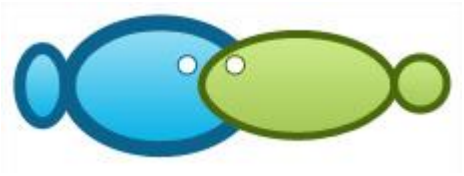

The sustainability of capture fisheries strategy in Lubuk Larangan area in Batang Bungo River, Jambi Province, Indonesia

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Abstract. Lubuk larangan is a conservation area formed by the community based on customary law that is mutually agreed upon in its management but the increasing number of prohibition areas in the Batang Bungo River causes fishing areas to be farther away and fishermen's catches to decrease. The study aimed to analyze the sustainability strategy of capture fisheries in the prohibition area on the Batang Bungo River. The study location was determined using a purposive sampling with an interview questionnaire of 40 fishermen caught in the prohibition area in the Batang Bungo River utilization zone. Based on Rapfish tests for capture fisheries' sustainability strategies, in the Batang Bungo River, in general, all dimensions show a less sustainable status. The ecological dimension is below 50% (48%), the economic dimension is in the sustainability status of values above 50% (51%, based on their contribution to the Gross Domestic Product (GDP) and on their profit/price range), the social dimension is below 50% (39%), the technology dimension is below 50% (24%) The dimension of the code of ethics falls within the unsustainable category, scoring below 50% (15%), while the institutional dimension exhibits intervals below 10%, categorizing it as having poor value
Key Words: conservation area, rapfish, management.

Introduction. The Fisheries Management Area of the mainland public waters (KPP PUD) 438 is one of the 14 such areas in Indonesia (Hanintyo et al 2015; Purwanto et al 2023). The establishment of areas is aimed to specifically manage fishery resources in inland public waters, which are part of the Republic of Indonesia's Fisheries Management Area (WPP NRI) (Husnah et al 2014). The management of public waters in Batang Bungo River, Jambi Province, is carried out by establishing a suburban area by the community who live along Batang Bungo River. Based on a research study from Hertati et al (2023), there are 33 restricted fish capture areas, locally known as "Lubuk Larangan," in the Batang Bungo River, Bungo Jambi Regency. Additionally, there is one designated reserved area in Rantau Pandan. The Lubuk Larangan area alongside the Batang Bungo River was formed by the community, traditional stakeholders, and related institutions with the aim of preserving the fishery resources.

The negative impact of the Lubuk Larangans, according to fishermen's perception around the river, is the distance of the fishing location being too far and the catch volumes of fish being decreased (Suhadha and Asriningrum 2020; Safruddin et al 2021), causing profits decrease and simultaneous increase of the operational costs of fishing along Batang Bungo River (Patawari et al 2022). In addition, the implementation of Lubuk Larangan areas is perceived as a driver of the loss of fishing grounds. Fishing activities by fishermen in Batang Bungo River are still performed by fishermen either using fishing methods that are not environmentally friendly, such as poisons, or not having permit documents, and not reporting catches (Hertati et al 2023). This situation directly affects the sustainability of capture fisheries in Batang Bungo River. Fishing activities performed without considering conservation and sustainability of resources can cause problems in the future (Gjertsen 2005; Itonaga 2005). The use of fishing gear

must be in line with the sustainability criteria and prevent damages to other biota, in particular those triggering a broad effect on existing ecosystems (Hanafi et al 2019).

The above-mentioned facts illustrate that fishing activities and resource conservation efforts in the Lubuk Larangan area of the Batang Bungo River have not been running in harmony with the objectives of sustainable capture fisheries resource management, as outlined in the Code of Conduct for Responsible Fisheries (FAO 1995). Fishery activities must be in line with a responsible and comprehensive management, which must consider a bio-technico-socio-economic approach. Firstly, it should not biologically damage or disturb the fish resources. The current research is related to the sustainability of capture fisheries strategy in Batang Bungo River conservation area, Jambi Province.

Material and Method

Time and sites. This research conducted in April-September 2021 in the Lubuk Larangan area in Batang Bungo River, Jambi Province, specifically at three stations. The first station is located in the upper reaches of the river, in Laman Panjang village, Bhatin III Hulu District, the second station is in Lubuk Manik Rantau Pandan Reservation Utilization Area, Rantau Pandan District and the third station is located in the lower reaches of the river, Muko-muko Bhatin VII Sub-District, Tebat village. The distances between first, second, and third stations are ±11 and ±9 km for each of them (Figure 1).

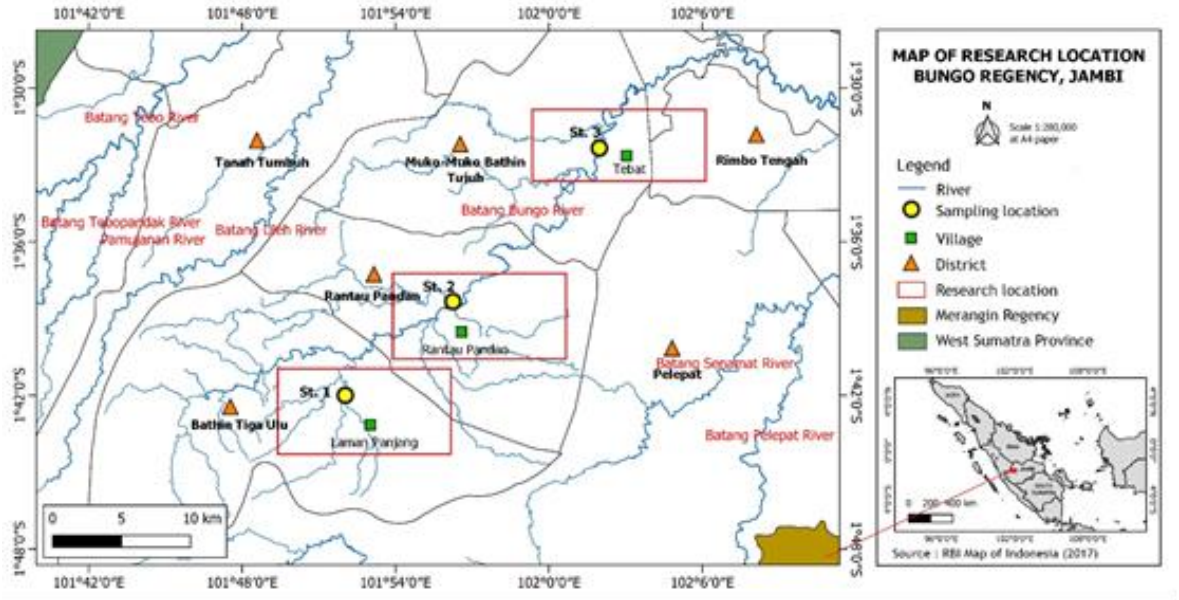

Figure 1. Map of research location (the Batang Bungo River, Jambi, Indonesia) (map generated using QGIS 3.16.11 Hannover).

Data collection. Data collection was conducted by using a survey system at three observation stations in the Lubuk Larangan area of Batang Bungo River. The surveys of the three villages were carried out purposively (purposive sampling) by considering the fishery activities and anglers' activity in catching fish. In addition, interviews were also conducted, selecting 40 respondents per station (local anglers), by focusing on describing the condition of fisheries in the zone of utilization as the data. Then, the data obtained will be categorized based on dimensions. Moreover, the scoring of the attributes, adjusted to the opinions of academics/researchers at the Faculty of Fisheries, Muara Bungo University and Bungo District Fisheries Service and related agencies as part of focus group of discussion. Furthermore, data used consist of secondary data and primary data. Secondary data was collected from various literature and primary data obtained based on the result of observations at the research location through interviews with

respondents using questionnaire. Meanwhile, all attributes and criteria in the analysis are related to the Rapfish technique.

The observed parameters consist of several attributes and criteria that are adapted to the conditions of capture fisheries in the Batang Bungo River, referring to Pitcher & Preikshot (2000) and Mulyana et al (2012). We calculate all dimensions based on attributes and assign a score to each dimension. The parameters observed in this research are:

1. Ecology (exploitation status, recruitment variability, changes in trophic levels, migration range, size of fish caught and catchability).
2. Economics (profits/prices, fisheries in GDB, other incomes, ownership, market reach and government subsidies).
3. Social (socialization of fishing, growth of fishing communities/groups, number of fishing households (RTP), fishermen's environmental knowledge conflict of interest, RTP participation in local wisdom, level of education, percentage of fishing income and others, participation of fishermen's household members in fisheries and community rules have a positive impact).
4. Technology (length of time to catch fish per trip, fish landing place catching fish on a ship/boat, handling/processing fish before selling, characteristics of fishing gear, selectivity of fishing gear, fishing aids, size of ship/boat, CPUE of fishing gear and environmentally friendly fishing gear).
5. Code of ethics (Alternative work, Restrictions on exploitation of SDI, Involvement of stakeholders, prohibition of catching certain types of fish, conditions of fish habitat, efforts to improve ecosystems, IUU fishing, number of fish wasted in fishing and fisheries/water management regulations).
6. Institutional (Regulative, Normative, Cognitive and Organizational)

Data analysis. In order to know the level of sustainability of capture fisheries in the Batang Bungo River Conservation Area, 5 dimensions were analyzed, including (1) ecology; (2) economics; (3) technology; (4) social; (5) ethics (FAO 1995; FAO 1999a,1999b; Pitcher et al 1998). Then, one dimension was added, the institutional dimension (Charles 2001; Kavanagh & Pitcher 2004; Bawole & Apituley 2021). Furthermore, the Monte Carlo test was used to find out the most influential attribute, and the leverage analysis was performed. A Multidimensional Scaling (MDS) analysis was also conducted in order to determine the relative sustainability position of fisheries, from a good to a bad status (Nababan 2007). The level of sustainability is assessed based on a sustainability score with values ranging from 0%, which describes a "bad" condition, to 100%, which describes a "good" condition. It can be seen in Table 1 below.

Table 1

Index interval and sustainability status of capture fisheries (Nababan et al 2007)

No	*Interval of sustainability index*	*Sustainability status*
1	0-25	Bad
2	26-50	Poor
3	51-75	Adequate
4	76-100	Good

Results. The strategy for sustainable capture fisheries on the Bantang Bungo River is based on six aspects of the dimensions of fisheries sustainability, namely ecology, economy, social, technology, code of ethics, and institutions. The ordination of measurements describes the sustainability of the capture fisheries in the river. The statistical stress value must be less than 0.25, while the r-squared should be close to 100%. For example, the ecological dimension has an r-squared of 93.8%. This result is based on the procedure of the MDS, the value of the resulting stress is less than 25% (s<25%), indicating that Rapfish has met the goodness of fit and the correlation confidence level is quite high, namely an average of 94.2%, as it can be seen in Table 2 below.

Table 2

Statistical results of measurement of stress and r-squared using MDS

No	*Dimension*	*Stress*	*Squared correlation (%)*
1	Ecology	0.15	93.8
2	Economics	0.16	93.6
3	Social	0.13	94.8
4	Technology	0.13	94.6
5	Code of ethics	0.13	95.4
6	Institutional	0.15	93.0
	Average	0.14	94.2

Ecology dimension. The sustainability of the ecological dimension of the Rapfish ordinance, as determined by the study of six attributes in the "Lubuk Larangan" area of the Batang Bungo River, has a value below 50%, which means that the attributes of the ecology dimension have the status of less sustainable. When one attribute is excluded from the analysis, the ordinance effect on the ecological sustainability is indicated by the level of sensitivity of the other attributes; the size attribute of the fish caught is the most sensitive attribute of the sustainability of fisheries in Batang Bungo river, with a value of 5.91% (Figure 2, Figure 3).

In addition, the second-order attributes should be considered. Using a size threshold corresponding to the fish deemed appropriate for capture could serve as an alternative policy. The findings of the biological studies on the gonad maturity size (TKG 4-5) of various target fish species in the Batang Bungo River have to be communicated to anglers or fish catchers. This dissemination is crucial to ensure that fish not yet matured and those laying eggs for release are still alive and can afford more time for reproduction, thereby enhancing the resource sustainability.

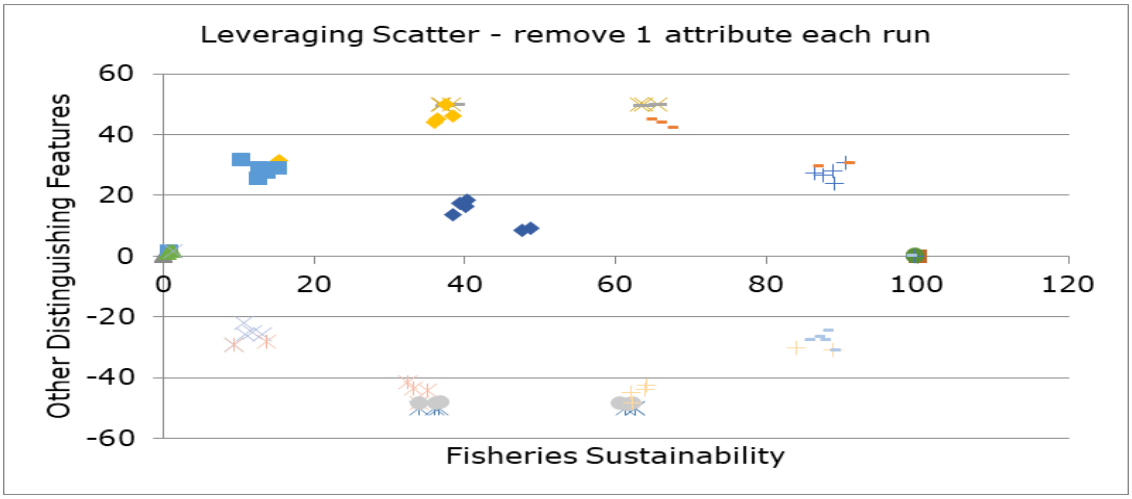

Figure 2. Ordinances of the sustainability of the ecological dimension in the Batang Bungo River.

The leverage analysis in Figure 2 shows the influence of the ordinance on the ecological sustainability score, which can indicate the level of sensitivity of the overall attributes. The sensitivity of the ecological dimension in this study shows that the size of the fish caught is the most sensitive characteristic of the sustainability of fisheries in the Batang Bungo River (Figure 3).

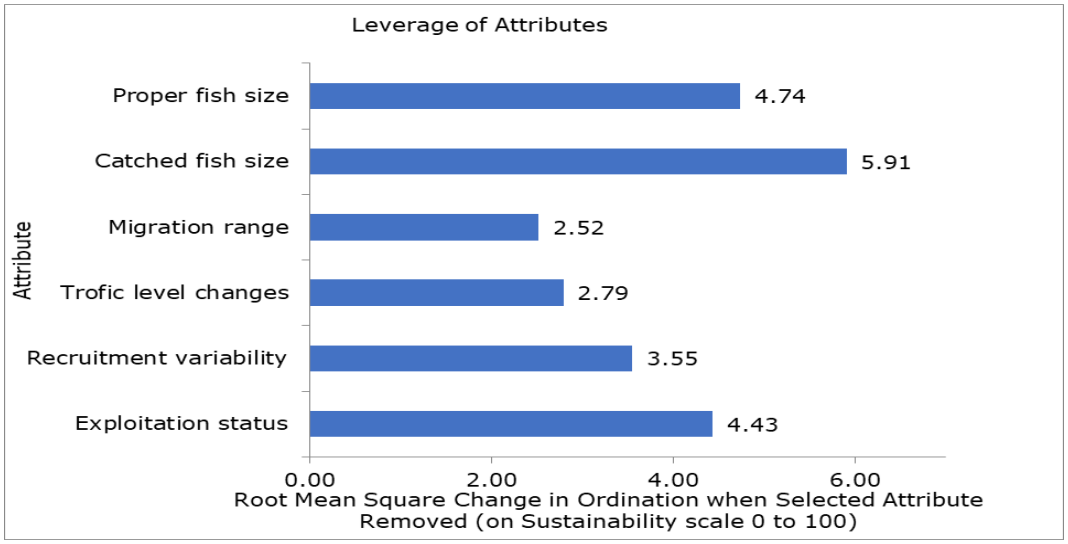

Figure 3. The Root Mean Square (RMS) value of the ecological dimension's attributes of the Batang Bungo River.

Economic dimension. Fishing activities in the Batang Bungo River significantly contribute to the local economy by directly enhancing people's income through catches. The appropriate sizing of fish can further maximize benefits, as it ensures proper valuation in both fresh and processed markets. The results of the Rapfish ordinance analysis on the economic dimension indicate varying levels of sustainability for capture fisheries in the Batang Bungo River, ranging from less sustainable to moderately sustainable. Three attributes fall within the less sustainable range: government subsidies, market access, and ownership, scoring below the 50% index. On the other hand, the other attributes fall within the quite sustainable range, scoring above the 51% index. These attributes include the government subsidies, the sector's Gross Domestic Product (GDP), the profit/price, the intensive marketing and high selling prices of fish (Figure 4, Figure 5). The regulation of fishing seasons would support the effective management of the fish demand, while ensuring the sustainability of fish resources.

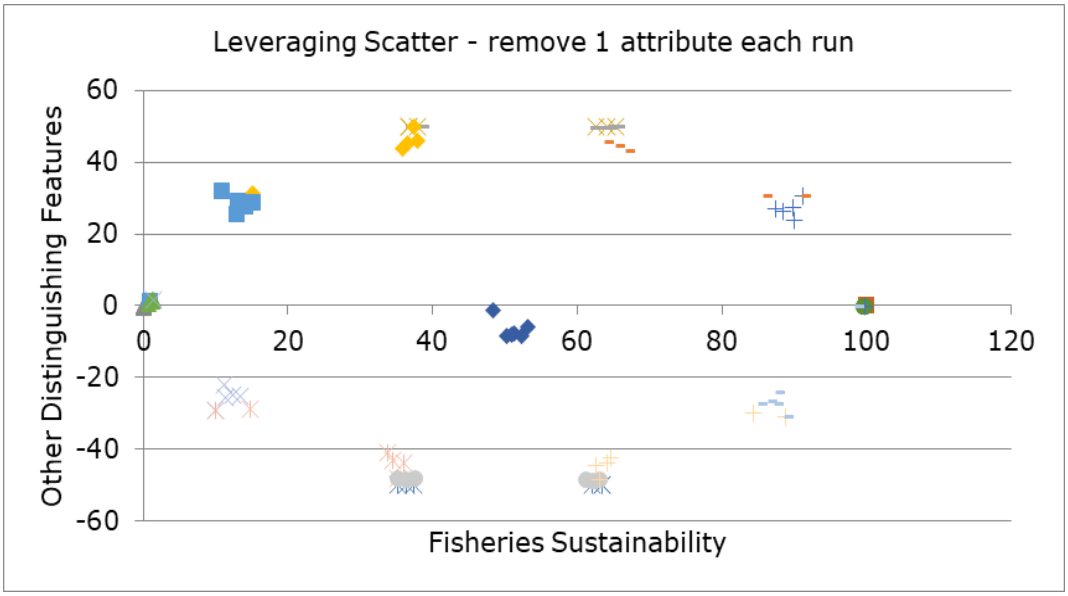

Figure 4. Ordinance of the sustainability of the economic dimension in the Batang Bungo River.

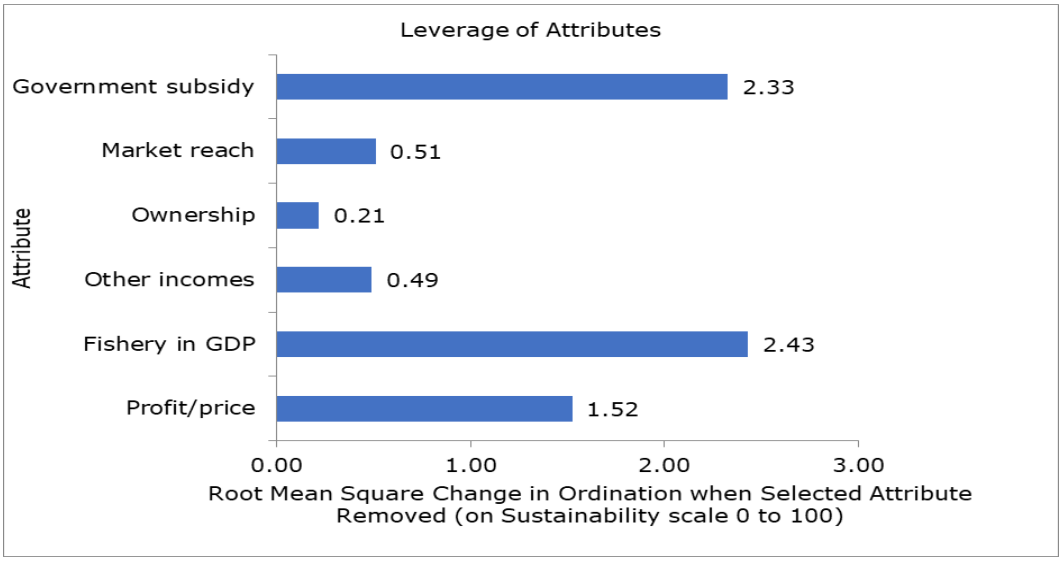

Figure 5. The Root Mean Square (RMS) value of the economic dimension's attributes in the Batang Bungo River conservation area.

Figure 4 showed several sensitive attributes. "Fisheries in GDP", which is the cumulative fishery activities' value, as part of the local/regional/national aggregate economic structure, is influenced by various factors, such as: catch volumes, number of fishing gear in operation, skills of fishermen, supporting facilities and infrastructure, capital and sales value, that directly contribute to the income of fisheries business actors.

Social dimension. According to the Rapfish Ordinance, the social dimension highlights that the sustainability index for the status of capture fisheries in the Batang Bungo River falls below 50%, indicating a less sustainable condition. This implies that the human social system, particularly the fishing community, needs to actively support the continuous development of capture fisheries in the long term, in a sustainable manner. The attribute "conflicting interests" is particularly sensitive, scoring 5.45% (Figures 6 and 7), because Batang Bungo River serves not only as a resource for fishing activities but also as a site for various other activities. The river is utilized for activities such as: excavation and gold mining (without proper permits) along its banks or improper disposal of industrial and household waste into the river, which can impact the sustainability of fish resources within the river. Furthermore, ensuring the sustainability of fishery resources in the Batang Bungo River necessitates a careful consideration of the level of community participation to the environmental protection.

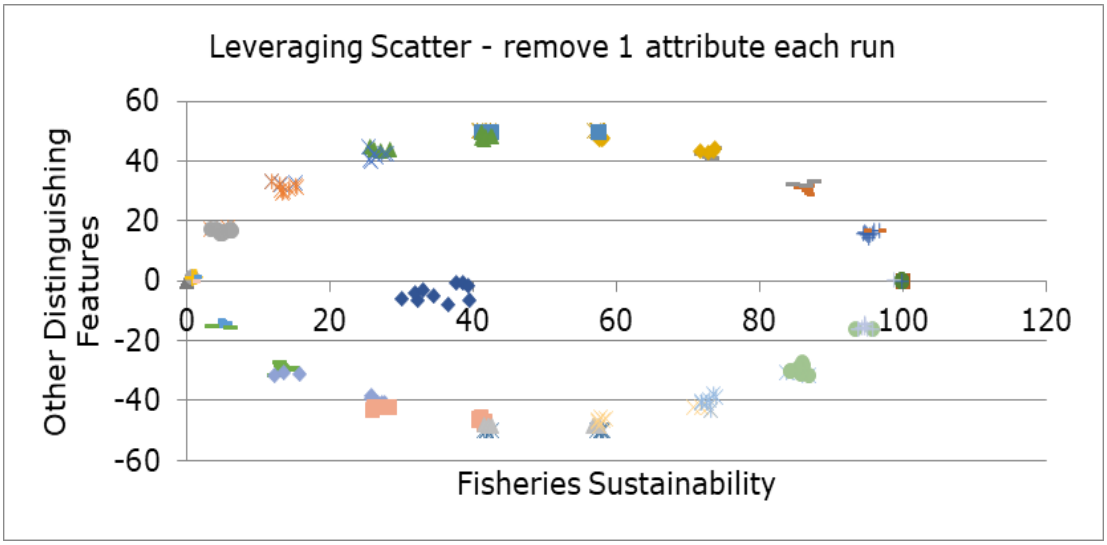

Figure 6. Social dimension sustainability ordinances in Batang Bungo River.

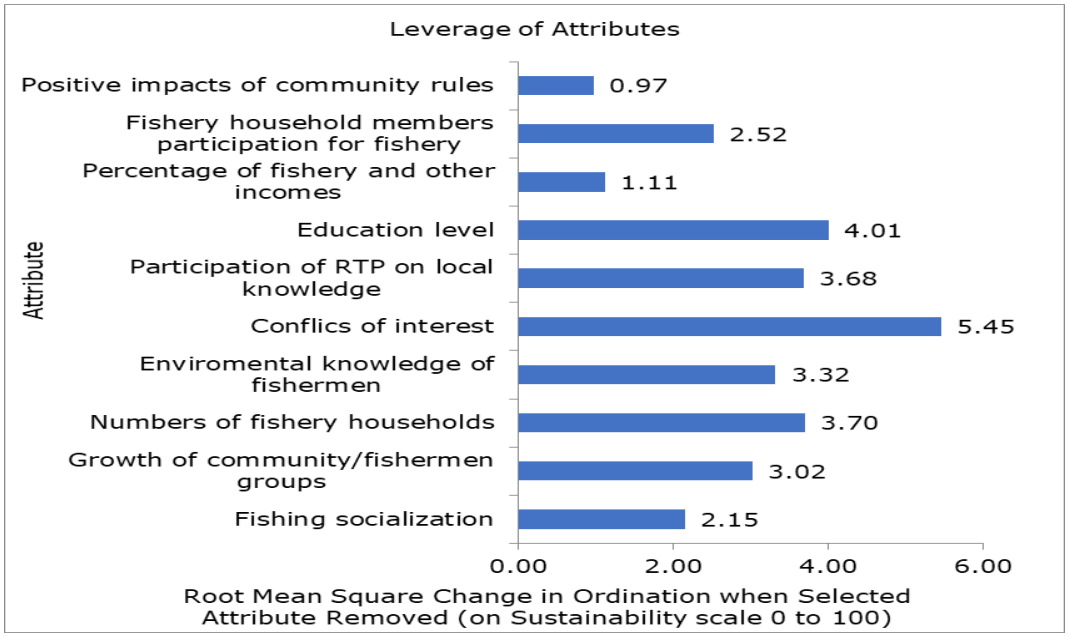

Figure 7. The Root Mean Square (RMS) value of the social dimension's attributes in the Lubukban area of the Batang Bungo River (RTP = the number of fishing households).

The results of the leverage analysis (Figure 6) in this dimension provide an illustration that the resource conflicting, due to contradictory interests, is the most sensitive attribute, with a value of 5.45. This condition can be explained by the presence of various activities in Batang Bungo River, specific to competitive groups. Apart from that, upstream areas and downstream areas are impacted by the use of the river bodies for other activities such as excavation and gold mining activities, as well as for the discharge of industrial and household waste.

Technology dimension. The sustainability index for capture fisheries activities in the Batang Bungo River is generally low, categorizing it as poor or unsustainable (Figure 8). Despite this, the fish caught using the current technology (Figure 8, Figure 9) are of higher value, albeit in lower quantities, compared to situations where efforts have not been made to enhance the selectivity of fishing gear. This improvement results in a reduction of the capture of low-quality fish.

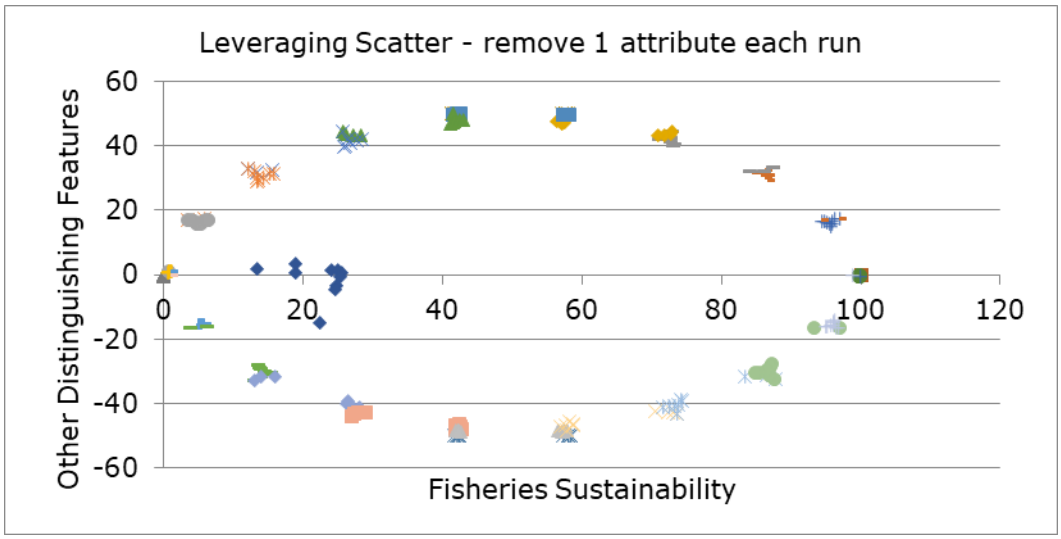

Figure 8. Technological dimension sustainability ordinances in Batang Bungo River.

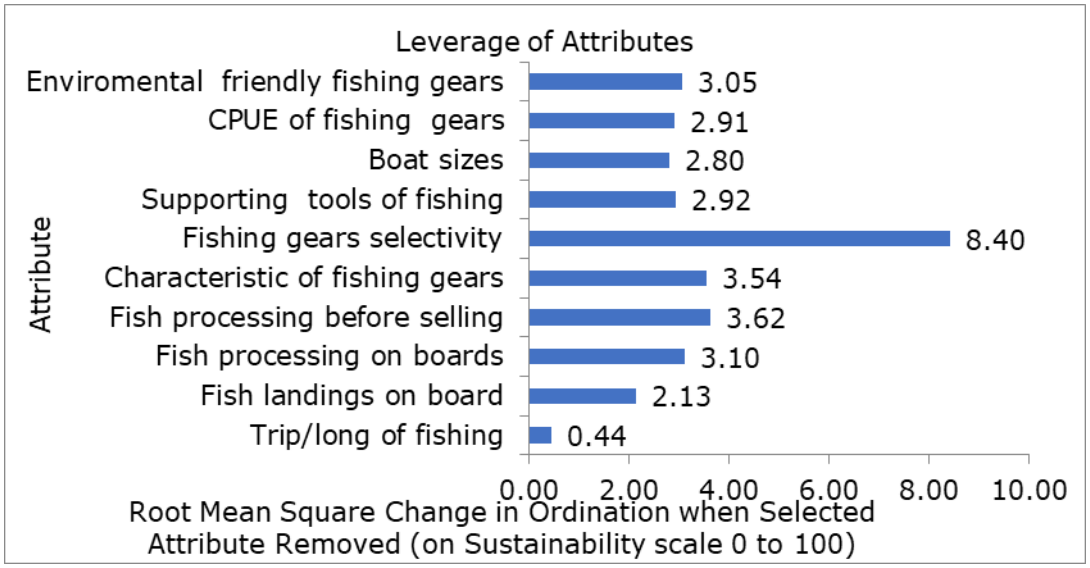

Figure 9. The Root Mean Square (RMS) value of the technological dimension's attributes in the Batang Bungo River Area.

The dimensional leverage analysis reveal that the selectivity of fishing gear is the characteristic that most influences the fishing's sustainability status of in the Batang Bungo River, which, in the long term, may reduce the availability of fish stocks. Non-selective fishing gear can catch fish that have never reached gonads maturity (never spawned) and also fish species that have less economic value when sold on the market, as explained in the ecological and economic dimensions.

Code of ethics dimension. The position of the sustainability status of capture fisheries in Batang Bungo River lies in the unsustainable (poor) range below 50%. The leveraging analysis results indicate two highly sensitive attributes: the extent of fish wasted in the catching operations (discards), at 6.99%, and the fisheries/water management regulations, at 5.68% (Figure 10, Figure 11).

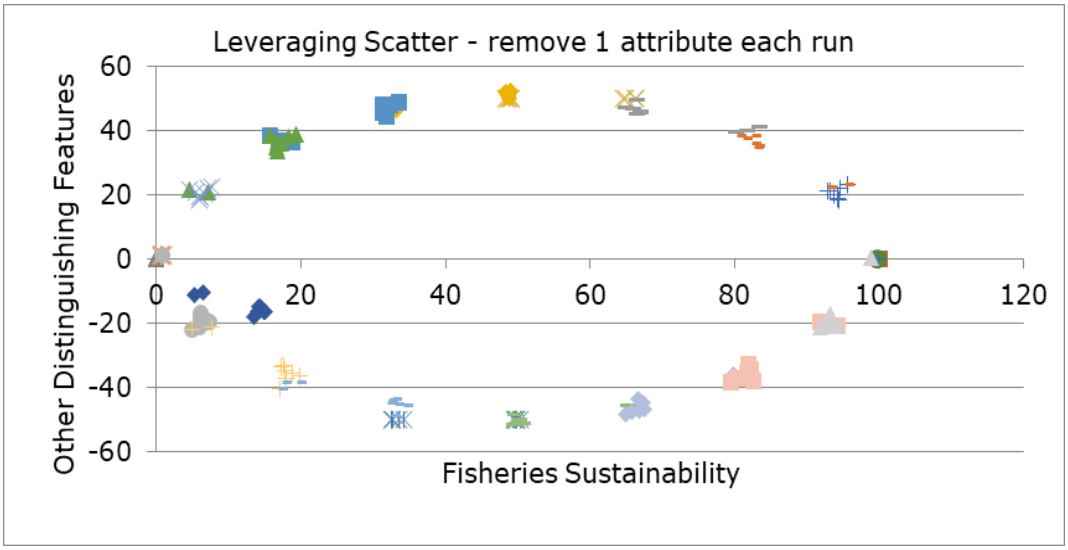

Figure 10. Ordinances of sustainability code of ethics dimensions in the Batang Bungo River conservation area.

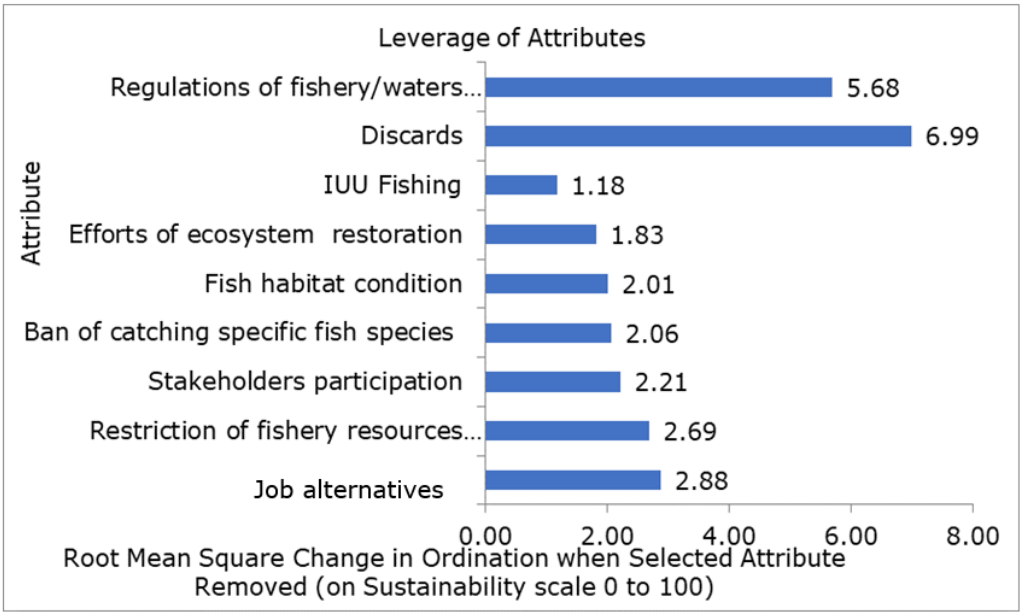

Figure 11. The Root Mean Square (RMS) value of the attributes of the code of conduct dimension in the Batang Bungo River conservation area.

These attributes play a pivotal role in ensuring an effective management of fishery resources within the code of ethics dimension. The extent of fish wasted is directly related to the selectivity of fishing gear. The selectivity of fishing gear varies in the Batang Bungo River, depending on the type of gear used and the target fish species. Non-targeted fish, commonly referred to as bycatch, are frequently found in gear with low selectivity. Regulations must be crafted to facilitate fishermen's understanding of the existing fisheries regulations. Moreover, the absence of water fishery regulations in certain fishing areas may result in adverse effects, including unregulated fishing that disregards biological factors (such as spawning season and fish size), economic considerations (where small fish size is economically undervalued), and a lack of restrictions on the number and types of fishing gear used.

The leverage analysis of this dimension indicates a value of 5.68 for the attribute "fisheries and water management regulation". This can be explained by the decrease of biodiversity, which will impact the income of permanent fishermen along the Batang Bungo River, requiring conservation and restoration strategies (for example, by considering biological factors, such as the spawning season and fish size, and economic factors, such as the capture value, and by limiting the number and type of fishing gear).

Institutional dimension. The sustainability status of capture fisheries in the Batang Bungo River is characterized by a low value, specifically categorized as poor, falling below 10%. The leveraging analysis results underscore the crucial role of regulatory attributes in determining the sensitivity of the sustainability within the institutional dimension of capture fisheries in the Batang Bungo River (Figure 12, Figure 13). The presence of regulatory policies established by institutions, particularly governing the permissible use of fishing gear, designated catch times, and allowable catch quotas, is pivotal in securing the sustainability of fisheries in the Batang Bungo River.

The results of the leverage analysis (Figure 12) show that regulatory attributes play an important role in the sustainability sensitivity of the institutional dimensions of capture fisheries in the Batang Bungo River. The existence of regulatory policies of institutions, regarding the use of equipment, fishing times and minimum sizes, will enforce the sustainability of fisheries in the river (Figure 13).

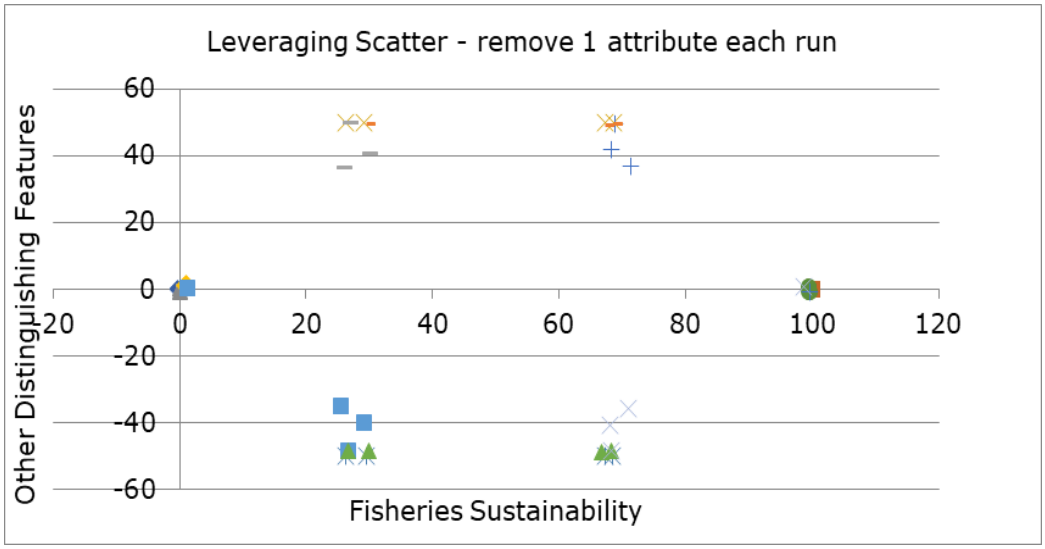

Figure 12. Organizational dimensions of sustainability ordinances in the Batang Bungo River conservation area.

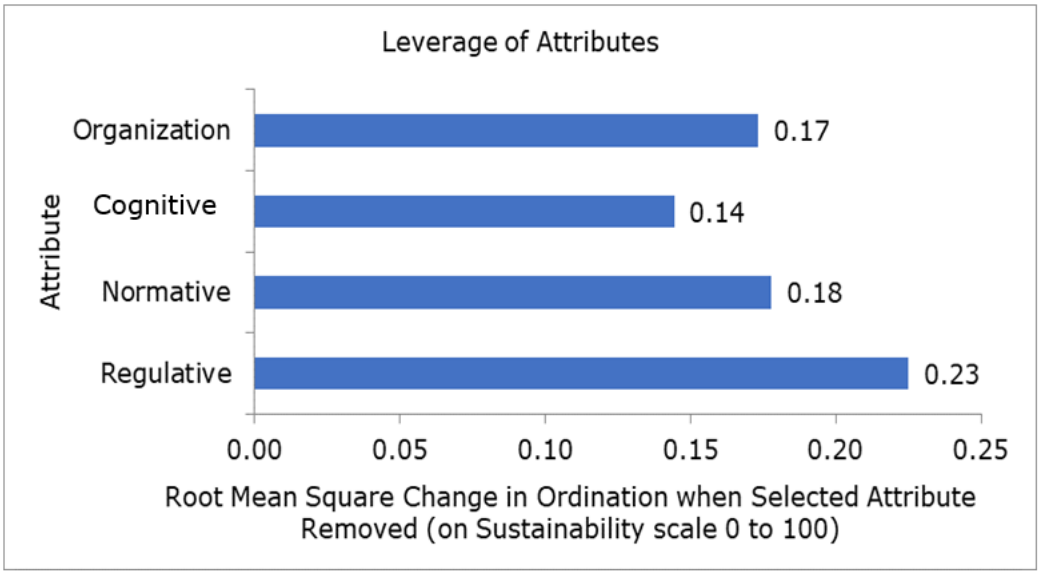

Figure 13. The Root Mean Square (RMS) value of the institutional dimension's attributes in the Batang Bungo River Conservation Area.

The fly chart diagram illustrates the interrelationships among the six study dimensions, simultaneously. This diagram presents a scoring range from 0 to 100%, with intervals of 25%, representing categories such as bad, poor, adequate, and good. The outward movement of the index points indicates a better sustainability status, while inward movement suggests the opposite.

In the diagram below, it is evident that the overall capture fisheries index in the Batang Bungo River falls within the range of 10% to 50%, signifying a status ranging from bad to quite sustainable. Specifically, the economic dimension is the only one displaying a relatively sustainable status, while the other five dimensions range from bad to less sustainable. This implies that focusing on these five dimensions could enhance the condition of capture fisheries in the Batang Bungo River, Jambi Province (Figure 14).

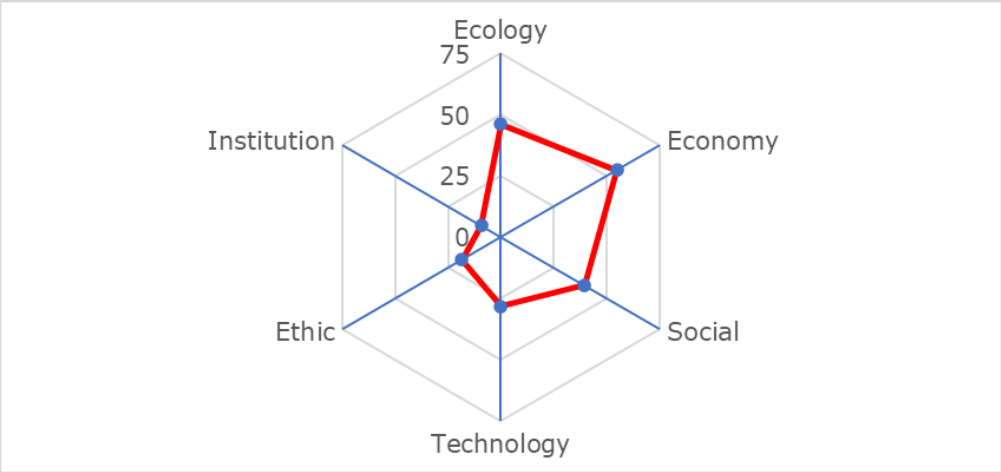

Figure 14. The fly chart analysis of capture fisheries sustainability analysis in the Batang Bungo River, Jambi Province.

Discussion. According to Ogutu-Ohwayo et al (1998), the use of ordination techniques through the MDS method yields an index value and sustainability status below 50%, indicating a "Poor sustainability" status. This sensitivity underscores the need for an ecological-based response or policy to address changes in the size of fish caught. A decrease in the size of fish caught can lead to over-exploitation, resulting in overall fish stock depletion. To manage fish resources effectively, implementing a minimum size limit for the exploited fish, determined by the minimum mesh size allowed, is crucial (Shallof et al 2008; Hutubessy 2021). The exploited fish should be larger than the size at which gonads mature (El-Kasheif 2015). Additionally, determining the optimal economic value of fish involves considering a size larger than the first gonad maturity (Fauzy & Anna 2002). Regulations regarding suitable fish sizes for catching and exploitation management are integral in traditional fisheries in Kenya.

In the economic dimension, attributes such as "ownership", "market reach" and "other income" significantly influence the sustainability of the economic dimension, but the Gross Domestic Product (GDP), government subsidies, and profit/price are the most sensitive attributes. Factors such as catches, fishing gear, fishermen's skills, supporting facilities, infrastructure, capital, and fish selling values influence these attributes.

The social aspect, as highlighted by Fauzy & Anna (2002), emphasizes the importance of attributes such as conflict of interest, level of education, and the number of fishing households (RTP) in determining the fisheries' sustainability. A good education is strongly correlated with various socio-economic aspects in society (Nababan et al 2007). The number of fishing households is also a crucial consideration, as it changes with the fishery potential fluctuations along the river.

Community participation is essential in determining the adhesion to formal and non-formal rules related to the protection of natural resources (McClanahan & Mangi 2004). Sustainability index values below 25% are categorized as bad, indicating a need for enhanced conservation efforts. The selectivity of fishing gear is a dominant attribute affecting the sustainability of fishing activities in the Batang Bungo River, emphasizing the importance of gear selectivity for preserving the fish stocks.

In the technological dimension, the use of selective gear is highly sensitive and dominates the other attributes in the sustainability determination. Policies directed at improving gear selectivity can reduce the by-catch and enhance the catch value. An appropriate ethic involves the stakeholders in the fisheries resource management, which is a sensitive attribute in the ethical dimension. Involving stakeholders, considering environmentally friendly fishing technologies, and adhering to criteria for eco-friendly fishing gear are essential for sustainable fisheries.

In terms of institutional sustainability, the legal sustainability indexes for various fishing gears coincide, indicating a less sustainable status. Strengthening the community capacity, recognizing community rights through formal regulations, and improving the local management institutions' organizational structure are critical steps towards the

fisheries' sustainability. Various successful examples of a sustainable fishery's resources management based on the central role of local communities are known in Indonesia, such as the management of Sasi in Maluku, Awig-awig in West Lombok, Panglima Laut in Aceh, and other locations (Nababan et al 2007).

Conclusions. The Rapfish analysis effectively identified critical factors influencing the sustainability status of capture fisheries in the Batang Bungo River. Overall, nearly all dimensions indicate a less sustainable status, including the ecological, economic, technological, and code of ethics dimensions. Among the six studied dimensions, the institutional dimension exhibits the least sustainability. To enhance the sustainability of capture fisheries in the Batang Bungo River, strategic improvements should target attributes within each dimension that are categorized as sensitive, as these attributes significantly impact the sustainability status of capture fisheries.

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Conflict of interest. The authors declare no conflict of interest.

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