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Systematic review on the implementation of mangrove community-based restoration in Indonesia and beyond

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Abstract. World's mangroves are decreasing, and the remaining are continuously at risk, so restoration seen as one of key strategies in the mangrove management. Mangrove ecosystems are ecologically important for coastal life, as well as play a key role for the livelihood and food security that put coastal community as important actor in the mangrove restoration efforts, including in Indonesia. This study aims to understand the current practices and lesson learned from the implementation of community-based mangrove restoration (CBMR). We used a combination of systematic review and co-learning workshops to identify relevant case studies, interventions, and outcomes from the implementation CBMR. We selected 71 relevant case studies from nine countries and ran a Principal Component Analysis (PCA). We identified four group of intervention implemented in the case studies, those are active restoration (include replanting), passive restoration (focus on protection and depend on natural regeneration), model business development and strengthening the community institution. Case studies analysis suggested that combination of four type of interventions helps to achieve both aims of CBMR which are restored mangrove and improved livelihood.

1. Introduction

Mangroves are part of wetland ecosystem in the coastal area and provide various ecosystem services for environment and people (Brander *et al.,* 2012). Mangrove ecosystems are located at the intertidal zones and serve as a buffer zone between land and sea [1] which plays important roles for coastal protection against natural hazard and disaster as well as maintaining water quality from pollution such as metal sedimentation and microplastics [1], and [2]. Mangroves also present to support biodiversity habitat, especially as feeding, spawning and nursery ground of marine and other wildlife species [3]. Related to climate change mitigation, mangrove forest is important not only for adaptation to the impact e.g., protect coastal community from natural disaster, but also for mitigation as carbon stocks in mangrove is estimated to be 3 times higher than terrestrial forest ecosystem [4], [5], and [6].

World's mangroves are distributed in 124 countries and in 2020 the mangrove covers 14.7-million-hectare area in which 40% is in Asia, especially Southeast Asia, while 20% global mangrove is in

Indonesia [7]. Although the global mangrove loss is mostly occurred in 90's and decreasing by time, however, mangroves are continuously at risk [8]. Two main driver and threat for mangrove ecosystems are identified, the human activities majority due to conversion to aquaculture, agriculture, and infrastructure, and destruction to natural events that mostly due to climate change [9] and [10]. In Southeast Asia, main drivers of mangrove loss are anthropogenic while half of the lost is associated with marine and agriculture commodity production [11], while in Indonesia the identified key drivers are land conversion (37%), aquaculture (36%), agriculture (22%) and infrastructure (23%) [12].

There is already global awareness on the importance of mangroves and mangrove management has been priority by international and regional government [13]. Although in the last 10, the anthropogenic pressure can be reduced, however, restoration efforts still need to be done along with conservation efforts because there are no more remaining mangroves so the efforts to increase and maintain the world's mangrove area [9,] [10], and [11]. Since mangrove ecosystem existence and loss associated with livelihood and daily life of coastal community, it is critical to involve community in the mangrove restoration activities. Unsustainable livelihood can cause environmental destruction; however, the environmental sustainability cannot be achieved if neglecting the community welfare [14]. Action from actor has direct influence towards environmental sustainability [14], and the mangrove restoration should involve the role of coastal community. A study on the global world's mangrove initiative shows that small initiatives by community, with area less than 100 ha has also success potential compared to large scale initiatives [15]. Whilst implementation of mangrove restoration is quite challenging due to strong influence of environmental factors [13], [16], and [17], however, mangrove restoration initiatives often failed due to social factors [18], [19], and [20].

This study aims to understand the current practices and lesson learned from the implementation of community-based mangrove restoration (CBMR) in Indonesia and beyond. We define here CBMR as a mangrove restoration approach that involve community as main actor and aims to restoring ecological function of mangrove ecosystem as well as improving socio-economic benefit for community. A main research questions is to determine what the ideal activities for CBMR intervention towards achievement of both ecological and socio-economic outcomes.

2. Methods: Data collection, case studies selection, and analysis

We collected relevant case studies of CBMR through systematic review and co-learning workshops. Systematic review defines as structured and pre-defined processes for evidence-based data collection [21], while co-learning described as process where multiple stakeholders gather with different knowledge, experiences, perspectives, values, and capacities, then engage in dialogue, critical reflection to understand predefined issues [22]. Co-learning processes is also important for reflection phase in the participatory approach, to facilitate problem understanding and co-production of potential solution [22], [23].

The first step was by search and analyse news articles from online media in Indonesia with aims to identify existing CBMR in Indonesia, as well as stakeholder mapping for the co-learning workshops. We searched relevant news articles from 15 national digital media outlets with highest traffic rank at the time of analysis with applying systematic keywords and selection criterias. The relevant articles were captured using NCapture software from the media website, and the analysed using NVivo. The search resulted in 152 news articles in Bahasa Indonesia and the content analysis resulted in 60 relevant case studies of CBMR. During this first step, we identify location, addressed issues, intervention, business model and actor involved in the CBMR initiatives. After that, we implemented three co-learning workshops to provide platforms for community-based mangrove restoration initiators or practitioners in Indonesia to share lessons learned. We invited Indonesian stakeholders identified in the news article search.

In parallel with above processes, we conducted search and analysis to peer reviewed articles (e.g., journal articles) and grey literature to capture more relevant case studies from Indonesia and beyond. There are three literature search processes. First journal article search is using manual search by entering 58 combinations of relevant keywords at Web of Science database. Second search is using Boolean Search Query produced by Colandr software. The search resulted in additional 2053 articles after duplication sorting. We conducted abstract screening to 6456 articles using Colandr and resulted

in 140 relevant articles. Third search is by Google Search Engine using keywords and found 127 relevant grey literatures. We analysed the full text of 140 journal articles and 127 relevant grey literatures for further analysis using NVivo software. In total, there are 25 relevant case studies from co-learning workshops and 80 case studies from systematic review of journal articles and grey literatures. However, only 71 case studies selected for in-depth analysis on the lesson learned due to data availability about the cases and selection criteria that the initiative in the case study should put community as main actor in restoration and has two outcomes of ecological mangrove restoration and community welfare. We identified type of intervention and outcomes of CBMR from these 71 case studies. Then case studies were assessed using Likert scoring and statistically analysed by applying Principal Component Analysis (PCA) method with R Studio to extract further lesson learned.

3. Results and findings

3.1. CBMR case studies in Indonesia and beyond

From 71 selected case studies, 69% is from Indonesia, while 21% from other countries in Southeast Asia (e.g., Philippines, Thailand, and Vietnam). The rest 10% is cases from other countries e.g., India, Ecuador, Ghana, Srilanka). Various approach applied by the cases for CBMR but most of cases (32%) adapted co-management as the main approach, other approach and business model developed for the CBMR are mangrove planting, ecotourism, social forestry, aquaculture, and fishery, as well as Payment for Ecosystem Services (PES). Lot of cases were initiate by independent initiatives by community (32%), but CSO and NGO identified as main actors that support implementation of CBMR identified in 39% of cases, follows by government (21%). Some cases are initiated by research institution or university, and private sector.

3.2. Type of CBMR interventions and outcomes

The analysis to 71 case studies suggested two main outcomes of CBMR: 1) Restored mangroves, and 2) Improved community welfare. We identified restored mangroves as biophysical outcomes of CBMR and improved community welfare as socio-economy outcomes. According to content analysis, there were 3 main indicators of biophysical outcomes, those are: 1) Improved biomass and carbon stocks; 2) Improved water and soil quality; and 3) Enhanced biodiversity. For the socio-economic outcomes, the main indicator is increased community income.

Towards two outcomes, we identified four types of intervention in CBMR implemented in the case studies: 1) Active restoration; 2) Passive restoration; 3) Business model development; 4) Strengthen community institution. Active restoration is defined as restoration action that focusing on the advancement of ecological restoration, and we identified four types of activities implemented: 1) Participative planning; 2) Participative action, including mangrove planting; 3) Participative monitoring; and 4) Enrichment planting. The focus of passive restoration focus is more to support natural regeneration such as by protection or conservation actions, and we identified three main approaches implemented: 1) Law enforcement; 2) Implementation of PES scheme; and 3) Monitoring for protection. The third type of intervention are community-based model business development that consists of: 1) Development of business plan; 2) Business implementation, 3) Marketing, and 4) Product diversification. Strengthen community institution is identified as important intervention and the form of activities such as 1) Community group establishment; 2) Obtaining legality for community group; and 3) Capacity Building.

3.3. Case studies assessment: consistency of intervention implementation and potential achievement of the outcomes

Our assessment shows that participative action (e.g., seedling production, mangrove planting, maintenance) is the most frequent active restoration activity implemented in the case studies with 87.33% of studied cases scored high consistency. However, most of the planting were not preceded by planning nor followed by monitoring or enrichment planting. These supporting activities have been proved to be crucial to ensure the sustainability and success of mangrove restoration and rehabilitation projects. Planning allows for setting and alignment of objectives and goals, selection of appropriate

site, species, and method according to biophysical and socioeconomic factors, as well as decision on managing institutional and funding requirements. Monitoring program can also be planned since the beginning of the projects. Observational monitoring of key indicators is necessary to evaluate success and failures of implementation and changing conditions and circumstances, fostering adaptive management and decision-making [24] and [25].

Among 71 cases studied, passive restoration activities were mostly done with law enforcement, including creating formal regulations such as village regulation. However, only a little over a quarter of the studied cases shows consistent implementation in this activity, mainly due to no supporting institution or limited institutional capacities to enforce the regulation effectively. The greater number of informal community groups involved in the mangrove restoration and rehabilitation projects, with only 35.21% of studied cases scored consistent implementation of group legality, and the lack of institutional capacity building programs for the community groups might have contributed to this condition. Successful community-based mangrove restoration and rehabilitation depends on the social capital of the community, necessitating a high level of community involvement and support as well as institutional strength [25] and [26]. Lack of enforcement of existing regulation is often stated as a major reason for failed mangrove restoration and rehabilitation projects. This challenge might root from failure in considering inter-actor relations and power dynamics, which subsequently influence decision-making process [25] and [27].

Similar with mangrove planting, community-based business in mangrove restoration and rehabilitation is mostly implemented without documented planning and further analysis such as marketing activity. Only few studies has product diversification as part of intervention. Some of the challenges often faced by community-based businesses are capital modal, human resources, and market access. These challenges can be overcome with capacity building, assistance, and partnership program [28], [29], and [30]. Furthermore, encouraging participation and empowering initiative of local community in every phase of business development is crucial to build trust and sense of ownership which is fundamental in ensuring the sustainability of community-based businesses [31].

For the biophysical outcomes, the most documented outcomes are the improved mangrove biomass and carbon stocks. There are 81.69% case shows consistent documentation and stated high success potential of this indicator. Lack of documentation for impact to water and soil quality as well as biodiversity in the selected study cases. This is relevant because mangrove cover is the main monitoring indicators of mangrove restoration efforts. For socio-economic outcomes, impact to community income is quite documented in the selected case studies. Around 47.89% case studies documented success on the achievement of the socio-economic impacts.

3.4. Results of Principal Component Analysis

We ran PCA to the assessment results to explore and analyse relation of each indicator and extract further lesson learned. Our PCA result accounts for 30.7% of variation in the data. We are plotting the loading scores for each case studies towards PC1 and PC2; then clustered the case studies (Figure 1). The analysis suggested four clusters with various common cluster (Table 1). In total 46 case studies included in four clusters, and 25 others are too scattered and put out of the four clusters as “other”. Around 38% cases are included in the first cluster, 20% in the second cluster, 4% in third, and 3% in fourth.

The common character of the first cluster that tends to have strong consistency on the implementation of active restoration intervention by “participative action” with strengthen the community institution intervention by “community group establishment” and “capacity building”. Cases in this cluster shows high potential of biophysical success by high average impact score in increased mangrove biomass and carbon stocks and fair impact to the increased of community income. The second cluster’s common characters are the consistent implementation of active restoration activities through “participative action”, whilst it resulted in fair impact in “increased biomass and carbon stocks”. The third clusters characterized by combining active restoration, passive restoration, business model development, and strengthen the community institution. The three cases included in this cluster has the most comprehensive intervention design and most successful achievement towards to main goals of CBMR. The cases implemented very consistent “participative action”, and consistent

"law enforcement", "business implementation", and "product diversification" that supported also with fairly consistent "community group development" and "capacity building". The third cluster shows very high impact for the "increased biomass and carbon stocks" as well as "improved quality of water and soil" whilst the impact for the community income is just fair. Cases in cluster four combined passive restoration by consistent "monitoring for protection" and consistent "group establishment". However, the cases in the fourth cluster shows no biophysical impact and low impact to community income.

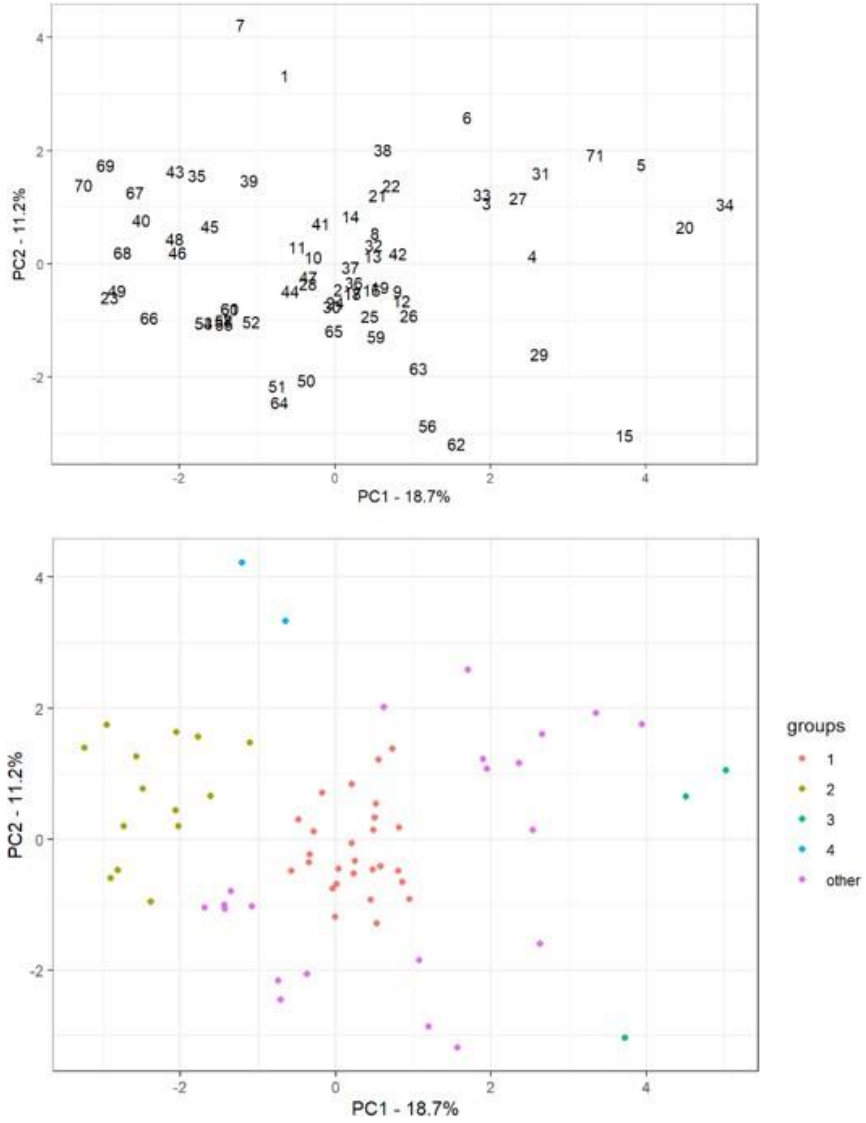

Figure 1. Upper: PCA loading plot for case studies; Bottom: Case studies clustering results

Table 1. Cluster of selected CBMR case studies

Cluster	Common interventions	Achievement of the outcomes
Cluster 1 (n=27, 38%)	• Combined **active restoration and strengthen community institution.** • Consistent implementation of activities: participative action, capacity building and	• High impact in increased mangrove biomass and carbon stocks. • Fair impact to community income.

Cluster	Common interventions	Achievement of the outcomes
	establishment of community group.	
Cluster 2 (n=14, 20%)	• Consistent **active restoration,** especially "participative action".	• Fair impact in increased biomass and carbon stocks. • No impact to community income.
Cluster 3 (n=3, 40%)	• Combined **active restoration, passive restoration, business model development, and strengthen the community institution.** • Very consistent implementation of "participative action" activities. • Consistent implementation of "law enforcement", "business implementation", and "product diversification" activities. • Fairly consistent implementation of "community group development" and "capacity building" activities.	• Very high impact for the "increased biomass and carbon stocks" as well as "improved quality of water and soil". • Fair impact to community income.
Cluster 4 (n=2, 3%)	• Combined **passive restoration and strengthen community institution**. • Consistent implementation of "monitoring for protection" and "group establishment".	• No impact to "increased biomass and carbon stocks", "improved quality of water and soil", and "enhanced biodiversity". • Low impact to community impact.

4. Discussions

Improved ecological condition of mangrove ecosystem and community welfare is undoubtedly the common goal of almost all CBMR initiatives. Our study found that the best combination of intervention to achieve biophysics and socio-economic outcomes from CBMR are combining "active restoration" through participative action, "passive restoration" that focusing on protection by law enforcement, "community-based business model development" by implementation of business model and product diversification, and "strengthen community institution" by group establishment and capacity building.

This study emphasize participative approach is key of CBMR implementation. However, genuine participation of community often become a challenge for CBMR implementation, as stated also by previous studies in the Philippines, Myanmar, and Indonesia [32] and [33]. Community participation contingent to various factors, however, community tends to participate if they perceived that the activities is benefiting them [34]. Provision of socio-economic benefit has always been an obstacle from various CBMR implementation on the ground, as perception is diverse towards value of mangrove restoration. A study from Indonesia shows that most of community perceived benefit of mangrove restoration associated to direct benefit for their livelihood such as income [35]. Our analysis suggested that the increased mangrove cover may not automatically influence direct benefit for the community e.g., financial benefit or income, but more indirectly as follow up impact to biodiversity enhancement. It is demonstrated by a case study in Demak, West Java, Indonesia. It shows that increased mangrove cover influenced richness of fishery resources that bring more benefit for community that majority work as fisherman, and with capacity building to community to implemented sustainable fisheries, it resulted in increased income [36] and [37].

Providing "cash for work" (CFW) for community, especially for mangrove planting, has been seen as strategy to provide direct socio-economy benefit at CBMR initiatives. CFW defines as providing cash payments to community as labour contribution benefit of the programme, and CFW has widely use especially for government programmes including with environmental outcomes [38], for example implemented by Government of Indonesia through National Economy Recovery Strategy (PEN), especially to keep economy resilience post COVID-19 pandemic, and various national reforestation programmes in the Philippines. CFW is effective strategy to mobilize participation of community in CBMR, however it cannot lead into sustainable livelihood [38].

This is relevant with a previous study that shows that provision of sustainable income for community is from creation of small business development such as ecotourism and selling mangrove NTFP products [39]. Therefore, the community-based business model is important as part of intervention, in related to support providing community alternative livelihood during CBMR implementation. Our findings suggested that development of business plan and product diversification is key activities to provide socio-economic benefit for community.

5. Conclusions and implications of the study

Results from this study provides an evidence-based lesson learned from existing CBMR activities that has same goals towards improving ecological and social stance of mangrove ecosystems. It is highlighted the importance of community-based business model development and strengthen community institution as part of interventions, especially to mobilize community and sustain the participatory approach in the CBMR. This study also suggested lesson learned that shows that both active restoration that focusing in advancing regeneration especially through replanting and passive restoration efforts that focusing on protection and ensure the natural regeneration e.g., by law enforcement is complementary and provide better outcomes if combined. Although intervention design will be contextual, however, the suggested best combination of activities that resulted in increase of mangrove biomass and community income are participative mangrove restoration with law enforcement, implementation of the community-based business that supported with strengthening community institution through group establishment, providing capacity building for community, and product diversification.

This study is part of reflection phase of participative action research (PAR) for community-based mangrove restoration and business model development in South Sumatra that is implemented by CIFOR-ICRAF and partners. Lesson learned from this study that supported with other science-based activities such as baseline studies, will provide important consideration for co-design the needed interventions with key stakeholders in the research location. Hopefully, the lesson learned will provide useful insights for CBMR project developers or initiators. This study also demonstrates more systematic ways to support reflection phase for PAR with utilizing evidence-based information.

6. Limitations

Main challenge in this study was the data availability that constrains us to run more advance scientific analysis. Although many relevant CBMR cases found, not all cases have complete documentation of activities and outcomes. The average data availability rate of CBMR indicators is 30.17% and our PCs in PCA only explained 30.07% of data variation. The PCA can be strengthen with better data analysis. This relevant with previous findings that suggested that lack of monitoring and documentation influence the biased success rate of mangrove restoration activities [64]. We tried to address this data availability issue through systematic scoring and co-learning workshops, so the synthesized lesson learned were validated among the key CBMR practicians in Indonesia.

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