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RESEARCH ARTICLE

Using a participatory impact assessment framework to evaluate a community-led mangrove and fisheries conservation approach in West Kalimantan, Indonesia

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Abstract

1. Community-based conservation has been identified as a solution to biodiversity loss, climate change and the reduction of rural poverty. The heterogeneity in social and economic inequalities often acts as a barrier to community engagement in resource management and further inhibits the distributional equity of social and ecological outcomes.
2. This study presents a participatory impact assessment (PIA) framework that evaluated the outcomes of a cross-sector community-led conservation initiative. Community members involved in the programme identified activities and outcomes for the conservation cooperative (CC), ranking the influence of the former on the latter as well as their daily life through multiple focus group discussions (FGDs). Participants were asked to rank the impact of activities on outcomes and the scale of the outcome which was totalled to identify the most impactful programme activities and outcomes during the project period.
3. Community members reported improved income, health, education and the creation of a locally led natural resource management system. Members also reported improved crab harvest rates and reduced mangrove deforestation. Environmental outcomes identified by community members through the PIA were verified through a secondary spatial analysis and mud crab independent fisheries monitoring.
4. The results support the hypothesis that environmental non-governmental organizations (NGOs) need to consider a multi-dimensional view of human well-being, and that cross-sector integrated interventions may be effective at improving multiple outcomes.
5. Future steps should focus on spatial replication of the CC programme which will provide further insights by testing for differences in outcomes between villages, how those are impacted by pre-existing social and ecological systems and comparing outcomes between control sites that did not receive interventions.

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KEYWORDS
community-based conservation, impact evaluation, mangroves, mud crabs, participatory methods

1 | INTRODUCTION

The question of how to reconcile human development with conservation has emerged as a key global issue in response to the costs associated with conservation interventions on local communities (Cardinale et al., 2012; Diaz, Fargione, Chapin, & Tilman, 2006; Ehrlich, 1988; Worm et al., 2006), and the dependence of vulnerable groups on biodiverse ecosystems (Coad, Campbell, Miles, & Humphries, 2008; Coulthard, Johnson, & McGregor, 2011; West, Igoe, & Brockington, 2006). The marginalization of local resource users is a known driver of biodiversity loss as communities often resort to the exploitation of natural resources to overcome socio-economic hardships (Naughton-Treves, Holland, & Brandon, 2005). The feedback loop between biodiversity loss and its impacts on local communities has sparked global calls for community-based interventions that integrate biodiversity conservation with the improvement of human well-being (Borrini, Kothari, & Oviedo, 2004; Cooney et al., 2017; De Souza, 2003; Kremen, Merenlender, & Murphy, 1994; Torell et al., 2012; Woodhouse et al., 2015; Yavinsky, Lamere, Patterson, & Bremner, 2015). It is important for community-based approaches to carefully consider the heterogeneity within communities and how synergies, trade-offs and distributional equity of social impacts may vary given cross-sector interventions attempting to achieve multiple outcomes (Daw, Brown, Rosendo, & Pomeroy, 2011; Fox, Mascia, Basurto, Costa, & Glew, 2012; Gill et al., 2019). The heterogeneity in both pre-existing inequalities *and* the distribution of programme outcomes across resource users may inhibit local engagement in community-based conservation (Gill et al., 2019; Persha, Agrawal, & Chhatre, 2011; Singleton et al., 2019).

Long-term solutions to conservation issues need the participation of local communities in order to achieve social and environmental outcomes (Kremen et al., 1994). Although these grassroots interventions are critical for efforts to halt biodiversity loss (Allison & Ellis, 2001), studies evaluating community-based approaches are scarce due to the difficulties of achieving multiple outcomes towards conservation and improved human well-being (Adams et al., 2004; Borrini et al., 2004; Daw et al., 2016; Gill et al., 2019; Kremen et al., 1994). Due to the complex and context-specific social, economic and ecological systems, evaluation of causal pathways between cross-sector interventions and their outcomes is challenging (Adams et al., 2004; Borrini et al., 2004). Furthermore, calls have been made to move beyond mono-consequential assessments evaluating the influence of an intervention on individual outcomes, to methods that evaluate variation and distribution of equity and social impacts given the heterogeneity within communities (Gill et al., 2019).

Improvements to community-level interventions can be made by accounting for human well-being, institutional fit and appropriate local context while also altering existing livelihoods to be environmentally sustainable as opposed to complete transformation (Allison & Ellis, 2001; Ancrenaz, Dabek, & O'Neil, 2007; Berkes, Colding, & Folke, 2008; Borrini et al., 2018; Woodhouse et al., 2015). This can further enable the consideration of complex, locally specific, societal and environmental relationships (Ancrenaz et al., 2007; Oldekop et al., 2015). Calls have been made for community-based interventions that include the involvement of local resource users in the decision-making process, support the development of community-based governance and improve the capacity for users to participate in the implementation and monitoring of natural resource management (Brooks, Waylen, & Mulder, 2012; Oldekop, Holmes, Harris, & Evans, 2016).

Programmes may be initiated by an external organization, but long-term change depends on supporting community systems that are locally self-sustaining and adaptable once external support resides (Ancrenaz et al., 2007). Including community members in a participatory manner through all steps of the natural resource management process from design, to implementation, to exit strategy is essential to produce a sense of ownership and strong community-led governance post-intervention (Woodhouse et al., 2015).

Studies have also underlined the importance of using participatory processes to measure the impact of conservation interventions at the local level (Leeuw & Vaessen, 2009; Woodhouse et al., 2015). For example, a participatory impact assessment (PIA) is based upon the recognition that programme beneficiaries and local communities are central to identifying and measuring their own indicators of change and outcomes. Rakotomahazo et al. (2019) used a participatory approach to design a mangrove conservation programme in Madagascar and found that these methods were useful in the context of planning for community-led management of mangroves. These processes can lead to the maximal use of local knowledge, generating valuable insights into the drivers of biodiversity loss and spatial distribution of resource use in regions where data are often scarce (Rakotomahazo et al., 2019). Other studies have found that mapping species distributions, evaluating land use and even estimating wildlife densities can be done accurately and efficiently through participatory approaches with local communities (Brown, 2012; Cox, Morse, Anderson, & Marzen, 2014; van der Hoeven, de Boer, & Prins, 2004; Vergara-Asenjo, Sharma, & Potvin, 2015). This highlights how community involvement in determination of a project influences outcomes to improve livelihoods and conservation of the environment. These types of processes and community-level interventions offer promising opportunities for communities highly dependent on natural resources.

Coastal communities who depend on small-scale fisheries for food and income are prime candidates for these community-level interventions and participatory designs due to their geographically

isolated nature and their direct dependence on their surrounding ecosystems (Béné & Friend, 2011; McGoodwin, 2001). Although small-scale fisheries contribute to around half of global fish catches and employ nearly 95% of the world's fish-workers, many of these communities suffer from low income and have limited access to basic services such as healthcare (Béné & Friend, 2011; McGoodwin, 2001; Needham & Funge-Smith, 2015; Pomeroy & Andrew, 2011; Singleton et al., 2019). Community-led small-scale fisheries reform to improve food security, gender equity and economic development that can be achieved through a marine management plan that incorporates multiple use of areas by managing anthropogenic impacts (McGoodwin, 2001; Mills et al., 2011).

Strategies focused on limiting human activities is globally recognized as an effective management and conservation tool, but the ability of these strategies to achieve both conservation and socio-economic outcomes is often criticised (Butchart et al., 2012; Clark, Boakes, McGowan, Mace, & Fuller, 2013; Laurance et al., 2012). Attempts to halt the destruction of these ecosystems by removing local access for resource users have been made, but these methods are often ineffective and unethical (Adams et al., 2004; Borrini et al., 2004; Cernea & Schmidt-Soltau, 2006). In contrast, management plans utilizing a multiple-use design that are managed in part by local communities show improved long-term conservation outcomes (Brooks et al., 2012; Naughton-Treves et al., 2005; Nelson & Chomitz, 2011).

However, recent studies have called for conservation studies to move beyond evaluating win–win, lose–lose, or win–lose trade-offs between social and conservation outcomes (Daw et al., 2016; Gjertsen, 2005; Persha et al., 2011) and embrace more complex domains of scale, time and space representing the existing heterogeneity in social systems (Persha et al., 2011). Human well-being comprises multiple domains (e.g. economic, cultural, health) and it is possible for individuals to experience positive and negative outcomes across these domains differently, given various conservation interventions (Daw et al., 2016; Gill et al., 2019; Woodhouse et al., 2015).

This study presents a PIA framework that evaluates the outcomes of community-led interventions to manage a mud crab fishery, conserve mangrove forests and improve human well-being (as defined by Woodhouse et al., 2015). This study attempted to move beyond a mono-consequential assessment of impact and consider the synergies and trade-offs, given the heterogeneity of impact of cross-sector interventions (see Gill et al., 2019). Specifically, our study presents the results of the PIA framework in evaluating a community-led intervention that was implemented in the village of Sungai Nibung in West Kalimantan, Indonesia.

2 | METHODS

2.1 | Study area

The study area includes 3,058 ha of mangrove forest (SK. 3883/Menlhk-PSKL/PKPS/PSL.0.7.2017) managed by the village of Sungai Nibung in the Kubu Raya Regency of West Kalimantan, Indonesia. The village is located in a remote area with no access to government provided electricity or clean water and is currently only accessible by boat. More than 90% of the village's primary livelihood is dependent directly (e.g. fishermen) or indirectly (e.g. selling fishing gear, making products from fish bycatch) upon the local fishery. The other 10% is a mixture of shop owners selling basic goods and semi-migrant farmers. The total population is 1,745 individuals across 401 households. The highest education provided within the village is elementary school. Students wishing to attend higher levels of education must attend middle school and high school in neighbouring villages, also only accessible by boat. There is one government health clinic that has one staff member. Unfortunately, the government has not provided medicine or equipment and the clinic remains empty. The village of Sungai Nibung successfully gained tenure of 3,058 ha of mangroves through the Indonesian Government's Social Forestry ('Perhutanan Social') scheme in 2017. Prior to this, the surrounding forest status was a protection forest ('hutan lindung') and managed by the Department of Forestry. The village, as a requirement of the social forestry scheme, has a Forest Management Unit ('Lembaga Pengelolaan Hutan Desa') and is charged with annual work plans and reports to the Department of Forestry on activities in and around the 3,058 ha of mangroves (Figure 1).

2.2 | Programme overview

Planet Indonesia (PI) is an environmental grassroot non-governmental organization (NGO) located in West Kalimantan, Indonesia and the implementer of the programme evaluated in this study. The PI model provides community-based services to reduce socio-economic inequalities in rural communities while improving mangrove conservation and natural resource management practices. Our approach recognizes the hardship of rural poverty as a major barrier for coastal communities to engage in natural resource management. Our programme design looks to remove these barriers and create the conditions for community-led conservation. The PI model aims to enable communities undertake conservation and resource management while simultaneously addressing the underlying drivers that cause individuals to exploit natural resources.

The core element of our model is the creation of a conservation cooperative (CC), a community-led organization which engages in governance and conservation of coastal ecosystems. These CC's act as the platform through which biodiversity is conserved by targeting rural poverty and socio-economic inequalities which were identified as local drivers of degradation through focus group discussions (FGDs) prior to project design. CC's and their members take conservation action to protect forests, wildlife, and manage natural resources while acting as a mechanism to improve livelihoods, access to healthcare and education within villages. The CC itself is also intended to improve inclusive governance at the community level, as CC's host monthly meetings, annual elections and serve as a local management authority. The CC approach was developed by listening and sourcing ideas from local communities that were engaged in exploitative activities.

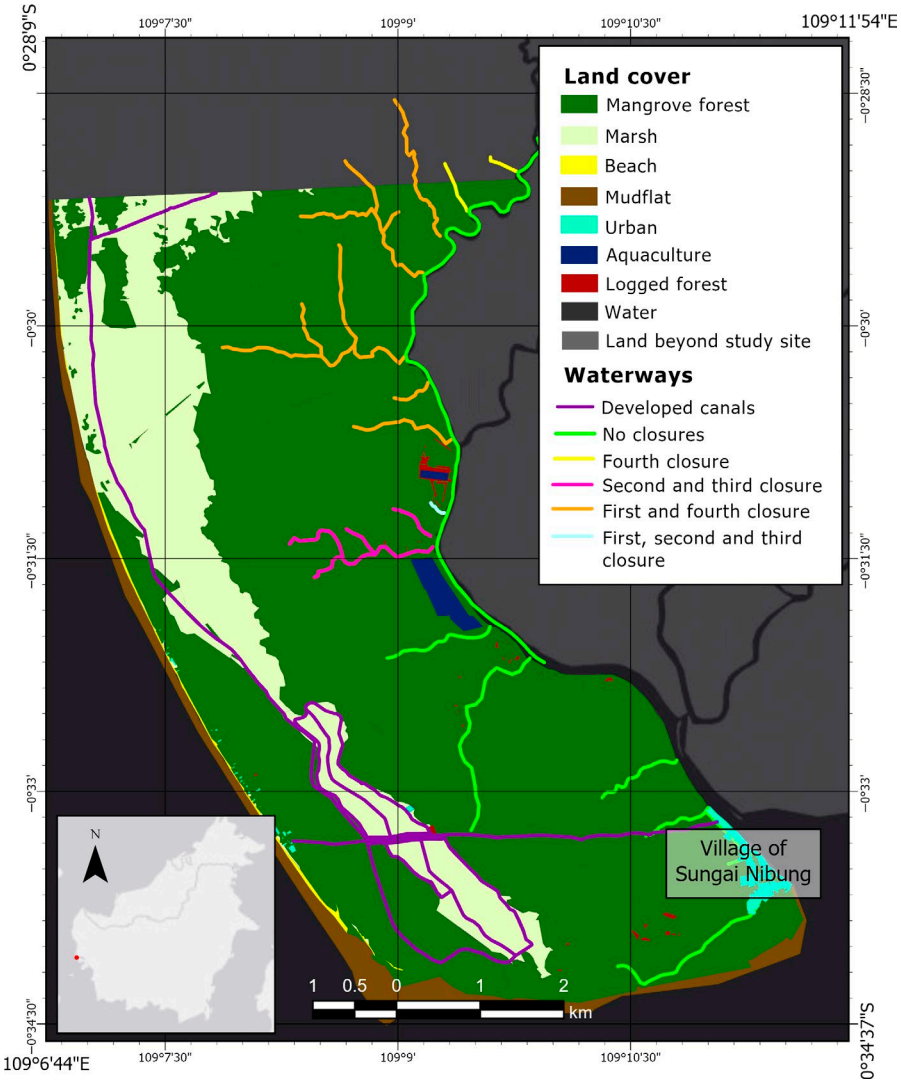

FIGURE 1 The land use in Sungai Nibung. Inset is the island of Borneo with the red dot representing the study site. The settlement in the south-east of the study site is where the majority of the population of Sungai Nibung lives, in a dense village. There are a handful of other scattered buildings on the coast, where a smaller population exists. Waterways are highlighted to indicate which temporary marine closure they were involved in, the first being from November 2017 to January 2018, the second from April to July 2018, third from December 2018 to February 2019, and fourth from August 2019 to October 2019. Developed canals are waterways dug and maintained by the locals for transport. Within the study site the land is dominated by the primary mangrove forest followed by marsh, and is primarily used for housing, aquaculture farming and harvesting of wood from the mangrove forest. The village attains most of its sustenance from fisheries in open water and in the creeks of the forest

Specific community needs were sourced through community hearings, semi-structured FGDs, in May–July 2017. Community members were asked to identify issues they felt that influence social, economic and environmental dimensions of their day-to-day lives. Facilitation teams also asked for individuals to identify obstacles and barriers to their future. Semi-structured vision exercises were conducted to visualize conditions 15 years ago and 15 years in the future without fundamental changes made to social, economic and environmental dimensions. Three hearings were conducted, one with village leaders, one with only women, and one 'mixed' with community members. These community hearings were open with no participant limit as they were intended to facilitate and activate discussion early in programme design. Participants often came and left. The following five major issues were identified by local community members.

2.2.1 | Collapse in fish stocks and income

Communities detailed a collapse in fish, crab and shrimp populations that had directly led to reduced household income. This stemmed from lack of clear fishing grounds, inter- and intra-village conflict and high rates of migrant fishermen from other areas entering the fishing grounds. Mud crabs were highlighted as the most valuable commodity currently collapsing.

2.2.2 | Lack of access to government services

Due to the rural nature of the village, communities noted that access to education, health and other government services were almost non-existent. Issues in public health and education were noted repeatedly by community members. For villages that did have community health clinics and schools, many were not staffed or had been built by government agencies but then never staffed or equipped.

2.2.3 | Mangrove loss

Communities identified that illegal logging, aquaculture development and logging for firewood was a cause of conflict between and

within villages by resource users. Resource user rights were still unclear and despite Sungai Nibung having management of their forests restored through the Social Forestry scheme, outside users often illegally logged and cleared within their mangrove forest areas.

2.2.4 | Lack of 'bargaining power' and supply chain issues

Communities identified that they had no systems in place that allowed for fishermen or other producers to negotiate with middlemen on commodity prices. Many villagers noted the lack of communal structures (e.g. business groups or coops) and noted failed past attempts to develop fishermen cooperatives and social business schemes. This led to a dependency on middlemen who often dropped prices during peak seasons and exploited resource users and producers across the landscape.

2.2.5 | Lack of financial services and institutions

Communities also identified that many villages had no access to financial services (loans, savings, etc). However, the majority of villages that did felt they had been exploited by Credit Unions and Banking Schemes that often lured villagers into loan programmes with high interest rates. This caused a negative feedback loop that drove many individuals into logging and exploitative activities to repay their debts.

Thereafter, the services and interventions identified by these hearings were provided to the five pillars that underlie the CC. Based upon community identified solutions to challenges the five pillars that uphold the model are:

1. Community health: the People- Health -Environment (PHE) approach aims to improve community health through health advocacy and improve access to basic services (see Mayhew et al., 2020). The PHE approach is intended to remove the barrier of poor health that often limits community engagement in marine conservation (see Singleton et al., 2019).
2. Fisheries management: the programme strategy included temporary mangrove reserves (TMR) for 18 rivers in Sungai Nibung. This system periodically banned fishing and use of a fishing ground (river) for 3 months to improve catch rate and size of the target species, a management strategy that has worked elsewhere (see Goetze et al., 2018).
3. Education and Literacy: there is a lack of access to education in Sungai Nibung, three year-long literacy courses were made available to women and youth. Similar to PHE, the conservation tool education services were intended to remove barriers and create the enabling conditions that engage resource users in natural resource management.
4. Livelihood improvement: the CC approach provides training, start-up capital and access to a village savings and loan programme to improve economic resilience and secure livelihoods. Livelihood diversification and support is an important pillar to address the root causes of resource exploitation while supporting community engagement in marine conservation.
5. Mangrove protection: forest patrols made up of local community members and a local NGO staff enforced conservation agreements by monitoring for illegal or unsustainable activities.

2.3 | Participatory impact assessment

The PIA was adopted from the PRISM Conservation Evaluation toolkit (Dickson et al., 2017). The framework was adapted to include a nested ranking system to evaluate indirect changes identified by community members, changes that can be directly attributed to the project, and the impact these changes have made in people's lives. In addition, the PIA was designed to follow the nine principles presented in Woodhouse et al. (2015) and to evaluate the impact of conservation interventions on human well-being. The PIA method focused on project beneficiaries and hinges on basic knowledge of the project activities by the members of the FGD. Within the first step of the PIA FGD, members created an *activity list* based upon their knowledge of programme progress to date. They were then asked to score each of the activities for each of the following criteria.

1. The importance of an activity as a motivator to engage in the CC.
2. The importance of the activity for your daily life.
3. The time expended by the community in implementing this activity.

Scores were on a scale of one to four, where one is low importance/ labour and four is high importance/ labour.

The second step of the PIA was to create an *Influence Matrix* based upon the results and activities in step one. Activities from step one were discussed and facilitators asked community members if there were similar activities that could be combined. If members proposed combinations, similar activities were consolidated into large umbrella activities. FGD participants identified *changes* that have occurred in the community. These were then consolidated by participants into six areas of most significant change since the start of the programme in August 2017. Participants scored the level of influence of each activity on the observed change, with *0 = No Influence*, *1 = Weak Influence*, *2 = Moderate Influence and 3 = Strong Influence*. Results were discussed with all FGD participants to understand the reasoning behind rankings and the FGD decided upon the final scores.

The PIA was conducted twice, on two different FGD's—first with a mixture of men and women involved in the programme, and second with village leaders, cooperative leaders and important village figures. The first FGD was conducted with seven men and five women in May 2019. Programme participants were informed 3 days prior to the FGD and on the day of the FGD we capped the group at the first 12 individuals who arrived. We asked the

important figures to not join the first FGD to prevent leaders from dominating the discussion and over-rule community members in nested scoring. The second FGD was conducted in June 2019 and consisted of five men and two women, all important figures within the village. FGDs were not repeated with members of villagers who did not enroll in the CC; the PIA asked programme participants to reflect upon activities and outcomes not applicable to non-programme members. FGDs discussions lasted 3–4 hr with a lunch break included.

All respondents were told upon the start of the FGD the objective of the PIA and that the results would be shared with FGD members at the end of the session. We asked members to be truthful in their responses and informed individuals that their feedback would not harm the programme or individuals themselves, but would be used to improve the programme in future months. The methodology, process and intended use of the PIA was clearly explained to members before the FGD and all individuals were given a choice to voluntarily join if they were interested. Verbal consent was required by each individual before the start of the FGD. Throughout the FGD, participants were allowed to leave at any point and the facilitation team fully respected all rights and well-being of the participants. All names of members were kept confidential and individuals were given a chance to opt-out if they felt uncomfortable.

2.4 | Fisheries independent data

To add complementary data to support PIA findings and the success of the TMR to improve mud crab harvest, fisheries independent data were collected. Sampling occurred 7 days before the closure began in November 2018 and 7 days before the TMR rivers re-opened to fisheries in February 2019. A minimum of 20 crab pots were randomly deployed in each river. All three TMR rivers were sampled and effort was distributed across them to account for natural variation. The four rivers that were sampled as controls were immediately adjacent to the TMR rivers, two to the north and two to the south, to eliminate geographical variation as a factor. Mean carapace width of crabs in centimetres, number of crabs and number of pots were recorded. Catch per unit effort (CPUE) was calculated by dividing the number of crabs by the number of pots for each zone in each sampling period.

Mean carapace width and CPUE were compared between two zones (open and TMR rivers) in two sampling periods (November 2018, February 2019), for four total sampling units. Zones were compared against each other within each sampling period, and each zone was compared between sampling periods. All statistical tests were conducted in R studio (version 1.2.1335). The mean carapace width comparisons were conducted using two sample independent *t* tests, and when the assumption of normality was not satisfied, transformations were explored. If these did not satisfy this assumption, a Wilcoxon rank sum test with continuity correction was conducted. CPUE comparisons were conducted using a generalized linear model with a quasi Poisson distribution, where x values were discrete and represented the sampling unit.

2.5 | Mangrove forest cover and disturbance

To test that indicators of tree cover loss observed from the PIA had been achieved, a simple spatial analysis was conducted to detect the occurrence of mangrove clearing during the project period. We analysed tree cover data and mangrove forest coverage using data from the Global Forest Watch platform from the World Resource Institute (Hansen et al., 2013). To test for disturbance, tree cover loss within the 3,054-ha project area was analysed using Global Land Analysis and Discovery (GLAD) alerts and Terra Alerts (Hansen et al., 2013). There was a limitation to the Global Forest Watch platform at calculating fine-scale forest disturbance which therefore restricted our analysis to mangrove forests within the area using Global Mangrove Watch (v2.0, Bunting et al., 2018). We analyzed tree cover loss from intact forests (defined by having >75% canopy density) from 1 January 2001 to 31 December 2018, and GLAD alerts from 1 January 2015 to 30 April 2019. According to Global Forest Watch, tree cover is defined as all vegetation >5 m in height and may take the form of natural forests or plantations across a range of canopy densities. Tree cover loss is defined as 'stand replacement disturbance', or the complete removal of tree cover canopy at the Landsat pixel scale (30 m by 30 m). A GLAD alert is an observation of tree cover loss on a per pixel basis by a supervised learning algorithm, therefore one GLAD alert is equal to a tree cover loss of 30 m by 30 m (ref). The clear land surface observations in the satellite images were assembled and a supervised learning algorithm was applied to identify per pixel tree cover loss.

3 | RESULTS

3.1 | PIA with mixed community members

The community identified 11 core activities, of which all but the chip making training were identified as 'important' or 'very important' motivators to engage in the cooperative. All activities with the exception of training on TMRs were rated as 'important' or 'very important' for daily life (Table 1). The fish chip making training was the only activity not discussed in the Influence mapping.

The activities requiring the greatest time commitment from the community are the closure system, patrols and the meetings of the CC. There were no areas where the amount of labour expended was disproportionate to the importance given to the activities. Health services were an instrumental motivator for project engagement, very important for daily life and required limited community labour.

The mixed FGD identified six major outcomes of the programme, and compiled the activities into six interventions (Table 2).

TABLE 1 The activity list determined by the focus group discussion (FGD) of mixed men and women, and their scores for the importance of each activity in motivating community engagement, importance for daily life and the labour expended by the community. The beneficiaries of each activity identified by this FGD are also presented. Cells are highlighted in green to represent very high importance for or very low labour expended, yellow is high importance or low labour, orange is low importance or high labour and red is very low importance and very high labour

Activity	Importance as a motivator to engage in the cooperative	Importance for daily life	Labour expended	Beneficiaries
Health training				Family/households
Literacy monthly tutoring				Young people, men and women
Conservation cooperative involvement				Men and women
Savings and loans				Family/households
Conservation agreement meetings				Crab fishermen
Mangrove and fisheries patrols				Community as whole
River mapping and marking				Community and fishermen
Landing site data collection of fisheries				Community, fishermen, natural resource management team
Fish 'chip' making				Women
Periodic closures				Men, young people
Training on periodic closures				Men

TABLE 2 Influence matrix scored by the mixed focus group discussion on the effect that interventions had on outcomes. Colours represent scores chosen where red has no influence (score = 0), orange has a weak influence (score = 1), yellow has a moderate influence (score = 2), and green has a strong influence (score = 3). Rows and columns are totalled to show the outcome with the greatest magnitude and the activity with the greatest impact across outcomes

	Activities						
Outcomes	Area and time closures	Literacy training	Patrols	Conservation cooperative	Savings and loans	Health training	Total influence of activities
Increased income							14
Increased savings							14
Mangrove and fisheries management							17
Better education level							11
Improved community health							11
Reduced illegal logging							13
Total positive impact of activities	12	12	11	18	14	13	

Improvements in mangrove and fisheries management were the area with the highest magnitude of positive change with a score of 17. Increased income and savings were the second highest level of change (14), reduced illegal logging was the third highest (13) and the lowest was improved health and better education levels (11). The CC was identified as the most important activity overall, having a strong influence on all changes identified with a score of 18. The activity driving the least amount of change across multiple areas was mangrove patrol units (11).

3.2 | PIA with community leaders

The village leaders FGD identified five project activities (Table 3). Village leaders felt more comfortable grouping activities such as 'Cooperative Monthly Meetings' and 'Savings and Loans Program' as well as 'Conservation Agreement' and 'Monthly Mangrove Patrols' together. Village leaders listed all activities as very important for daily life and as a motivator to join the cooperative, with the exception of the conservation agreement

TABLE 3 The activity list determined by the focus group discussion (FGD) of village leaders, cooperative leaders and important village figures, and their scores for the importance of each activity in motivating community engagement, importance for daily life and the labour expended by the community. The beneficiaries of each activity identified by this FGD are also presented. Cells are highlighted in the same manner as Table 1

Activities	Importance as a motivator to engage in the conservation cooperative	Importance for daily life	Labour expended	Beneficiaries
Conservation agreement and mangrove patrols				Community
Conservation cooperative monthly meetings and savings/loans				Cooperative members
Literacy monthly tutoring				Community members with low education
Health ambassador outreach (PHE)				Families/communities
Mangrove planting and restoration				Community

TABLE 4 Influence Matrix results from the focus group discussion with *village leaders only* displaying the effect that each of the interventions is having on each of the outcomes. Colours represent scores chosen where red has no influence (score = 0), orange has a weak influence (score = 1), yellow has a moderate influence (score = 2) and green has a strong influence (score = 3). Rows and columns are totalled to show the outcome with the greatest magnitude and the activity with the greatest impact across outcomes

Outcomes	Activities					
	Conservation agreement and mangrove patrols	Conservation cooperative monthly meetings and savings/loans	Literacy monthly tutoring	Health ambassador outreach (PHE)	Mangrove planting restoration	Total influence of activities
Increased crab and fish harvests						6
Improve financial access and start-up capital						9
Improved environmental awareness						8
Improved community assets (financial and non-financial)						11
Improved livelihoods/income						10
Total positive impact of activities	12	8	7	7	10	

and mangrove patrols which was rated as less important for daily life than others. As identified by the community FGD, health was found to be a 'low level of labour expended', but conversely village leaders did not find that the CC was time-consuming which was ranked the same as the health programme in labour expenditure (Table 2).

The FGD conducted with only village leaders yielded different results to the FGD with community members. Village leaders identified five major outcomes with the 'Conservation Agreement and Monthly patrols' having the largest impact across multiple outcomes. The outcome with the greatest magnitude of change, according to village leaders, was 'improved community assets' that were both financial and non-financial. Similar to the mixed FGD health activities were listed as low labour expended and high impact. Interestingly, village leaders noted that the cooperative activities required a low level of labour while the mixed FGD identified is the one requiring high labour (Table 4).

3.3 | Fisheries independent data

Crabs in the open rivers were significantly larger than in the TMR rivers in November ($W = 78$, $p = 0.00132$), but after the closure crabs were significantly larger in the TMR rivers than the open ones ($t = 3.703$, $df = 41$, $p = 0.000629$ (Figures 2 and 3). Crabs in open rivers were the same size in November and February ($W = 1{,}082$, $p = 0.561$), however, in the TMR rivers, crabs were significantly larger after the 3 month closure ($W = 94$, $p = 0.000441$ (Figures 2 and 3). The size of crabs in the rivers open to fishers remained the same, while rivers that were closed temporarily, went from significantly smaller crabs before the closure compared to open, to significantly larger than it was as well as becoming significantly larger than in open rivers.

Catch per unit effort was significantly greater in open rivers compared to TMR ones in November ($p = 0.028$), and was similar in all rivers in February ($p = 0.333$; Figure 4). CPUE remained the

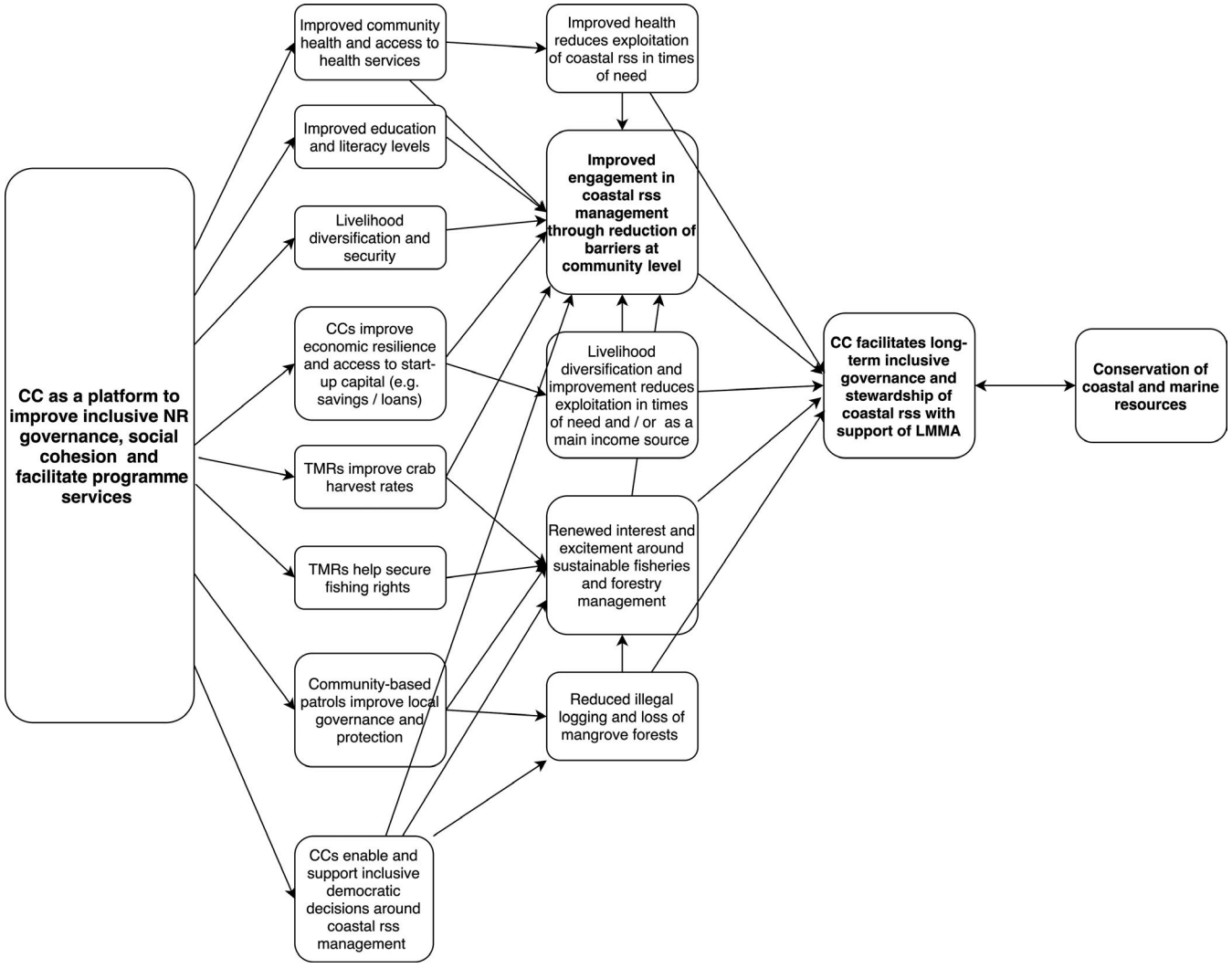

FIGURE 2 The above concept model represents a simplified theory of change that shows the programme pathways and how interventions were intended to improve community engagement and create long-term interest in mangrove and fisheries conservation

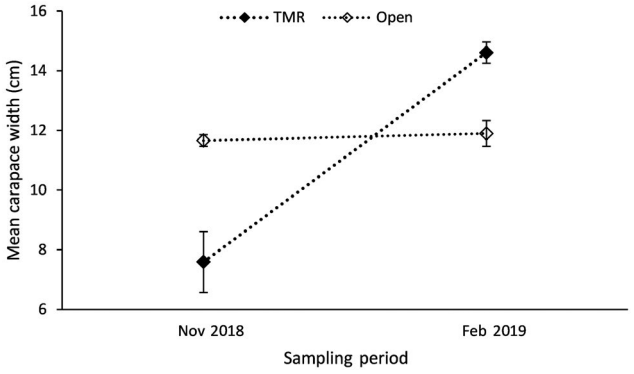

FIGURE 3 Mean carapace width (cm) of crabs in temporary mangrove reserves (TMR) and open rivers before (November 2018) and after (February 2019) the third closure. Error bars represent *SE*

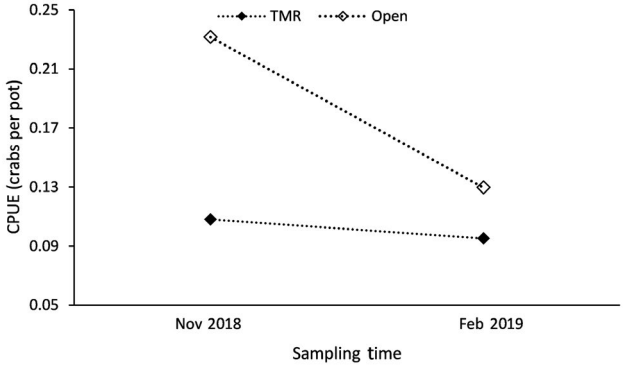

FIGURE 4 Catch per unit of effort for crabs in temporary mangrove reserves (TMR) and open rivers before (November 2018) and after (February 2019) the third closure

same for TMR rivers in both sampling periods ($p = 0.782$); however, in open rivers it significantly decreased after 3 months ($p = 0.0039$; Figure 4). There was no impact on CPUE in TMR rivers, however, CPUE in open rivers went from significantly greater in TMR ones before the closure, to significantly less over 3 months to become similar to the closed river.

3.4 | Mangrove forest cover and disturbance

A total of 143 ha of mangrove forest were lost within the project boundaries between 2001 and 2016 according to Global Forest Watch, equating to roughly 9.5 ha a year. Since the start of our project, we found that forest loss was 0.95 ha per year over a 2-year period. Terra-I alerts revealed a total of 10 ha of forest lost from 2004 to 2016, and no clearing since the start of our project. Before the commencement of the project, there were 92 GLAD alerts in 2016 for our study site, which decreased to 46 in the first year of our project in 2017. In the second year of our project (2018), only 25 GLAD alerts were detected.

4 | DISCUSSION

This study provides evidence that the CC model can be effective in achieving cross-sector conservation, social and economic outcomes. We recognize our small sample size and the scope of this study and therefore underline that inference drawn from these findings is limited. However, our intimate approach allowed us to gain insights directly from community members, offering an opportunity to consider qualitative and quantitative socio-economic and conservation outcomes in detail.

Through the participatory assessment, community members indicated they had experienced an improvement in income, health and education, while also observing a reduction in mangrove forest loss and improvement in coastal fishery harvest rates. This overarching theme appeared across both FGDs and was conducted with village leaders and community members (mixed men and women). We validated the two environmental outcomes with a forest cover analysis and fishery independent data, which supported outcomes identified in the PIA by community members. This provides more confidence in the ability for the PIA to detect environmental outcomes, and further verifies that the method is capable of assessing the impact of project interventions.

For many social and economic outcomes, no independent data of the PIA was collected to affirm that these results reflect change beyond group perception (e.g. repeated household surveys, one-on-one interviews). However, Bennett (2016) argues that it is positive perceptions of change from resource users that ultimately ensures the support of local constituents thus enabling the long-term success of conservation. This may suggest that despite our lack of complementary data to confirm health, education and economic outcomes identified by PIA members, detailing that the positive perception of these changes identified by constituents may be equally if not more insightful (Bennett, 2016).

Overall, community members identified six major social, economic and environmental outcomes. The outcome listed with the highest impact score was the implementation of a 'mangrove and fisheries management system', which is in line with the programmes overarching goal to conserve mangrove forests ecosystems. This differed slightly from the FGD with village leaders who had the major outcome of 'improved community assets' and 'improved livelihoods' as the outcomes with the greatest magnitude.

The outcomes identified with the least amount of overall change across both FGDs were related to 'improved education' and 'improved community health'. This is not surprising as the community health intervention was implemented nearly 12 months after the start of the CC in August 2017; meaning that at the time of the PIA for community members, the health intervention had only been implemented for roughly 8 months. Additionally, education and health services are voluntary for Cooperative members to use and within the FGD there were a number of community members who were not using either service as they did not feel that it would benefit them. This may have been the cause of the lower ranking for 'improved education' and 'improved community health' outcomes as not all programme constituents opted in for these services.

The PIA framework presented in our study was useful as it allowed for the nested rankings of outcomes *and* provided insights into how multiple interventions contributed to those outcomes. The PIA allowed for a more complex assessment of well-being and conservation outcomes and moved beyond a mono-consequential assessment that only identifies winners and losers. This was also clear based upon gender-related observations within FGDs. Women tended to feel more positively towards health and education services and their associated outcomes, linking them directly to their children's well-being, while men often focused on economic impacts of the programme and their impact on monthly income. We do acknowledge that a more detailed assessment of the distributional equity of outcomes across gender is needed in this study, and suggest in future iterations, a women-only FGD be included in the methodology.

Overall the intervention identified as having the largest contribution to the outcomes of the programme was the Cooperative for community members. We attribute this finding to the overall strategy of the programme (see concept mode), as membership in the CC is the first step for local resource users to access a suite of services provided such as education, health or savings and loan interventions. The CC also acts as the local governing body that oversees periodic closures and mangrove patrols and enforces community agreements about how natural resources are managed. Therefore, we would expect the CC to contribute the most to overall outcomes as it is linked strongly to both social and environmental interventions within the programme strategy.

Village leaders identified a slightly different process compared to community members, highlighting the conservation agreement (mangrove usage, periodic closure dates and rules, etc) and mangrove patrols as the intervention driving the greatest impact across multiple outcomes. This is likely due to the hierarchical systems within villages where leaders are drawn more towards regulations, agreements and local law enforcement while community members themselves are driven more by social drivers (such as the Cooperative). This finding requires further investigation with spatial and temporal replication of the PIA.

Among community member results, there were two interesting findings from the PIA that need further investigation. Despite 'improvement of health' as ranking low in the nested ranking of outcomes (score of 11), the health intervention ranked third (score of 13) for overall magnitude of contribution to the outcomes of the programme.

The health intervention in the first activity was also ranked 'extremely important for daily life' but 'requiring little energy expenditure,' meaning community members felt that the programme was not a time burden and did provide considerable benefit. Furthermore, facilitators observed that women participants within the FGDs seemed to be in favour of health interventions and more active in describing their influence on the overall magnitude across a number of outcomes. This finding is crucial in improving our understanding of the synergies, trade-offs and distributional equity of outcomes and barriers that may impede involvement between men and women in a particular programme activity. It is also important to note the PHE intervention was relatively new at the time of the PIA, and it is surprising that it has the third highest impact of the overall outcomes of the programme.

Mayhew et al. (2020) underline the importance of the integrated health-environment approach for achieving global sustainable development goals and emphasize health interventions as important strategies to achieve environmental and social outcomes. Singleton et al. (2019) found that by improving the right to healthcare, environmental NGOs may be able to improve community engagement in marine resource management by removing the barrier of poor health. Observations from FGDs in this study suggest this may be particularly true for women. Our preliminary results echo global calls for the integration of human and ecosystem health into programme strategies and interventions (Moore, Townsend, & Oldroyd, 2006) and support a rights-based approach to marine conservation (Singleton et al., 2019).

The second interesting result from the PIA was that mangrove patrols had the lowest impact on overall outcomes of the programme. This differed greatly from the FGD with village leaders who identified the agreement and patrols as the major driver of all outcomes.

This may have implications for conservation planning and can be linked to the global debate on multiple-use versus strict protectionist policy that fuels the conservation-poverty dispute (Brechin, Wilshusen, Fortwangler, & West, 2003; Colchester, 2003; Roe, 2008). It is also interesting to note that within our PIA, community members felt that although patrols had a high magnitude of impact (score of 3) towards environmental outcomes (e.g. 'reduce logging' and 'mangrove and fisheries management system'), the other interventions such as the TMRs, CCs, Health and Savings and Loans had equally as high impact (score of 3) on environmental outcomes. Further investigation into the mechanisms and explanations behind these findings are needed, but our result has potentially strong implications that conservation interventions designed to address socio-economic issues may be as impactful, if not more so, than traditional law enforcement and patrolling in reducing the loss of biodiversity.

Another interesting result can be seen in comparing both matrices across FGDs. Activities and outcomes identified between FGDs with community members and village leaders had a surprising amount of variation. Gill et al. (2019) emphasize the importance of synergies, trade-offs and equity of social outcomes as a result of conservation interventions. They call for the use of 'distributional equity' that assesses direction ('How were they impacted? Negatively? Positively? Not impacted?'), magnitude ('At what scale or how much were they affected') and distribution ('Who was impacted? Where?') of the intervention's outcomes. The variation in the influence matrices across FGDs has potentially important implications for conservation interventions and supports Gill et al. (2019) that heterogeneity within communities can greatly impact the scale and magnitude of social, economic and conservation outcomes.

The PIA suggested that the TMRs were an important intervention in harnessing short-term benefits for local resource users. Community members and village leaders in the FGD noted that 'increased income', was largely due to improved harvest rates from TMRs and economic opportunities provided by the CC. Fishery independent data suggested that there was not any impact of the closure on the abundance of crabs, however, there may have been the indirect impact of displaced fishing effort on open rivers causing density to decrease. A more likely factor causing this significant decrease is due to the life history of female mud crabs, which migrate offshore to spawn in stable abiotic conditions (Alberts Hubatsch et al., 2016; Hill, 1994; Le Vay, 2001). The timing of this decrease in abundance coincides with the monsoon season spawning period.

The reported increased harvest rates in the PIA is likely due to a result of the average size of crabs captured in the TMRs increasing over the closure period, despite the relative abundance remaining the same. This is likely to be the result of the behavioural patterns of male mud crabs, which are known to establish territories through aggression and cannibalism of smaller crabs (Mirera & Moksnes, 2013; Shelley, 2008). These territories are formed by the strongest individuals to occupy favourable habitat, and these individuals are also known to be the most successful at reproducing (Alberts-Hubatsch et al., 2016; Waiho et al., 2015). This indicates that in the TMRs, large males are able to move in and establish territories without being exploited, displacing the smaller males and thus resulting in a mean size greater than in the fished rivers, but not in higher abundance.

The usefulness of TMRs coincides with Goetze et al. (2018) who analysed 11 periodic closures systems, primarily on coral reef species and found that this management intervention provided pre-harvest protection benefits and limited post-harvest benefits, with the longer the closure occurring, the more beneficial the impact of the closure. There are significant differences in life history between coral reef fish and mangrove creek dwelling mud crabs, so comparisons must be interpreted with care. For mud crabs, having such a short closure may dramatically increase average size due to their behavioural traits, but these benefits will be mostly diminished as soon as fishing re-commences. This stresses the importance of advocating for a longer time period of fishery closure, or even permanent closure. Further fisheries monitoring will be able to determine the longer term impact of this TMR system, and reveal if they are only short-term benefits as observed in Goetze et al. (2018). This will be able to determine if the TMR system is more beneficial than total closures, and reveal the method with the best long-term impacts. Regardless of benefits to stock, the implementation of TMRs has also resulted increased stewardship in villages, awareness of impacts and voluntary release of juveniles and pregnant females and other outcomes that improve sustainability of the fisheries.

In addition to evaluating the overall CC approach, this study also looked to underline the importance of impact evaluations that put programme beneficiaries at the centre. Participatory methods have been identified by other studies as an important tool to measure the impacts of conservation interventions on human well-being (Leeuw & Vaessen, 2009; Woodhouse et al., 2015). Woodhouse et al. (2015) presented a set of guidelines for measuring the impact of conservation interventions on human well-being that were central to the design of our PIA framework. Our study further supports the authors' findings that socio-economic and environmental systems are complex and multi-faceted in nature, lending to the difficulties in evaluating cross-sector interventions (Woodhouse et al., 2015). Mixed methods, like the ones presented in this study, can be useful for conservationists in verifying qualitative and quantitative results and findings. This study also supports previous work that qualitative approaches are important for conservation impact evaluations to explain the process involved, allow the local community voice to be heard, and aid in identifying pathways of change to achieve simultaneous sustainable economic and ecosystem outcomes (White, 2002).

5 | CONCLUSION

In this study, we presented a PIA framework to assess progress towards community-led programme outcomes from both conservation and socio-economic perspectives. We then used the framework developed to evaluate a community-led conservation approach designed to achieve both environmental and social outcomes in the village of Sungai Nibung, West Kalimantan. Although this study represents a mid-term PIA implemented with just one village, our findings do support the theory that community-led programmes can achieve both conservation and socio-economic outcomes. The results also support the hypothesis that environmental NGOs need to consider a multi-dimensional view of human well-being, and that cross-sector interventions are effective at improving community engagement in marine conservation. Spatial replication of the programme will provide further insights to test for differences in outcomes between villages. Stronger influence could be drawn from future iterations if a similar method was used to measure change in control sites and villages not receiving an intervention. We also suggest future iterations that include more gender specific PIA's to better provide inference on the heterogeneity that exists within gender at the community level.

There is still the need to establish the long- term maintenance of these outcomes and the broad applicability of this approach to communities in similar context. This study does provide support for global calls for conservationists to use participatory methods to design conservation interventions, evaluate impact and promote engagement with local communities. We argue that the positive outcomes achieved by the CC approach can be attributed to the dedication to engage community-led solutions and co-designing interventions and programmes in direct response to community needs.

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CONFLICTS OF INTEREST

There is no conflict of interest related to our data sharing and study.

AUTHORS' CONTRIBUTIONS

A.E.M. wrote the manuscript, analysed PIA and spatial data; A.D. analysed fisheries data and aided in the creation of graphics; D.G., S.C. and C.H. helped create the introduction and reviewed the article; B.F. provided useful reviews and oversight for the Oceanwise team. N.S., Muflihati, Kartikawati, Sudaryanti oversaw data collection, trained field teams, worked with local stakeholders and reviewed the final drafts of the manuscript.

DATA AVAILABILITY STATEMENT

All data from this study are publically available in the online database Dryad Digital Repository: https://doi.org/10.5061/dryad.brv15dv75 (Miller et al., 2020).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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