

Sustainable mangrove rehabilitation: Lessons and insights from community-based management in the Philippines and Myanmar

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ABSTRACT

This study generally aims to synthesize the best practices and challenges in mangrove rehabilitation in the Philippines, Myanmar, Japan, China and India. It employed an in-depth review of secondary information such as policy documents and project reports, and participatory research activities with various mangrove stakeholders such as key informant interview and focus group discussion. Lessons and strategies obtained were used to develop a mangrove rehabilitation framework or guideline. The guideline was tested for suitability through case studies in the Philippines and Myanmar. It was concluded that mangrove rehabilitation will succeed if 1) it is built around an integrated and ecosystem-based approach that takes into account feedback between rehabilitation and other economic activities; 2) its scope is beyond mere planting; 3) local people are involved in planning and monitoring in addition to implementation; 4) all stakeholders are informed of their roles and responsibilities; and 5) species selection is based on ecological and silvicultural knowledge in conjunction with the needs and priorities identified by stakeholders.

1. INTRODUCTION

Mangroves provide a range of ecosystem services. These largely include the provision of timber, fuel wood, medicines, natural dyes, honey, and marine food. They also help in regulating floods, erosion and saltwater intrusion; and protect coastal communities against the harsh impacts of storms and tsunamis. Further, there are several aesthetic and cultural services that mangroves provide, including those related to tourism, education, and local indigenous knowledge and traditions. Mangroves are confined largely to the tropics and sub-tropics. Among the continents, Asia has the most extensive mangrove forest cover, but with the most serious deforestation rates (Food and Agricultural Organization of the United Nations [FAO], 2015). Mangroves, particularly in Southeast Asia, are globally distinguished for their high biodiversity (Tomlinson, 1986; Giesen & Wulffraat, 1998). Mangrove cover has been reduced from 6,025,000 ha in 2010 to 5,329,000 ha in 2015 (FAO, 2015). Many mangrove stands are on the brink of complete collapse after being converted to

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HIGHLIGHTS

- » Science-based approach in coastal rehabilitation is being promoted to solve worsening coastal environmental problems.
- » Community-based forest management approach encourages participation, strong collaboration and commitment of local communities in collaboration with research institutions, government and non-government institutions.
- » Science-based rehabilitation guidelines should be communicated well to local communities.
- » Key facilitating factors for successful mangrove rehabilitation are clear policies, secured rights, and good governance.

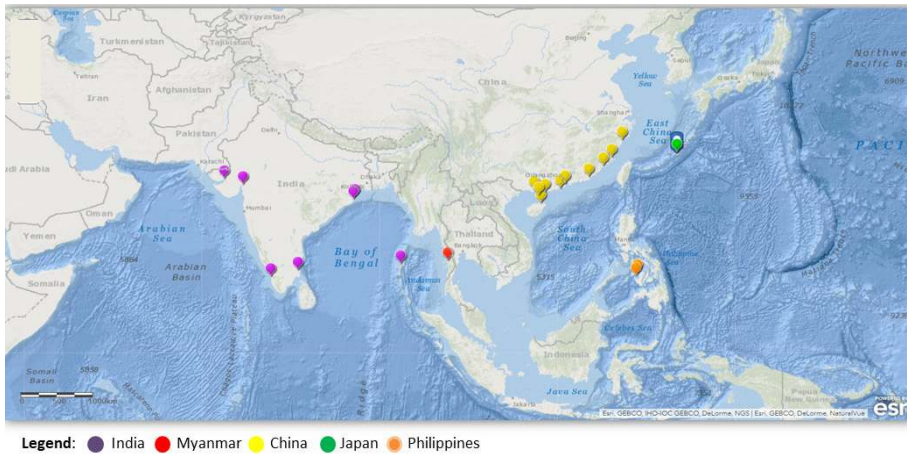


FIGURE 1. Location map of study areas in Asia. Source: ArcGIS Online.

aquaculture ponds, agricultural farms, oil palm and settlement areas (Kathiresan & Bingham, 2001; Gevaña, Pulhin, & Tapia, 2019). Low awareness of ecological and economic values of mangroves also led to their neglect in national forest conservation and biodiversity protection plans (Snedaker, 1984).

Over the past two decades, mangrove conservation and rehabilitation have gained interests with the increasing recognition of their role to minimize the impacts of tsunami and storm surge (Garcia, Malabrigo & Gevaña, 2014; Gevaña, Camacho, & Pulhin, 2018). Further, mangrove plantation development was also driven by the increasing demand for fuelwood, poles, charcoal and woodchips, and more importantly, because of their ecological ecosystem functions (Aksornkoae & Kato, 2011). However, numerous planting efforts implemented were unsuccessful due to the lack of science-based approach guidelines (Primavera and Esteban (2008); López-Portillo et al., 2017).

Given the challenges in mangrove conservation, a collaborative research study was undertaken to synthesize the best practices and challenges in mangrove rehabilitation in the Philippines, Myanmar, Japan, China and India. Further, this study endeavoured to develop mangrove rehabilitation frameworks/guidelines by distilling the best practices and lessons learned from the secondary information, participatory assessment of the outcomes of rehabilitation treatments in field in selected areas and collaboration of multi-country team of researchers, as supported by the Asia Pacific Network for Global Change Research (APN).

2. METHODOLOGY

To achieve the study objectives, participatory research methods were undertaken. These included:

- » review of secondary data (e.g. policy documents, project reports and scientific publications) in terms of the different elements of rehabilitation treatments; ecological, economic and social

costs and benefits; challenges and opportunities; and implementation arrangements described covering all mangrove areas in the Philippines, Myanmar, Japan, China and India (Figure 1); and

- » key informant interviews (KII) with various mangrove stakeholders (e.g. government agencies, non-government organizations, and local community organizations).

Results of the review and participatory research activities were synthesized to develop a mangrove rehabilitation framework, or guidelines. To check the guideline suitability, case analyses were undertaken in three communities in the Philippines, and one in Myanmar. This involved the conduct of focus group discussions with selected local community members implementing mangrove rehabilitation projects.

2.1 Study sites

The study covered mangrove rehabilitation efforts in the Philippines; Myanmar, Japan, China and India (Figure 1). The Philippines has estimated mangrove forests of about 356,000 ha, with a recent decadal deforestation rate of 0.5% (Gevaña, Camacho, & Pulhin, 2018). In Myanmar, mangroves span 502,911 ha. In India, Sundarbans are well-known as one of the most extensive contiguous mangrove forests in the world. India has 4,921 sq. km of mangroves, contributing 3.2% of the global estimate. Five provinces viz., Guangdong Province, Guangxi Autonomous Region, Hainan Province, Fujian Province and Zhejiang Province cover 57.3%, 25.5%, 13.7%, 3.4% and 0.1% of the total mangrove area (17,800 ha) of China, respectively. In Japan, mangroves are found chiefly in the southernmost prefectures of Kagoshima and Okinawa, with its northern limit located in Kiore. They cover about 553 ha.

2.2 Study components and methods

The study aimed to identify mangrove rehabilitation practices, challenges, and lessons learned among the

collaborating countries. In summary, the research team accomplished the following activities:

- » A literature review of past reports on mangrove rehabilitation (from the year 2000 onwards) and state-of-the-art knowledge of mangrove ecology was examined.
- » A list of criteria summarizing the success and challenges of rehabilitation was developed, namely: 1) site; 2) duration and budget; 3) planting design (including species composition); 4) survival rate; 5) stakeholder participation; 6) provision of socio-economic benefits; and 7) success and constraining factors.
- » In-depth on-site case studies in the Philippines and Myanmar describing suitability of the proposed guidelines/comprehensive framework through key informant interviews (KII) and focus group discussions (FGDs).

- » Policy consultations with relevant government, non-government, academic and research institutions were held through KII and FDGs. These were aimed at eliciting: 1) key mangrove rehabilitation policies and programmes and their congruence with sustainability; 2) effectiveness of policy implementation; 3) perceived issues and challenges in policy implementation; and 4) recommendations to improve policies.

3. RESULTS AND DISCUSSION

3.1 Mangrove rehabilitation best practices, challenges and lessons learned

The literature review supplemented by field observations in selected locations suggested that empowerment of local communities by legitimizing their resource

Country	Reasons for mangrove losses	Best practices	Issues and challenges	Lessons learned
Philippines	<ul style="list-style-type: none"> • Conversion to aquaculture ponds, rice paddies and reclamation for settlement and industrial development • Typhoons/storms 	<ul style="list-style-type: none"> • Adoption of community-based forest management (Executive Order No. 263, 1995) that has spurred collective efforts to rehabilitate other degraded coastal environments 	<ul style="list-style-type: none"> • Poor survival in plantations due to wrong choice of species for planting • The CBFM participants in mangrove areas cannot avail the incentives compared with the CBFM participants in the upland areas such as security of tenure and exemption from forest charges for harvesting 	<ul style="list-style-type: none"> • Need for harmonised mangrove policies and institutions to help promote effective sustainable management and rehabilitation • Science-based process is a prerequisite for rehabilitation
Myanmar	<ul style="list-style-type: none"> • Extraction of fuelwood/timber • Mangrove conversion into shrimp ponds, settlements and rice paddies • Large scale fish and prawn farming 	<ul style="list-style-type: none"> • Adoption of mangrove-based agroforestry practices, community-based mangrove management and ecological mangrove restoration 	<ul style="list-style-type: none"> • Limited studies that assess the causes of degradation and insufficient communication of results • Policy gaps on requiring feasibility assessment, monitoring and enforcement through multi-disciplinary approaches 	<ul style="list-style-type: none"> • Need for integrated approach to mangrove rehabilitation, including: <ul style="list-style-type: none"> – knowledge-based planting methods, – social mobilization, – livelihood support – policies on reaching planting
India	<ul style="list-style-type: none"> • Conversion to urban zones and shrimp farms • Overharvesting • Storms and urban pollution 	<ul style="list-style-type: none"> • Legal and regulatory institutions were set up for the protection of mangroves • Integration of apiculture with rehabilitation for local income 	<ul style="list-style-type: none"> • Inadequate labour resources, lack of facilities, and inappropriate use of financial resources • Both plantations and natural forests in deltaic regions suffer massive losses due to erosion 	<ul style="list-style-type: none"> • Need for long term-participatory-adaptive restoration programmes
China	<ul style="list-style-type: none"> • Conversion to agriculture/aquaculture • Reclamation for urban development • Overfishing and introduction of invasive species 	<ul style="list-style-type: none"> • Selective cutting and gap planting of <i>Sonneratia apetala</i> in secondary forests • Ecological aquaculture combining mangrove rehabilitation with shrimp farming 	<ul style="list-style-type: none"> • Reforestation on bare beaches and integration with human-made fish reefs are very costly to implement • Survival rate of mangrove seedlings remains quite low 	<ul style="list-style-type: none"> • Strengthen protection of mangrove nature reserves, rehabilitation of degraded mangroves, and provide more support for research and rehabilitation work
Japan	<ul style="list-style-type: none"> • Cutting for firewood, construction material, dyeing and antiseptic agents • Reclamation for urban and industrial areas 	<ul style="list-style-type: none"> • No aquaculture farms in mangroves area • Cutting and destroying mangroves are strictly restricted • Tourism is a more beneficial industry than aquaculture 	<ul style="list-style-type: none"> • Land-based problems such as red-soil runoff due to unsustainable agriculture practices and garbage pollution 	<ul style="list-style-type: none"> • Mangroves are well-conserved in Japan for their ecological, educational and touristic values

TABLE 1. Best practices, challenges and lessons learned regarding mangrove rehabilitation from participating countries.



FIGURE 2. Participatory Mangrove Rehabilitation Framework.

use rights as well as management responsibilities was the key factor driving successful mangrove restoration in the Philippines and Myanmar. Furthermore, local income from non-timber forest products (in India), ecotourism (in Japan), and shrimp farming (in China) are guaranteed if healthy mangrove forests are well-kept. In all countries, the feedbacks between mangrove restoration, other land uses and non-land economic activities were considered crucial for conserving biodiversity, mitigating climate change, increasing resilience to climate change, and sustainable socioeconomic development. Poor survival rates of planted mangroves were observed to be the result of: 1) poor planning; 2) limited understanding of the site's ecology; 3) poor programme management/governance/policy concerns; 4) tenure insecurity; 5) occurrence of natural disasters; 6) poor monitoring; and (7) lack of timely corrective measures (Table 1).

3.2 Guidelines and comprehensive framework for sustainable mangrove rehabilitation

Using the information from lessons learned on past and current efforts in mangrove rehabilitation (Table 1), a comprehensive framework for pursuing sustainable community-based mangrove rehabilitation was developed. This framework emphasizes that rehabilitation is not merely a process of planting of trees, but a holistic effort to address broader environmental, economic and social imperatives across spatial and temporal scales (Pulhin, Gevaña, & Pulhin, 2017). It involves several steps, as also reflected in the mangrove rehabilitation manual developed by Primavera et al. (2012) (Figure 2).

3.2.a Local site coordination.

Forest rehabilitation should be properly coordinated

with relevant stakeholders. Ensuring transparent, just and sound stakeholder engagement is at the heart of all successful rehabilitation projects. Rehabilitation must rest on a shared vision and all stakeholders should have a clear understanding of their roles, responsibilities and benefits. This sets the foundation for ensuring accountability.

3.2.b Comprehensive site assessment.

Comprehensive site assessment should be undertaken by an interdisciplinary team of researchers/experts together with local people. Involvement of local people in field data collection (e.g. measuring trees, assisting in social surveys and ground validation of land uses and maps) inculcates a sense of ownership and induces efforts towards voluntary replication and indigenous innovations. Comprehensive site assessment has two major components:

- » *Biophysical characterization.* Vegetation analysis can be done through rapid appraisal or rigorous assessment following a statistically efficient sampling design. It should capture the historical changes in land-use systems and landscape structure and function. The assessment should cover topography, hydrology, sedimentation, contamination, climate and ecosystem structure and processes. Participatory resource mapping and key informant interviews can supplement/complement the scientific data.
- » *Socioeconomic characterization.* Participatory Rural Appraisal (PRA) is an effective tool of capturing the level of awareness of the value of mangroves, local needs and priorities. Demographic (population, gender distribution, ethnicity, etc.), socio-economic (income and livelihood), and cultural profiles (traditional use and management of

mangroves) and existing institutional arrangements in managing mangroves such as property rights and stewardship arrangements must be analyzed for improved mangrove resource utilization and management practices.

3.2.c Participatory mangrove rehabilitation planning.

Rehabilitation planning starts with a Problem Tree Analysis. A good understanding of the problem root causes is critical to designing appropriate rehabilitation strategies. Results of the comprehensive site assessment provide insights about the key site-specific management issues. Visioning exercise, which aims to solicit a standard and ideal vision for the mangrove forest, follows the problem analysis. Such a unified vision is further interpreted into long term goals and achievable objectives over the short term in project mode operations. Stakeholders then proceed with strategic planning exercises. The following are the major components of the technical rehabilitation guidelines:

- » *Correct site selection.* Mangrove planting should only be done within the middle to upper intertidal zones of the coastal area where mangroves naturally grow and thrive (Primavera et al., 2012). Moreover:
 - › Original mangrove sites (including those that are abandoned fishponds after conversion) should be the target of rehabilitation and not habitats such as seagrass beds.
 - › Mangrove sites vary in sizes from tiny strip to several thousand hectares. Careful planning is needed taking into account the operational constraints of time, budget and human resources.
 - › Correct information about the site's ecology and hydrology is vital in designing rehabilitation programme. Planting on the wrong site, at the wrong time, with the wrong species leads to failures. In summary: a) get the hydrology right; b) do not start by planting mangroves: first, find out why mangroves are not there; c) see if the reason for mangrove absence can be corrected; if not choose another site; d) use a reference site to identify the conditions suitable for mangroves in the project area; e) for the reference site, be clear about its topography before considering another area; and f) evaluate costs and benefits early in project planning to maximize cost-effectiveness.
- » *Nursery management.* Size, cost and location of nursery depend on the amount of planting materials to be produced to complete the

rehabilitation target. Nursery should be established in a strategically located area that is near the seed or wildling source, sheltered from strong waves and close to plantation sites. Tending of seedlings largely includes watering, cleaning, and hardening-off to ensure vigour. Seedling transport may be needed if planting site is far.

- » *Outplanting.* This generally involves: a) selection of appropriate species for planting; b) configuration of species in mixed planting and spacing (number of seedlings per unit area); c) planting schedule taking in account tides; and d) selection of planting techniques.
- » *Site maintenance.* Key activities include removal of algae and barnacles on seedlings, establishment/maintenance of wave barriers and gap-filling.
- » *Field monitoring.* Regular monitoring is essential to check if rehabilitation objectives are met. Ocular inspections over extensive areas and census of survivors and their height, main stem and canopy growth in selected areas enable cost-effective monitoring and corrective actions.

3.2.d Participatory project implementation

- » *Forging agreements with partner governments and academic institutions.* This involves several meetings with key local government officials, NGOs and academic institutions to convey concerns for pursuing rehabilitation and clarification of property rights and roles that the community will play in rehabilitation. Eventually, an agreement (e.g. Memorandum of Agreement or resolution) with important stakeholders (particularly local community) could be sought to ensure provisions of sustained support or commitment to rehabilitation.
- » *Community organization (CO) and strengthening communications.* COs should immerse themselves in the local partner community to gain an in-depth understanding of local needs, strengths and opportunities. Once COs have a thorough feel for these aspects, they can conduct capacity building activities such as People's Organization (PO) formation, leadership training, and livelihood training. One of the major goals of these activities is to increase local awareness/knowledge about the importance of mangrove conservation, and how such endeavours will uplift their general well-being. Cross-site visits, hands-on training on mangrove ecology, nursery management, and site monitoring can be made available to the local community to further equip them with necessary technical knowledge.

- » *Community mobilization.* The local community should be mobilized in conducting their project planning, implementation, and monitoring and evaluation. In some cases, organized communities are tapped as partners in government mangrove planting projects, thus providing additional income source.
- » *Mainstreaming rehabilitation strategies.* Memoranda, partnerships and other forms of agreements on mangrove rehabilitation should be further elevated into local government resolutions or ordinances to incorporate rehabilitation in community-led local development plans.

3.2.e Participatory monitoring and evaluation.

Monitoring project progress, vis-à-vis satisfaction of objectives and targets by the local community and partner institutions, is vital to elicit measures to keep the project on track. Mutual sharing of information is an effective way of promoting transparency and commitments.

3.3 Suitability of the proposed mangrove rehabilitation guidelines: Case studies in the Philippines and Myanmar

In the Philippines, three case studies were completed to assess the applicability of the mangrove rehabilitation guidelines. These included: 1) Katunggan Ecopark at Leganes, Iloilo (a joint scheme of local community,



FIGURE 3. The Philippine Research Team with stakeholders at Katunggan Ecopark at Leganes, Iloilo.



FIGURE 4. The Philippine Research Team with stakeholders at Barotac Nuevo, Iloilo.

local government unit (LGU) and a Non-Governmental Organization viz., the Zoological Society of London (ZSL); 2) Taklong Island Marine Reserve in Guimaras Province (Scheme: local community in partnership with the Department of Environment and Natural Resources, or DENR); and 3) Jalaud Mangrove Rehabilitation in Barotac Nuevo, Iloilo (Scheme: local community in partnership with the Iloilo State College of Fisheries).

As a background, rehabilitation project in Leganes in Iloilo started in 2009. It began with the initiative of the ZSL. In Taklong Island Marine Reserve (TINMAR) rehabilitation was led by the DENR in response to an oil spill disaster in 2006 and as a component of the National Greening Programme (NGP) in 2011. Lastly, rehabilitation efforts in typhoon-damaged fishponds of Barotac, Nuevo, Iloilo started in 2013 as part of the national aquasilviculture programme of the Bureau of Fisheries and Aquatic Resources (DA-BFAR). Photos of these sites during field data collection of the Research Team are presented in Figures 3 and 4.

In Myanmar, the Myeik Forest Department organized the Taw HtwinGyi Community Forestry in 2016 to initiate community-based mangrove rehabilitation efforts in Myeik Township, Tanintharyi Region.

Results of the case study showed that before the establishment of Community Forestry, mangroves were cleared for urban expansion and agriculture. The lack of community ownership or tenure rights over mangrove areas was noted as the major challenge in promoting mangrove conservation. Mangrove rehabilitation was mentioned as an offshoot of the community forestry programme in partnership with local people, Myeik Forest Department officials, and NGOs namely, Myanmar Green Network (MGN) and Flora and Fauna International (FFI).

Table 2 summarizes the key activities and practices in view of the proposed mangrove rehabilitation framework. Results showed that rehabilitation was unlikely to succeed if people were excluded from the planning and monitoring process or, alternatively, were involved solely in the capacity as implementers of top-down decisions, an approach which was widespread until recently. Thus, wholehearted and committed participation of local communities is a prerequisite for successful rehabilitation, and this participation can be secured by actively involving people in the planning and monitoring process. It was also evident that mangrove species differed with respect to their adaptation to salinity and flooding and had a narrow range of tolerance in the establishment phase. There is an urgent need for enhancing silvicultural knowledge of mangroves, an aspect neglected in the past, to increase the effectiveness and efficiency of rehabilitation. These conclusions are

Steps in mangrove rehabilitation	Philippines case studies			Myanmar case study
	Katunggan Ecopark at Leganes, Iloilo	Taklong Island Marine Reserve (TINMAR), Guimaras	Barotac, Nuevo, Iloilo	
Local site coordination	ZSL initiated consultations with the LGU of Leganes. Consent was then secured from Barangay Nabitasan and Guaa represented by the Barangay captains in the form of a formal Memorandum of Agreement in 2009.	Under DENR-NGP, local site coordination was done by the stakeholders within the two barangays, namely Lapaz and San Roque within TINMAR. Local people organizations were tapped as direct collaborators of NGP. Following a series of consultations and meetings with the POs were conducted.	Orientation was conducted before project implementation. The LGU was in-charge of the coordination while the Iloilo State College of Fisheries (ISCOF) provided training through funding from the Bureau of Fisheries and Aquatic Resources (BFAR) with the fisherfolks as direct beneficiaries.	Myeik Forest Department officials facilitated the consultation and coordinated activities with communities using the funding assistance of NGOs. The community decided to establish community forestry to protect the remaining natural mangroves and to rehabilitate the depleted areas.
Comprehensive site assessment	At the start of the project, the needs and interests of the communities were not assessed, nor their understanding of mangrove ecosystems. Thus, the community members did not feel any form of ownership. This was one of the reasons why the people were organised into an association relatively late in the project because the LGU did not see the enthusiasm in the local people to participate in the project until the mangrove forest was starting to grow back.	TPOs were not in site assessment. Rapid assessment in response to the oil spill was only initiated by the technical staff of PENRO Guimaras, but hydrology patterns, slope and topography in the area were not considered. Under the DENR-NGP, different institutions were considered, such as the National Mapping and Resource Information Authority (NAMRIA) for the land use survey, mapping and zoning. The University of the Philippines Visayas was also tapped to do the socioeconomic and demographic survey.	There was no inspection on the condition of mangroves before the rehabilitation, although socio-economic surveys were performed by the academe in the community. The members of the PO, on the other hand, had many ways to assess if the site was appropriate for planting, one of which was when the fruit has already fallen.	Forest Department organised the site assessment team which includes the Taw HtwinGyi community forestry management committee members, representatives from MGN and FFI. However, the team did not involve scientists such as marine biologists or zoologists.
Participatory mangrove rehabilitation planning	Key problems and underlying causes that contributed to mangrove deforestation were not discussed among interest groups. Activities were planned by LGU and ZSL and implemented by the community.	POs within TINMAR were not involved in the planning process. During site selection and setting of targets, community members were informed through several FGDs.	PO was involved in the planning process.	MGN and FFI facilitated the participatory development of the management plan for the Taw HtwinGyi Community Forestry. The management plan was developed by the management committee.
Participatory project implementation	From 2009 to 2013, rehabilitation efforts involved more than a thousand volunteers and planted almost 60,000 seedlings in the site. However, it was only during the stage implementation when the community members realised the benefits that could augment their livelihood through tourism, food catering and recreation.	POs were directly involved in the implementation process from nursery management, planting and mangrove monitoring. Meetings for updating and regular sharing of information were conducted. Technical training was also conducted, such as hands-on training on GPS reading, tagging, bagging, identification of seeds, nursery management, and mangrove pest diseases prevention and control.	Meetings were held once a month wherein the process of seedling production and planting were among the topics discussed. Capacity-building activities were conducted as part of the project's implementation.	Forest Department provided two training activities on nursery management and seedling production. Aside from the technical support, training and facilitation were also provided by the FFI, MGN and as well the Forest Department.
Participatory monitoring and evaluation	PO participates in the monitoring and evaluation of seedlings planted, primarily to assess if replacement planting is needed. However, they do not have a monitoring and evaluation plan. The project was deemed successful since it has brought back the mangrove.	Both POs in TINMAR were trained on how to assess the health of mangroves planted under the NGP project. Thus, they also participated in monitoring. Part of this activity is the replacement or replanting of dead seedlings.	PO members were given the task of monitoring the site, while the LGU conducts weekly visits. Likewise, BFAR conducts monitoring, although rarely.	Taw HtwinGyi community has organised an internal audit team following the Community Forestry Instructions. The audit team not only audits financial matters but also monitors and assessed the activities of the community. However, they do not have a systematic framework for monitoring and evaluation.

TABLE 2. Testing the applicability of proposed mangrove rehabilitation guidelines in the Philippines and Myanmar.

corroborated by the reports of Walters (2004), Samson and Rollon (2008), Primavera and Esteban (2008), and Thompson, Clubbe, Primavera, Curnick, and Koldewey (2014).

4. CONCLUSION

Mangrove rehabilitation should be understood as an inherently slow, expensive, complex and uncertain process. Rehabilitation demands: 1) integrated and ecosystem-based approaches taking into account feedbacks between rehabilitation, other land/aquatic resource uses, and non-land/ocean-based economic activities; 2) widening the scope of rehabilitation beyond merely planting; 3) participation of local people in planning and monitoring in addition to implementation; 4) clarity in the roles and responsibilities of different stakeholders; and 5) selection of plantation species based on ecological and silvicultural knowledge in conjunction with the needs and priorities identified by the stakeholders. In summary, ensuring sustainable and effective mangrove rehabilitation, active collaboration among government, non-government organizations, funding agencies, and research institutions and, most importantly, by local communities is vital.

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REFERENCES

Aksornkoae, S., & Kato, S. (2011). Mangroves for the people and environmental conservation in Asia. *Bulletin of the Society of Sea Water Science, Japan.*, 65 (1), 3–9.

Food and Agriculture Organization of the United Nations. (2015). *Global forest resources assessment 2015: Desk reference*. Rome: Food and Agriculture Organization of the United Nations.

Garcia, K., Malabrigo, P., & Gevaña, D. (2014). Philippines' mangrove ecosystem: status, threats and conservation. In *Mangrove Ecosystems of Asia* (pp. 81–94). New York: Springer.

Gevaña, D., Camacho, L., & Pulhin, J. (2018). Conserving mangroves for their blue carbon: Insights and prospects for community-based mangrove management in Southeast Asia. In Makowski C., Finkl C. (Eds.), *Threats to Mangrove Forests* (pp. 579–588). Springer Nature.

Gevaña, D., Pulhin, J., & Tapia, M. (2019). Fostering climate change mitigation through a community-based

approach: Carbon stock potential of community-managed mangroves in the Philippines. In Krishnamurthy, Jonathan, Srinivasalu, Glaeser (Eds.), *Coastal Management: Global Challenges and Innovations* (pp. 271–282). Elsevier.

Giesen, W., & Wulffraat, S. (1998). Indonesian mangroves, part 1: Plant diversity and vegetation. *Tropical Biodiversity*, 5(2), 11–23.

Kathiresan, K., & Bingham, B. (2001). Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology*, 40, 81–251.

López-Portillo, J., Lewis III, R., Saenger, P., Rovai, A., Koedman, N., Dahdouh-Guebas, F., ... & Rivera-Monroy, V. (2017). Mangrove forest restoration and rehabilitation. In VH Rivera-Monroy, S Yip Lee, E Kristensen & RR Twilley (eds). *Mangrove ecosystems: a global biogeographic perspective*. (pp. 301– 345). Springer, Switzerland.

Primavera, J., & Esteban, J. (2008). A review of mangrove rehabilitation in the Philippines: Successes, failures and future prospects. *Wetlands Ecology and Management*, 16 (3), 173–253.

Primavera, J., Savaris, J., Bajoyo, B., Coching, J., Curnick, D., Golbeque, R., ... & Koldewey, H. (2012). Manual on community-based mangrove rehabilitation. *Mangrove Manual Series*, 1. London: Zoological Society of London.

Pulhin, J., Gevaña, D., & Pulhin, F. (2017). Community-based mangrove management in the Philippines: Experience and challenges in the context of changing climate. In R. DasGupta, & R. Shaw (Eds.), *Participatory Mangrove Management in a Changing Climate* (pp. 247–262). Springer, Tokyo.

Samson, M., & Rollon, R. (2008). Growth performance of planted mangroves in the Philippines: Revisiting forest management strategies. *AMBIO: A Journal of the Human Environment*, 37(4), 234–240.

Snedaker, S. (1984). The mangroves of Asia and Oceania: Status and research planning. *Proceedings of the Asian Mangrove Symposium*. 5–15.

Thompson, B., Clubbe, C., Primavera, J., Curnick, D., & Koldewey, H. (2014). Locally assessing the economic viability of blue carbon: A case study from Panay Island, the Philippines. *Ecosystem Services*, 8, 128–140.

Tomlinson, P. (1986). *The Botany of Mangroves*. Cambridge University Press.

Walters, B. (2004). Local management of mangrove forests in the Philippines: Successful conservation or efficient resource exploitation. *Human Ecology*, 32 (2), 177–195.