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Management status of mud crab fisheries in selected areas of FMA 713, East Kalimantan, Indonesia using the Indonesian Ecosystem Approach to Fisheries Management (EAFM) Assessment Methodology

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Management status of mud crab fisheries in selected areas of FMA 713, East Kalimantan, Indonesia using the Indonesian Ecosystem Approach to Fisheries Management (EAFM) Assessment Methodology

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Abstract. The selected study area in Fisheries Management Area (FMA) 713 in Kartanegara District, East Kalimantan Province, Indonesia has extensive mangrove forests with suitable habitat for mud crabs (*Scylla* sp.), a valuable fisheries resource. Concerns have been raised regarding reported declines in the abundance of mud crabs and in the condition of their mangrove habitat. To evaluate the management status of the mud crab fishery in this area, an assessment was carried out using the Indonesian Ecosystem Approach to Fisheries Management (EAFM) methodology. The 25 indicators assessed represent 6 domains: Fisheries Resources, Habitat and Ecosystems, Fishing Technology, Social, Economic, and Institutional. The flag model technique was applied using multi-criteria analysis through an expansion of the composite index. The results indicate that the overall management status of mud crab fisheries in Kutai Kartanegara District was in the Moderate class (on a scale of Poor, Insufficient, Moderate, Good, Excellent). Indicators in the Habitat and Ecosystems, Fishing Technology, and Institutional Domains highlighted areas of concern where improvements are needed. The Fisheries Resources Domain aggregate status (moderate) indicated that wild mud crab stocks were still reasonably abundant and reliable, supporting the moderate status in the Social and Economic Domains, which relate to the welfare of fishing communities. The Institutional Domain status was in the poor category. Good governance measures to improve the Institutional Domain indicators have the potential to strengthen the other domains, in particular the Habitat and Ecosystem Domain and the Fishing Technology Domain, and to improve the overall EAFM status of the mud crab fishery in the future.

1. Introduction

Mud crabs have been an important fisheries commodity in Indonesia since the 1980s [1]. Over the period 1980-1999, annual production was around 8,000 tonnes [2]. Meanwhile, the annual production during the period 2000-2016 reached 42,000 tonnes [3]. These statistics show that the rate of mud crab exploitation has increased by a factor of at least four since the beginning of the 21st Century. The contribution of wild-caught mud crabs was 77% while aquaculture only supplied 23% [3].

East Kalimantan is the Indonesian province with the second largest average annual mud crab production (after North Sumatra), amounting to 2,882 tons over the period 2000-2016. Kutai

Kertanegara District, which has an extensive estuarine area in the Mahakam Delta, is a major mud-crab producing region. The water of the Mahakam Delta have a high biodiversity value, with main indicators (species of important economic value) including 15 crustacean species, 81 fish species of fish groups, larvae dominated by Gobiidae, and 20 molluscan species [4]. Mud crab producing areas in the Mahakam estuary include Marangkayu, Muara Badak, Anggana, Muara Jawa and Samboja [5].

The promulgation of Ministerial Regulation (PERMEN KP) No. 1/2015 and No. 56/2016 aimed to maintain wild crustacean stocks by establishing minimum allowable catch sizes for lobsters, mud crabs, and blue swimming crabs. However, currently, the trend of mud crab fisheries status is decreasing, and in some areas the stock and habitat status need to be improved. For the afore-mentioned reasons, the management and utilization of mud crabs by various parties, especially the people in Kutai Kertanegara District, requires supporting data and appropriate planning.

The FAO Code of Conduct for Responsible Fisheries (CCRF) recommends that an ecosystem-based approach to fisheries management (EAFM) should be incorporated into existing regional and national fisheries management frameworks. With respect to its application in Indonesia, EAFM principles have been adopted as the basis for Fishery Management Plan (Indonesian acronym RPP). The assessment of EAFM indicators is very important to determine the status of a given fishery, such as the mud crab fishery, to define fisheries improvement measures, and to understand the impact of the fisheries management improvement programs, including those implemented in selected areas of Fisheries Management Area (FMA) 713, and in particular for the mud crab fishery in Kutai Kertanegara as one of the pilot sites for the Indonesia Seas Large Marine Ecosystem (ISLME) Program.

The aim of this study was to assess the management of mud crab fisheries in a selected area of FMA 713 according to the EAFM indicators adopted in Indonesia in order to provide an up to date evaluation of the status of mud crab fisheries. The results of this study are expected to provide basic information and serve as a reference for the development of national fisheries improvement programs, as well as providing recommendations for proposed management action interventions for sustainable mud crab fishery practices in Indonesia.

2. Method

2.1. Research Location and Period

This research was conducted during 10 weeks, from mid-December 2019 to February 2020. Data collection activities were focused on Marang Kayu (Location 1), Muara Badak (Location 2), Anggana (Location 3), Muara Jawa (Location 4), and Samboja (Location 5) (Figure 1). These sites are known as the main mud crab fishing areas in Kutai Kertanegara District. The activities implemented included the following:

a. Develop a detailed work plan for the assessment and consult with FAO and the Directorate of Fisheries Resources, Directorate General of Capture Fisheries of the MMAF on the proposed plan and methodology.

b. Desk Study to collect the best available data/information for use in evaluating the agreed EAFM Indicators

c. Field observations and assessment of EAFM indicators in the main areas of the mud crab fishery in Kutai Kertanegara, East Kalimantan, and coordination meetings with relevant parties at the provincial and district levels (DKP, BPS, and others)

d. Analysing the data/information from the literature study and field activities to make an assessment of each EAFM indicator

e. Formulate the results of the study in the form of an evaluation of the mud crab fishery management status based on the results of field observations and data analysis.
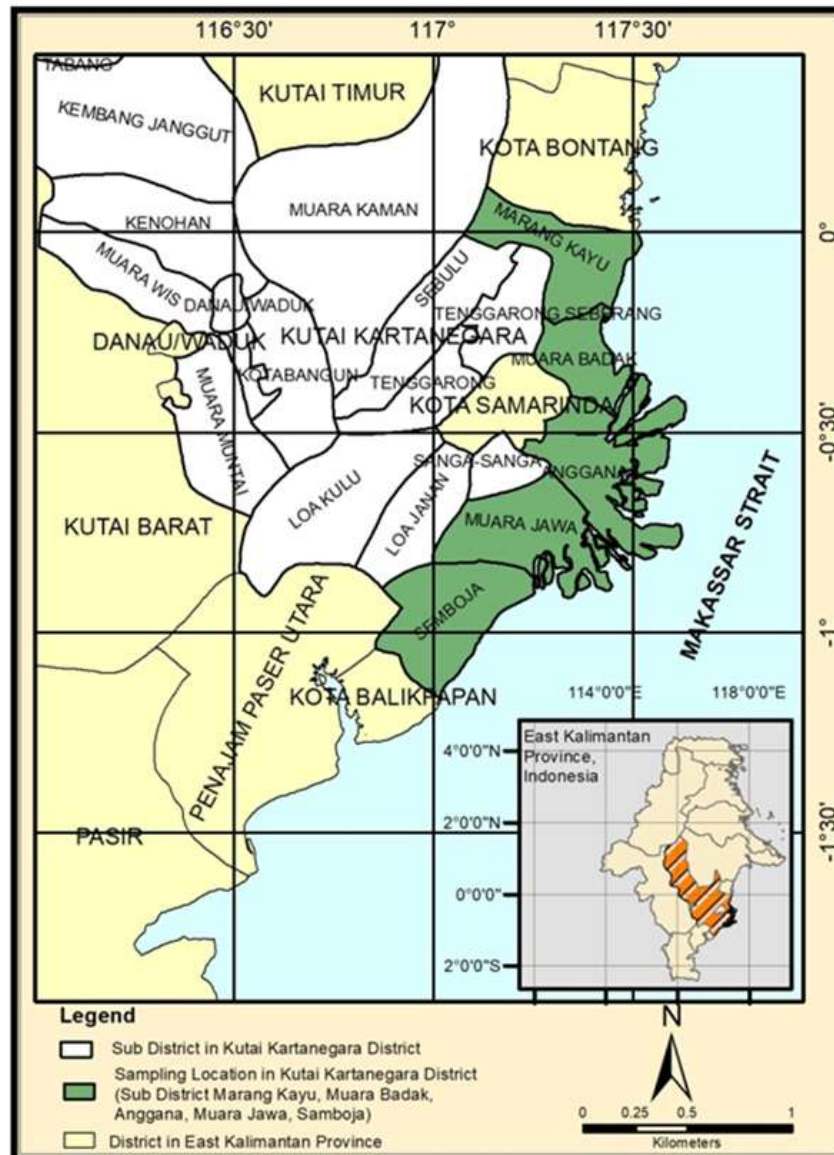
Figure 1. Map of the study area for the EAFM assessment of mud crab
fisheries in East Kalimantan, Indonesian FMA 713

2.2. Assessment of Management Status using the EAFM Approach

The EAFM approach was carried out using 25 indicators representing 6 Domains: Fishery Resources
(5 indicators), Habitat and Ecosystem (4 indicators), Fishing Technology (4 indicators), Social (3
indicators), Economy (3 indicators), and Institutional (6 indicators). In the next step, flag modelling
techniques were applied using multi-criteria analysis (MCA) through an expansion of the Composite
Index [6]. Composite Index calculations first produced several values for each domain which were
then used to determine the aggregate Composite Index value for the mud crab fishery in Kutai
Kartanegara. There were three stages in determining the aggregate Composite Index: making an
assessment for each indicator in each domain; using the Composite Index formula for each indicator =
$CA_i = f (CA_{ni}, n = 1,2,3, ..., m)$; and performing a simple arithmetical composite analysis to produce
the EAFM Flag Model output. The status of fisheries management using the EAFM approach was
determined based on the Flag Model together with the accompanying description, based on the criteria
in Table 1.

Table 1. Flag Model Status of Fisheries Management based on the EAFM Approach.

Range of Values		Flag Model	Description
Low	**High**		
1	20	 	Poor
21	40	 	Insufficient
41	60	 	Moderate
61	80	 	Good
81	100	 	Excellent

3. Results and Discussion

3.1. Management Status of Each EAFM Domain

3.1.1. Mud crab Resource Domain. The review of the Resource Domain status of mud crab fisheries management showed that the aggregate of all indicators was in the moderate management category. The flag model for each indicator in the mud crab resource domain can be seen in Table 2.

Table 2. Flag model status of each indicator in the mud crab resource domain

Indicator	Flag model
1. Basic CPUE	Good
2. Size trend	Moderate
3. Proportion of juveniles captured	Good
4. "Range Collapse"	Insufficient
5. ETP Species	Poor

In general, there are 6 (six) indicators for this domain, but some indicators are not suitable for mud crabs, in particular species composition. Most of the data used in determining the scores were sourced from interviews with respondents comprising fishermen, fish farmers/landowners, field officers, collectors, distributors, the Provincial/District Marine and Fisheries Service, and the Fish Quarantine, Quality Control and Agency (BKIPM).

The mud crab resources (stocks) can still be relied on to support the fishery, based on the abundance and size of the crabs, because natural regeneration or recruitment is still abundant. Based on data curated by the Maritime Affairs and Fisheries Office of Kutai Kartanegara District (2019), mud crab production is not only obtained from capture fisheries but also supported by aquaculture. Fishing comprises efforts to get mud crabs by catching them in their main habitat, namely in the mangrove areas. As for aquaculture activities, in local terms this means catching mud crabs in aquaculture areas such as brackish-water ponds (*tambak*). The poor status of the range collapse and ETP (Endangered, Threatened and Protected) species indicators was mostly due to the low level of association with mangrove ecosystems and mud crabs so that they do not contribute to the presence and condition of mud crabs in those areas.

3.1.2. Habitat and Ecosystem Domain. In the original EAFM assessment concept, there are six indicators in this domain, but two of these indicators are not suitable for mud crabs, namely seagrass ecosystem status and coral reef status. The flag model for each indicator in the mud crab resource domain can be seen in Table 3. The condition of mangrove ecosystems requires serious attention because they are a habitat for mud crabs. As seen in Table 3, even though the mangrove condition

indicator had a very good status, this key habitat could be under threat because other indicators do not support their continued existence. This is indicated by their insufficient management status.

Table 3. Flag model status of each indicator in the Habitat and Ecosystem domain

Indicator	Flag Model
1. Water quality	Insufficient
2. Status of mangrove ecosystems	Very good
3. Special habitat	Poor
4. Climate change impact on habitat condition	Poor

Based on field observations and interviews with respondents, visual observations showed that there was plastic waste and in some areas there was spilled coal material in the shipping channel in the Mahakam River. Furthermore, the lack of data or information relating to this unique/special habitat may be having an impact, e.g. regarding the minimal level of management implemented. In the case of fisheries management in a particular area related to climate change, it was found that the lack of knowledge about this matter resulted in a lack of awareness of the impacts that could be anticipated appropriately by the community.

3.1.3. Mud Crab Fishing Technology Domain. The status of mud crab fishery management in the review of the Fishing Technology Domain shows that based on the aggregate of all indicators this domain is in the insufficient category. The flag model showing each indicator in the fishing technology domain can be seen in Figure 4.

Table 4. Flag model status of each indicator in the fishing techniques domain

Indicator	Flag Model
1. Destructive fishing methods	Insufficient
2. Modification of fishing gear	Moderate
3. Fishing capacity and effort	Poor
4. Catch selectivity	Insufficient

In the original EAFM assessment concept, there are six indicators in this domain, but two of these indicators are not suitable for mud crabs, namely the agreement between vessel size and documents, and the proper certification of fishing vessel crews.

The fishing gear used by fishermen to catch mud crabs is called a *rakkang*. In principle, the *rakkang* fishing gear is considered non-destructive and legal. However, with the modification of the tool which is an adoption of a Malaysian gear type, it is considered not selective. This is due to the relatively small mesh size of 4 cm so that even small mud crabs (carapace width <15 cm) will be caught and cannot escape from the fishing gear.

Mud crab catching fishing capacity and effort was obtained by comparing this year's CPUE value with the previous year's CPUE value (calculated based on the average production trend and the number of fishing gears obtained from interviews with fishermen). The value obtained was <1 (low).

3.1.4. Social Domain. The status of mud crab fisheries management assessed for the Social Domain based on an aggregate of all indicators was in the medium or moderate category. The flag model showing the assessment of each indicator in the Social Domain can be seen in Table 5. In practice, there are still differences in perception between stakeholders regarding the implementation of regulations, a lack of socialization, a lack of control/mutual agreement on the market price of crabs between fishermen, collectors and distributors, and a low level of awareness of fishermen and

collectors. Furthermore, with respect to conflict between fishermen, information was obtained from all stakeholders that the mud crab fishery activities in the research location had never resulted in conflict. However, in terms of the potential for conflict, it is possible that conflict could occur in connection with the activities of fishermen who catch crabs in areas owned by fish farmers. One positive factor arising from local knowledge is that some fishermen will release crabs that are small (weight <200 gran) or have a soft carapace as well as berried crabs (egg-carrying females).

Table 5. Flag model status of each indicator in the social domain

Indicator	Flag Model
1. Stakeholder participation	Insufficient
2. Conflict in fisheries	Insufficient
3. Utilization of local knowledge	Very good

3.1.5. Economic Domain. The review of the status of mud crab fisheries management in the Economic Domain shows that based on the aggregate of all indicators this Domain was in the medium or moderate category. The flag model showing each indicator in the Economic Domain can be seen in Table 6.

Table 6. Flag model status of each indicator in the economic domain

Indicator	Flag Model
1. Asset ownership	Very good
2. Fisheries household income	Moderate
3. Savings ratio	Insufficient

Based on the results of interviews with respondents, on average each fisherman had 25-50 fishing gears of various types/models, such as regular (locally made) gear and the Malaysian (Tawau) *rakkang*. With the relatively good profit that fishermen always get from fishing for mud crabs, a proportion of the profit can be reinvested in increasing the number of new fishing gears or replacing/repairing fishing gear that is not functioning properly. The income of fishing households (Indonesian acronym RTP) in the mud crab fishery shows that this business is quite profitable. The results of the follow-up interviews on fishing household (RTP) income showed that the net income earned per month could reach IDR 4,000,000 per household. When compared with the East Kalimantan regional minimum wage (Indonesian acronym UMP) of IDR 3,175,000, it can be said that economically this business is quite profitable for the fishermen because the income earned exceeds the current UMP. The savings ratio of mud crab fishermen was also quite good. On average, fishermen have savings from the income earned in catching mud crabs ranging from IDR 500,000 to IDR 700,000. These conditions indicate that the mud crab fishery provides good business prospects and opportunities for fishermen.

3.1.6. Institutional Domain. The Institutional Domain review of mud crab fisheries management status shows that based on the aggregate of all indicators this Domain was in the insufficient category. The flag model for each indicator in the Institutional Domain can be seen in Table 7. The reality that the management of mud crab fisheries was assessed as insufficient in the institutional domain is based on the fact that more than 50% of the indicators were in the poor category. This condition should be suspected as the main cause of the objective conditions in the field, which indicate weak institutional presence.

Table 7. Flag model status of each indicator in the institutional domain

Indicator	Flag Model
1. Compliance with responsible fisheries principles	Insufficient
2. Comprehensiveness of fisheries regulations	Moderate
3. Decision-making mechanisms	Poor
4. Fishery Management Plan	Poor
5. Synergy between fisheries management policies and institutions	Poor
6. Stakeholder capacity	Poor

The three following indicators with a poor management status need special attention: decision-making mechanisms, the level of policy synergy between institutions and stakeholder capacity, all of which contribute to the poor level of management. The main factor causing this situation is that the institutional framework to bring together all the stakeholders has not yet been formed. Another causal factor of the poor level of management in this Domain is the lack of counselling, training and community assistance by the authorities to increase stakeholder capacity and competence in conducting mud crab fishery activities.

3.2. Mud crab Fishery Management Status
Overall, the management status of the mud crab fishery in Kutai Kartanegara District was classified as moderate. Specific indicators in the Habitat and Ecosystem, Fishing Technology, and Institutional Domains need to be improved. The results of the calculation of the Composite Index for the six domains of the EAFM assessment of mud crab fishery management can be seen in Table 8.

Table 8. Flag model status of EAFM Aggregate

Domain	Flag Model
1. Mud Crab Resources	Moderate
2. Habitat and Ecosystem	Insufficient
3. Fishing Techniques	Insufficient
4. Social	Moderate
5. Economic	Moderate
6. Institutional	Insufficient
EAFM Aggregate	**Moderate**

The moderate status of mud crab resource management indicates a balance between the potential resources available in nature and the fishing rates that could threaten the future of the resource base and thus the fishery, such as the catching of crabs with a carapace width less than 15 cm, which is in violation of the provisions of regulation Permen KP No. 1 of 2015, as well as hunting for berried crabs, which is in violation of regulation Permen KP No. 56 of 2016.

However, the potential for mud crab fisheries in the Kutai Kartanegara District is still quite good, which encourages intensive exploitation, involving fishermen who catch crabs both in the natural environment and in aquaculture ponds, local collectors/middlemen and helpers, and large-scale traders. From an economic and social perspective, this fishery provides good business opportunities for the community, reduces unemployment, and significantly improves people's welfare. These conditions are considered to give a management status in the social and economic domain equal to that of the mud crab resource domain, which is at a moderate level.

As for the habitat and ecosystem, fishing technology and institutional domains, all of which had an insufficient status, this is due to several reasons. These include the prevalence of violations of

regulations related to these aspects, such as water pollution, environmentally unfriendly fishing technology, and a lack of public understanding regarding regulations related to environmental and fisheries resources management. Therefore, to improve these Domains, management activities need to concentrate on monitoring and surveillance activities, community empowerment, and other community assistance activities.

4. Conclusion

The status of the mud crab fisheries management in the Kutai Kartanegara District as a selected location in FMA 713 is moderate. Indicators related to habitat and ecosystems, fishing technology, and institutional aspects need to be improved. The aggregate value of the Fisheries Resources Domain is in the medium category and indicates that mud crabs are still available from natural stocks which are in reasonable condition. This enables the resources to support the achievement of the moderate category in the social and economic domains also, with a positive influence on the welfare of the fishing community. Meanwhile, the Institutional Domain is in the insufficient category. Appropriate measures to improve the institutional domain have the potential to strengthen other domains, in particular the habitat and ecosystem and the fishing technology domains, so that the future status could be improved.

Acknowledgements

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