal* to improve survival rates; and
5. Broadening women's empowerment through additional economic opportunities and support systems.

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